URBANIZATION AND AFFORDANCES THAT PROMOTE WELL-BEING FOR (URBAN) PEOPLE AND FOR A HEALTHY BIOSPHERE

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URBANIZATION AND AFFORDANCES THAT PROMOTE WELL-BEING FOR (URBAN) PEOPLE AND FOR A HEALTHY BIOSPHERE

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The world is urbanizing at an unprecedented rate. It is estimated that in the near future urban landscapes for another ca. 2.7 billion people will be built on planet Earth, approximately converting land equivalent to the size of South Africa. Such land conversion, coupled with citizen densification, increasing in-equalities, shifting diets, and emerging technologies, challenge human well-being and pose ever-increasing demand for resources generated by the Biosphere.

This Research Topic concentrates on the various ways urbanization can promote individual well-being (mental, physical, and social health) as well as ecological health (a healthy Biosphere). What kind of affordances for human health promotion can urbanization include? What kinds of affordances for a psychological connection with nature can urbanization include? What kinds of nudges for pro-environmental behavior and consumption (decreasing detrimental consumption behaviors) can be actively designed in urban settings?

The Research Topic at hand uses a transactional approach, where an affordance can be understood as a non-deterministic in-situ precondition for a human activity, enabled by relations between abilities of an individual with features of an environment. We encourage a broad definition of the concept of affordances, where 'the environment' must not be restricted to the material biophysical environment alone, but also could be combined with social immaterial features. We see that the transactional approach of this Research Topic posits that meaning arises in relations between humans and their environment, that it will be equally applicable to natural and designed environments, and that it doesn't regard dichotomies like city-contra-nature or social-contra-ecological. Hence, this Research Topic is interested in if the transactional approach can be used as a conceptual tool, not only for promotion of mental, physical, and social health in cities, but simultaneously for unraveling relations at the micro scale in cities which can be used for solutions that also promote a healthy Biosphere.

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Table of Contents

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CONCEPTUAL ANALYSIS
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Sense of Place, Fast and Slow: The Potential Contributions of Affordance Theory to Sense of Place

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Over the past 40 years, the sense of place concept has been well-established across a range of applications and settings; however, most theoretical developments have "privileged the slow." Evidence suggests that place attachments and place meanings are slow to evolve, sometimes not matching material or social reality (lag effects), and also tending to inhibit change. Here, we present some key blind spots in sense of place scholarship and then suggest how a reconsideration of sense of place as "fast" and "slow" could fill them. By this, we mean how direct and immediate perception–action processes presented in affordance theory (resulting in immediately perceived place meanings) can complement slower forms of social construction presented in sense of place scholarship. Key blind spots are that sense of place scholarship: (1) rarely accounts for sensory or immediately perceived meanings; (2) pays little attention to how place meanings are the joint product of attributes of environmental features and the attributes of the individual; and (3) assumes that the relationship between place attachment and behavior is linear and not constituted in dynamic relations among mind, culture, and environment. We show how these blind spots can begin to be addressed by reviewing key insights from affordance theory, and through the presentation of applied examples. We discuss future empirical research directions in terms of: (1) how sense of place is both perceived and socially constructed; (2) whether perceived and socially constructed dimensions of place can relate to one another when perceived meanings become unsituated; and (3) how place attachment may change over different stages of the life course based upon dynamic relationships between processes of perception–action and social construction. We conclude with insights into how processes of perception–action and social construction could be included in the design and management of urban landscapes.

Keywords: ecological psychology, place meanings, human–environment relationships, place attachment, embodied cognition, affordances, dual-process models

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INTRODUCTION

Interest in sense of place has grown rapidly in recent years, with the concept extended from leisure and recreation to a wide range of applications and settings. The concept broadly describes human connection to places, including place attachment and place meaning (Stedman, 2003; Farnum et al., 2005; Smaldone et al., 2005). Place attachment refers to the emotional bonds between an individual

and a geographic locale, or how strongly a person is connected to a place (Low and Altman, 1992; Jorgensen and Stedman, 2001; Raymond et al., 2010), whereas place meaning is the descriptive, symbolic meaning that people ascribe to a place (Smaldone et al., 2008; Stedman, 2008, 2016).

Historically, sense of place research, including emphases on both meaning and attachment (**Figure 1**), has "privileged the slow." We see this in the "conservativism" of place critique(s) which views place meanings as slow to evolve, sometimes not matching material or social reality (lag effects), and also place meanings as tending to inhibit change (the maladaptive nature of place meanings) (Marshall et al., 2012; Stedman, 2016; Masterson et al., 2017). It is also generally accepted that place attachment endures over time (Giuliani, 2003; Lewicka, 2011), and slowly changes in intensity or structure with one's length of residence in a given place (Hammitt et al., 2004; Brown and Raymond, 2007), or waxing and waning over the course of one's connection to a place (Smaldone et al., 2008). Its stability can be affected by life stage (Elder et al., 1996), by economic, social, political, and other external disruptions to a place (Brown and Perkins, 1992; Feldman, 1996; Devine-Wright, 2009), and across short-term and long-term residents (Kaltenborn and Williams, 2002; Stedman, 2006). Despite these limited engagements of variability, the general tendency in research has been to emphasize the steady, "slow" development of strong attachments and stable meanings.

Within sense of place scholarship, Williams (2014a) identifies two branches of enquiry: "place as a locus of attachment" and place as a "center of meaning" (**Figure 1**). The former refers to an operational construct designed to measure the intensity or strength of a bond to a geographic locale. Scholars rarely acknowledge that this branch of enquiry is based on an interactionist worldview in psychology (Altman and Rogoff, 1987). In this worldview: (1) reality comes divided into subjects and objects in that aspects of the environment are seen as independent of the properties of human minds or bodies (Altman and Rogoff, 1987; Lakoff and Johnson, 1999); (2) the individual is driven by factors located outside in the surroundings, including biological determinants; and (3) the bases for change in the state of the individual are the impacts stemming from entities and conditions in the surroundings, as well pushes from within the individual (Heft, 2013). Researchers commonly employ top-down information processing strategies using deductive approaches. Contextual information is used as "inputs" (in the forms of cognitions, beliefs, attitudes, or other mental representations about a place, see Williams, 2014a) in order to create meaningful mental perceptions ("output") (Bernstein, 2010).

In contrast, "place as a center of meaning" refers to the broader processes of meaning-making, and how to characterize experience, meaning, and relationships to places in more experiential qualitative terms (Williams, 2014a). Emphasis is placed on an interpretative approach to cognition (Bruner, 1990), with hermeneutic, discursive, dialogical, or phenomenological research paradigms used to interpret how place meanings form, or are collectively shared, disseminated and deployed (see **Table 1** and section "Sense of Place Scholarship Rarely Accounts for Sensory or Immediately Perceived Meanings" for further explanation).

Regardless of differences between the above perspectives, they have in common a general emphasis on "slow" progression of meanings and attachment, and are often interested in the social construction of meaning. Unlike in the sense of place scholarship,

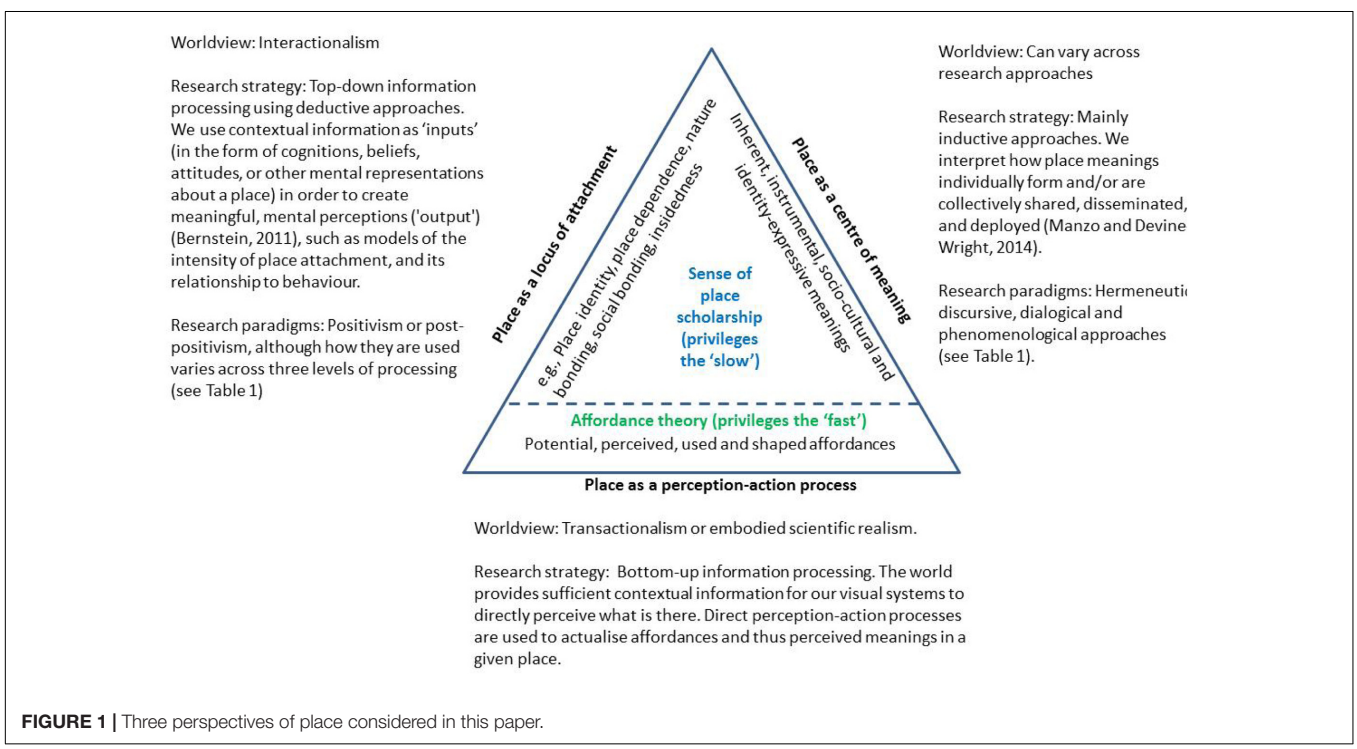

FIGURE 1 | Three perspectives of place considered in this paper.

TABLE 1 | An overview of the differing approaches to sense of place and affordance scholarship.

	Foci of place	Research strategy	Different research paradigms or approaches used to understand place			
Sense of place scholarship (privileges the "slow")	Place as a center of meaning (focus on place meaning)	*Inductive*. We interpret how place meanings individually form and/or are collectively shared, disseminated, and deployed	*Hermeneutic approach*. Meaning is generated in the individual subjective mind through the interpretation of texts. Place has to be interpreted in order to reveal a deeper meaning. Landscape legibility is therefore a key to understanding place meaning (Drenthen, 2011).	*Discursive approach*. Place meanings are treated as a social practice that cannot be understood outside of interactional, cultural, and institutional contexts in which they emerge. They are formed through everyday language use and social practice and have significant rhetorical relevance (Di Masso et al., 2014).	*Dialogical approach*. "Meaning arises out of the relationship between an act and those trying to understand it – it is the product of an interaction of two subjects" (Fay, 1996, p. 142). Dialogical approaches highlight the central role of actions and practices in producing place meaning (West, 2016).	*Phenomenological approach*. A holistic approach to cognition whereby individual or group actions, experiences, intentions, and meanings are drawn together spatially (Relph, 1976; Casey, 2009). Emphasize subjective place experience, deep emotional ties, and individually constructed place meaning (Tuan, 1974, 1977, 1980; Relph, 1976) often created through lived experience (Seamon, 2014).
	Place as a locus of attachment (focus on place attachment)	*Top-down information processing/deductive*. We use contextual information as "inputs" [in the form of cognitions, beliefs, attitudes, or other mental representations about a place (Williams, 2014a)] in order to create meaningful, mental perceptions ("output") (Bernstein, 2010).	*Computational level*. What is the goal of the computation? What problems does the system solve or overcome? (Marr, 1982; David et al., 2004). For example, what is the goal behind forming certain attitudes or beliefs about place?	*Algorithmic-representation level*. What representations does the system use and what processes are employed to manipulate inputs and outputs (Marr, 1982; Bechtel, 2008). For example, what is the dimensionality of place attachment (Kyle et al., 2004; Lewicka, 2005, 2010; Raymond et al., 2010) and how do these dimensions affect behavior (Stedman, 2003; Raymond et al., 2011)?	*Implementation level*. How is the system physically realized in the human brain (David et al., 2004)? For example, how is place attachment realized in the human brain? We are not aware of any place attachment studies in this area of cognitive neuroscience.	
Affordance scholarship (privileges the "fast")	Place as a perception-action process (focus on affordances)	*Bottom-up information processing*. Perception starts at the stimulus. The real world provides sufficient contextual information for our visual systems to directly perceive what is there, unmediated by the influence of higher cognitive processes (Gibson, 1979).	*Individual perspective*. Affordances exist by virtue of a relationship between the physical properties of the world and the action capabilities of the individual (Gibson, 1979; Jongeneel et al., 2015).	*Social perspective*. For some scholars, a type of affordances exist that are social and that take the form of possibilities for coordinated behavior (e.g., Shockley et al., 2009; Wiltshire et al., 2014). However, it is more commonly assumed that all affordances are "social" because they belong to a shared reality and are bound up with normatively constrained social practices (Kiverstein, 2015).		

there is a wider body of literature in Ecological Psychology which "engages the fast," as reflected in the theory of affordances (**Figure 1**). An affordance refers to the "possibility for action" provided to an individual by an environment – by the substances, surfaces, objects, and other living creatures that surround the social actor (Gibson, 1979). Affordances are the result of real-time or direct perception–action processes in that they depend on the existence of an organism that can perceive them and the actions which the organisms can undertake within a particular setting (Chemero, 2003). For example, a ledge approximately 6 inches high in a public area may function as an edge marker for adults; however, for a young child it can function as a place to sit, as a structure to climb on and to leap over, and as a challenging edge on which to walk (Heft, 2010). The geographic scale of place in this context refers to one's immediately perceivable environment. Three core principles underpin Gibson's ecological approach (Chemero, 2003): (1) perception is direct in that it does not involve computational or mental representations; (2) direct perception–action processes are primarily for the guidance of action; and (3) because perception does not involve mental computational or mental representations yet it can still guide behavior, all the information and meaning necessary to guide adaptive behavior must be available in the environment to be perceived (Chemero, 2009).

We now articulate and engage a new branch of place enquiry that engages with the fast as "place as a perception–action process" (**Figure 1**), resulting in the formation of immediately perceived place meanings. This branch takes a bottom-up view of information processing whereby it is assumed that the world provides sufficient contextual information for our visual systems to directly perceive what is there without the need for lengthy cognitive abstraction. It is based on a transactional worldview of psychology, akin to embodied scientific realism, which supports the inseparability of subject and object (Maturana and Varela, 1987; Lakoff and Johnson, 1999). In other words, dynamic, multi-level relationships are possible between elements of mind, body, culture, and environment (Raymond et al., 2017).

In this conceptual paper, we highlight the potential contributions of affordance theory to sense of place scholarship. We first critically discuss a set of "blind spots" in sense of place scholarship and suggest how affordance theory may address them. We then outline a set of future research directions for reconceptualizing sense of place theory to take account of fast and slow processes of cognition associated with perception–action and social construction, respectively.

KEY BLIND SPOTS IN SENSE OF PLACE SCHOLARSHIP

Sense of Place Scholarship Rarely Accounts for Sensory or Immediately Perceived Meanings

Sense of place scholars have largely focused their investigations on the social construction of place attachment or place meaning using interpretative or top-down information processing approaches (**Table 1**). Each approach has a different emphasis on place. Briefly, at the risk of over-simplification, interpretive approaches within "place as a center of meaning" often focus on the meanings that shape actions or everyday experiences (Wagenaar, 2011). Within the diversity of interpretive traditions, sense of place scholars usually employ hermeneutic, discursive, dialogical, and/or phenomenological approaches. In a hermeneutic approach, meaning is generated in the individual subjective mind through the interpretation of texts. Landscape legibility or being able to "read" the landscape is therefore crucial to the formation of a sense of place (Drenthen, 2011). In a discursive approach, place meanings are treated as a social practice that cannot be understood outside of interactional, cultural, and institutional contexts in which they emerge. They are formed through everyday language use and social practice and have important rhetorical relevance (Di Masso et al., 2014). Dialogical approaches emphasize the central role of actions and practices in producing place meaning (West, 2016). A phenomenological approach seeks to qualify the long-term relationship between an individual and a place through lived experience (Relph, 1976; Norberg-Schulz, 1980; Seamon, 2014). Emphasis is placed on subjective place experience, deep emotional ties, and individually constructed place meaning (Tuan, 1974, 1977; Relph, 1976). Meaning is not solely a person–environment relation, but an intersubjective matter of people–environment relations. It is the shared performance of individuals (e.g., by inventing, constructing, and deconstructing structures) that turn lived space into a special place (Graumann, 2002). Much of the early work on sense of place and place attachment focused on this holistic approach (Stedman, 2002).

In contrast, in "place as a locus of attachment" scholars have frequently employed a top-down information processing approach in order to quantify the relationships between activities, physical attributes, and meanings (Moore, 2014). How top-down information processing is used can vary across different levels of processing. In cognitive psychology, three levels of information processing are commonly discussed: computational, algorithmic–representational, and implementational (Marr, 1982; Newell, 1990). Computational level addresses questions such as what is the goal of computation? What problems does the system solve or overcome (Marr, 1982)? Here, we need to consider what drives different attitudes or beliefs about place. In contrast, algorithmic–representational approaches describe how the system represents the problem and what processes are employed to manipulate inputs and outputs (David et al., 2004). Most quantitative research on place attachment has focused on this level of computation. For example, researchers have attempted to psychometrically distinguish between functional goals using the dimension of place dependence and symbolic meanings using the dimension of place identity (Kyle et al., 2004; Hammitt et al., 2006; Raymond et al., 2010; Ramkissoon et al., 2013a; Brown et al., 2015). Psychometric scales that measure these two dimensions of place attachment have been widely used in environmental psychology (Lewicka, 2011), and have been extended to measure the bonds developed between an individual and broader elements of the social and biophysical context to place (Kyle et al., 2005; Jorgensen and Stedman, 2006; Raymond

et al., 2010; Ramkissoon et al., 2013b). Implementation-level theory answers the question of how representations and algorithms can be realized physically in the human brain (David et al., 2004). For example, what happens in the human brain when one becomes attached to a given place? No studies have as yet employed neuroscience approaches to the assessment of sense of place.

These differences notwithstanding, common to all these approaches to sense of place is that they rely on a high level of intellectual abstraction of cognitions, beliefs, attitudes, or other mental representations about the physical, social, or personal qualities of a setting and comparatively neglect the role of the local context in direct perception (Vanclay et al., 2008). We also see this intellectual abstraction in studies that question the relative contribution of physical, social, or personal dimensions of place (e.g., Beckley et al., 2007). For example, Williams (2014b) discusses four layers of place meaning: inherent, instrumental, socio-cultural, and identity–expressive (**Figure 1**). Places can have inherent meaning (Lynch, 1960) which transcends any culture, and reflects essential properties of a place that many people perceive. Places can have instrumental meanings associated with their material properties that contribute to desired social or economic goals. They can have socio-cultural meaning which recognizes that places can be socially or symbolically constructed within the cultural, historical, and geographical contexts of day-to-day life (Hay, 1998; Gustafson, 2001; Seamon, 2014). The identity-expressive layer focuses on how individuals become attracted to and attached to place because those places possess intangible emotional, symbolic, and spiritual meaning.

Despite the above, it remains unclear how the *immediately perceived and sensory dimensions* of sight, smell, hearing, taste, and touch (i.e., aspects of sensory experience) contribute to overall place meaning. Crucially, these perceived meanings do *not* involve mental computational or mental representations. Rather, they involve a bottom-up theory of perception whereby perception starts at the sensory input, the stimulus (Bernstein, 2010). Sense of place scholarship has been largely silent on this question with general assumptions made that aspects of the senses represent a particular category of place meaning (Russ et al., 2015). Others imply that sensory experience reflects an intensity of place meaning. For example, Hay (1998) showed that as the amount of time spent in a place increases, the relationship to the place, and in particular the attachment, intensifies and becomes deeper (from "aesthetic experience" to "part of place"). A wider view of the literature suggests that senses themselves are an important element of place perception. Vanclay et al. (2008) suggest that full experience of a place can only be experienced through the senses (smell, taste, feel, sight, and spiritual dimensions), whether we are aware of them or not, and call for the consideration of both intellectual abstraction and sensory perception. They highlight the importance of different senses to people with disabilities, as in the case of the history of "deaf places of silence" which are commonly known to deaf people (Gulliver, 2008). In the marketing and branding literatures, scholars have found that aesthetics and visual cues are powerful ways of tailoring products to the perceived desires of consumers (e.g., Porter, 2013). Other work considers the way in which non-visual senses can, or could, play in the way places are branded (Medway, 2015; Medway et al., 2016).

The complex relations among sensory, inherent, instrumental, socio-cultural, and identity-expressive meanings have not been adequately engaged in the sense of place literature. A holistic assessment would require scholars to accept that sense of place can form through both immediate and direct perception–action processes in addition to the longer-term processes of intellectual abstraction, representation, or computation, which are better represented in the sense of place literature (mainly in terms of social construction). Doing so will require a general willingness to explore sense of place across time, including a consideration of how sense of place forms and changes in response to both immediate perceptions and longer-term processes of social construction.

Sense of Place Scholarship Pays Little Attention to How Place Meanings Are the Joint Product of Attributes of Environmental Features and the Attributes of the Individual

Many of the debates in sense of place scholarship focus on the relative contribution of social relationships and physical environments to place attachment and place meanings. In psychology, place has been presented as a socio-physical construct comprising of physical, social, and personal/individual components. However, few papers discuss the potential for sense of place to be simultaneously determined by the intersection of attributes of the environmental feature in question and attributes of the particular *individual.* In a review of the literature, Lewicka (2011) found that physical factors have been found to be stronger predictors of place attachment among higher income respondents, whereas social ties are more important among lower income respondents. Scannell and Gifford (2010) found that physical factors were more important reasons for attachment to the city whereas social factors were more important to the home and region. Place meanings can also be influenced by a range of ecological characteristics (Russ et al., 2015) and features of the biophysical environment (Stedman, 2003), whereas others involve pivotal moments or other significant life experiences that happened in a place (Manzo, 2005).

The focus on the relative contribution of different dimensions of place meaning implies a duality between individuals, culture, and the environment in human–nature relationship assessments and stifles discussion on a more holistic concept of "relatedness." Absent in most discussions is the way in which sense of place is formed based on the nature of the setting, the kind/amount of experience with that setting, and socio-demographic characteristics of the individual (Stedman, 2003). The concept of "situated cognition" is one way to understand such relatedness of the conjoining of people and place. By situated cognition we refer to how meaningful actions are spatially and temporally located (i.e., *situated*) (Chemero, 2009) alongside socially and culturally constructed meaning (Lave and Wenger, 1991; Wenger, 1998). For example, how

decisions concerning the speed at which you ride your bike are shaped by your characteristics as an individual (e.g., are you in good physical condition, and are you generally risk averse or risk seeking), the visual perception of a bike trail on a given day (e.g., has it rained and are there muddy spots where you might fall), your previous experiences on that bike trail tied to deeply held place meanings and the social expectations of significant others accrued over time (Raymond et al., 2017). Such dynamic relations imply an inseparability of subject and object (Maturana and Varela, 1987; Lakoff and Johnson, 1999), which sense of place scholarship – at least as currently articulated – cannot clearly explain or describe. Gustafson (2001) has provided one of the most pivotal accounts of the potential for dynamic relations among person, physical environment, and social environment. He found evidence for a network of relational place meanings with some meanings situated in the relationship between self, others, and/or the environment. However, even this work has not seriously engaged the kind of situated cognition we envision.

Sense of Place Scholarship Implicitly Assumes That the Relationship between Place Attachment and Behavior Is Linear and Not Constituted in Dynamic Relations Among Mind, Culture, and Environment

Scholars have often assumed that sense of place is analytically separable from behavior and therefore it can be used to systematically predict it. For example, results showing that place attachment directly predicts self-reported pro-environmental behavior (Vaske and Kobrin, 2001; Stedman, 2002; Brehm et al., 2013) or place attachment indirectly predicts behavior through values, beliefs, and norms (Raymond et al., 2011). In most instances, the effect sizes of these linear models are only modest (<20%), raising questions about how to model the relationships between sense of place and action, and what the other "missing" predictors of behavior might be. These models also tend to test the relationships between place attachment and behavior at a point in time rather than how these dynamics may vary across time. Rather than a new model, perhaps we require a new set of assumptions about the links between sense of place and behavior. The above assumptions about the relationships between sense of place and behavior change if we engage an alternative worldview of "transactionalism," which emphasizes the inseparability of subject and object (Maturana and Varela, 1987; Lakoff and Johnson, 1999). Here, dynamic, multi-level relationships are possible between elements of the mind, environmental and cultural system, which imply that one cannot understand aspects of behavior without also understanding aspects of the intertwined socio-cultural system. There is growing evidence for this worldview in human–environment relationship studies, but not in sense of place research *per se*. Cooke et al. (2016) eloquently show that human–environment connections are not produced solely within the mind, but through relations between mind, body, and environment over time. Fischer and Eastwood (2016) find intersections between the co-production of ecosystem structures, ecosystem services, and the social construction of these structures and services. Brown (2016) demonstrates how the experience of textured terrain (e.g., the resistance, gradient, shape lumpiness, and irregularities of the terrain) can produce sensory and emotional experiences that motivate regular exercise.

Sense of Place Scholarship Does Not Account for How Both Place Meanings and Place Attachment Vary Across the Life Course

The sense of place literature typically engages experience and time over a longer time horizon. It is generally accepted across all approaches that place attachment slowly changes in intensity with one's length of residence in a given place (Hammitt et al., 2004; Brown and Raymond, 2007), and is shaped by economic, social, political, and other external disruptions to a place (Brown and Perkins, 1992; Feldman, 1996; Devine-Wright, 2009). Research has also considered how place attachment develops across long-term residents, with sequential stages in the development found across time in a given place [Hay, 1998; but see Stedman (2006) for a dissenting view; Rowles, 1983], and the role of nostalgia in facilitating attachments to place (Lewicka, 2011). Scholars have used identity theories to describe how physical changes (both actual and proposed changes) to place may threaten place-based identities (Proshansky et al., 1983; Stedman et al., 2002; Devine-Wright, 2009); and how place attachment may be both threatened *and/or* enhanced across place change (Devine-Wright and Howes, 2010). Place attachment can also vary across life-place trajectories of: long-term residence in a single place, return to the home place, residential mobility with continuity in settlement, residential mobility with discontinuity in settlement, and high residential mobility (Bailey et al., 2016).

Despite the above, the role of place experience in shaping place meanings and attachments across the life course has not been thoroughly considered. Scholars have made a general assumption that place meanings are sustained by regular environmental actions and routines, that are in turn maintained and strengthened across one's depth of experience with place (Seamon, 1979; Fullilove, 2004). For example, from a phenomenological perspective, place meanings are embedded in stories and metaphors, each highly dependent on context, and embedded or contained within an evolving set of experiences (Patterson, 1998). But how may these meanings change across place experiences at different life stages, and what role do these changing meanings have on one's overall place attachment? Sense of place scholarship cannot fully answer such questions. They are important to consider because wider psychology research has shown that the connections that we have with family and friends and the experiences we have in place during important transition times in life (e.g., children approaching decisions to leave home) are related to mobility preferences (Elder et al., 1996). Studying these relationships may help us better understand and predict the determinants of mobility and migration, which is a mega-trend of the 21st century and also addresses a major gap in sense of place theory concerning the interrelationships between place meaning and place attachment. Current discussions often

become confounded by conflicting views about the relative merits of qualitative vs. quantitative studies implemented over short time spans as opposed to understanding how they together may inform sense of place over different life stages.

HOW AFFORDANCE THEORY CAN ADDRESS BLIND SPOTS IN SENSE OF PLACE SCHOLARSHIP

Affordance Theory Demonstrates How Direct Perception and Actualization Inform Place Meanings

Two processes underpin the theory of affordances, namely *direct perception* and *actualization* (Kyttä, 2002, 2004). In contrast to most sense of place scholarship, an individual does not require mental computation or representations because the perception of meaningful behaviors is readily available in the environment, hence *direct*. An individual directly perceives what are his/her opportunities for action in an environment given the relations among the observer's knowledge, intentions, action abilities (constrained by body morphology, physiology, and emotional/intellectual development), and the properties of the environment itself (Canal-Bruland and van der Kamp, 2015). Perception is directly functional for the guidance of action rather than for gathering information (Chemero, 2009, p. 18). *Actualization* is then the processes of complementing environmental opportunities with personal abilities. In other words, the environment provides something that the individual perceives as offering the potential for activity, but actualization of the activity only emerges when the different characteristics of the individual, such as his or her physical abilities, social needs, and personal intentions, are matched in meaningful relations with the environmental features (Kyttä, 2004).

These relations mean that affordances can rapidly change from potential to perceived, used or shaped depending on the relationships between the individual, culture, and setting (Kyttä, 2003). Kyttä (2002) describes this dynamic. All environments have countless numbers of *potential affordances* that no agent has yet perceived. The array of potential affordances available to any given individual is defined by the individual's qualities such as the children's physical skills or bodily proportions. The qualities of the individual as well as his or her current intentions and other cultural factors determine which affordances out of all potential affordances the individual perceives in different situations (i.e., *perceived affordances*). Some of these affordances are used in the here and now. Individual and socio-cultural factors can have an influence on what affordances are utilized and when this occurs. It is also possible to actively shape the environment to create new affordances, or to change existing ones, in what is referred to as *shaped affordances*. Modifying the physical environment can open space for the identification of new affordances and new possible activities (Kyttä, 2002, 2004).

Hence, through direct perception and action we create various forms of perceived place meanings related to functional, social, or symbolic elements of a given area. Meanings are assigned to places within one's immediately perceivable environment. These places have clear material and perceptual components. Hereafter, we refer to them as "immediately perceived place meanings" to distinguish them from the more commonly known place meanings formed through social construction.

Affordance Theory Demonstrates That Cognitions Are Situated in Relation to the Environment, the Individual, and One's Socio-Cultural Context

In affordance theory, perception–action process and associated cognitions always occur in a *situation*. Because perception is direct, meaningful actions are always spatially and temporally located (i.e., *situated*), providing information about "here," "there," "me," and "now" (Chemero, 2009). Information perceivable in any given situation will specify patterns of relations between the organism and the environment (Shapiro, 2011). Situations can then have motivating qualities: as in the case of a low ledge for children (as a "climbing place"), or repelling like an aggressive dog (Heft, 2010) suggesting an affective dimension to affordances (Kyttä, 2003; Roe and Aspinall, 2011; Withagen et al., 2012). Thus, patterns at any given situation not only offer the opportunity to act, but also can invite and attract the action (Withagen et al., 2012) or repel and detract the action. Any given place can therefore have an array of positive and negative affordances that promote or inhibit action, respectively.

These perceptions and actions are not only situated with reference to a physical context (Heft, 2013). Associations between bodily experiences and abstract concepts are situated in a socio-cultural context, informed by cultural imperatives, values, and habits (Gibson, 1979; Varela et al., 1991; Leung et al., 2011), and social learning (Bandura, 1977), which can be readily applied to gaining competence in place. Individual and sociocultural factors together determine which of the perceived affordances become *used affordances* within a given experience (e.g., sat on, swam in, climbed on), as in the case of socialization during childhood development. During development, a child learns to perceive not only the affordances for the self, but also how those same objects furnish similar affordances to another (Gibson, 1979). Parents or significant others can introduce children to the conventional meaning of an object by manipulating which objects command attention and demonstrating how to use the object through performing its central function. For example, in a study of a kindergarten in central Norway, some 3–5-year olds needed to be socially invited into physical play, to realize the *potential affordances* for physical activity (Bjørgen, 2016). Encouraging invitations from others, responses, imitations, and sharing moment of fun were of significance in the involvement and duration level of physical activity. Hence, the physical activity is not always created by the children, but requires invitations from others in the environment where they are playing and regulation by significant others who promote certain behaviors.

In summary, this section highlights that immediately perceived place meanings are both temporally and physically located and are influenced by a range of physical and social

elements in one's immediately perceivable environment and by socio-cultural processes.

Affordance Theory Suggests That Bodily Action Is Constituted within Dynamic Relations among Mind, Body, Culture, and the Environment

Affordance theory suggests that cognition is not an activity of the mind alone, but is instead distributed across the entire relationship situation, including mind, body, culture, and physical environment (Heft, 1989). Through direct perception–action processes an individual actualizes those relations among environment, culture, body, and mind that reflect and support his or her capabilities and intended actions at any moment in time (Kyttä, 2002). How they are actualized depends on the *real-time relationship* between a mental system in a body with particular capabilities with an environment that offers opportunities for acting on those services. Hence, bodily action is constituted within dynamic relations.

The coupling of perception and action in the social affordance literature is one example of these dynamic relations. It has been found that eye gaze patterns influence postural coordination, and gaze co-ordination is related to mutual understanding [see Shockley et al. (2009) for a review]. For example, pairs of individuals who are asked to perform a rhythmic task such as rocking in a chair rock independently in their chairs are pulled to spontaneously synchronize their movements (Richardson et al., 2005, 2007). The patterns of behavior that occur between the two individuals rocking independently in separate chairs with no mechanical (only informational) links obey the same dynamics as coupled components (Marsh et al., 2009). Studies have also shown coupling across a range of other behaviors including walking, running, and plank lifting (Anderson et al., 2012).

It is important to note that these perception–action processes are not static, but since they are related to activities, they happen over time and their actualization changes the subsequent patterns of relations between individual and environment (Chemero, 2009). In other words, an individual's perception–action in the environment influences both surrounding (e.g., by manipulating objects, affecting others, moving) and abilities (e.g., by learning, acquiring new skills), and in doing so opens up possibilities for new activities and thus novel or reshaped patterns of affordances (Shotter, 1983; Heft, 1996). Raymond et al. (2017) provide the example of a mountain bike rider to show a dynamic relation among the condition of the rider, perception of the environment, and riding speed (behavior). They note that the act of riding improves individual body condition and confidence, which in-turn has an effect on what kind of environment can be perceived as safe and enjoyable. Skills are embodied by repeatedly practicing mountain-biking allowing a rider to perceive a rocky and wet slope as safe and enjoyable, thereby enabling the rider to approach it and enjoy it at faster riding speed.

In summary, this section highlights that elements of our own mind and bodily condition inform what types of meanings we immediately perceive in a given place. Human have the ability to learn new skills and to improve their physical condition which opens the potential for new forms of immediately perceived place meanings. We also change a place through our actions, which opens spaces for new meanings.

DISCUSSION

The objective of this paper was to highlight the potential contributions of affordance theory to sense of place scholarship. We asserted that most sense of place scholarship is preoccupied with the "slow" in that most research suggests that place meanings as slow to evolve, sometimes not matching material or social reality (lag effects), and thus as tending to inhibit change. Little attention is paid to the role of sensory or immediately perceived meanings in the formation of sense of place; how place meanings are the joint product of attributes of environmental features and the attributes of the individual (i.e., the importance of situated cognition); the non-linear dynamics between sense of place and behavior, including the dynamic relations among mind, culture, and environment; and how place meanings vary across the life course. In contrast, affordance theory engages the "fast" – the more immediate perception–action processes between an individual and their social and cultural environment. Affordance theory demonstrates how direct perception and actualization inform immediately perceived place meanings that cognitions are situated in relation to the environment, the individual, and one's socio-cultural context, and behavior is constituted within (and simultaneously determined by) dynamic relations among mind, body, culture, and the environment.

How do these different views on human–environment relationships influence our approach to sense of place research? Rather than viewing sense of place as exclusively (or even primarily) a social construction or representation, we suggest it could be seen as a *property of the relationship between perception–action and social construction processes both within and across place-based experiences*. Along these lines, we encourage sense of place researchers to assess the relationships among immediately perceived place meanings and other forms of place meaning that are socially constructed through longer-term processes of cognition and how each may contribute – independently, and collectively – to one's place attachment. To understand these relationships, we encourage place scholars to move away from a focus on concept development and measurement, based firmly in the social construction approach, to enquiries of place as a *multi-channel process* which provides for an understanding of the relational dynamics between perception–action processes and socially constructed processes. Integrating the perceptual and conceptual domains will require place scholars to engage with the theory of embodied cognition, dynamic systems, as well as multiple views of cognition and behavior. In the next section, we propose pathways through which to consider the potential relationships between these two understandings of human–environment relationships.

Embracing the "Fast" and "Slow" in Future Sense of Place Research

Future research could investigate how the qualities of both sense of place scholarship and affordance theory could be applied to solve important issues in sense of place scholarship, such as how place attachment may form and change in a given place. The dual-process theory of higher cognition could be a fertile ground through which to explore or examine the intersections between place meanings formed through socially constructed process and meanings formed through affordances, i.e., perception–action process. According to this theory, both slow and fast forms of cognition exist (Kahneman, 2003; Evans, 2010; Evans and Stanovich, 2013). Type 1 cognition is grounded in perception and intuition – thinking is fast, automatic, effortless, and associative, while Type 2 which is grounded in reasoning – thinking is slow, serial, controlled, effortful, and rule-governed. Type 1 generates impressions of the attributes of objects of perception and thought. In contrast, Type 2 is involved in judgments, irrespective of whether they originate in impressions or in deliberative reasoning (Kahneman, 2003). While there have been a number of criticisms of dual-process theories (see overview in Evans and Stanovich, 2013), there is general acceptance that Type 1 represents a set of modes of cognition associated with rapid autonomous processes that yield habitual responses unless they are intervened on by higher order reasoning processes of Type 2 (Evans and Stanovich, 2013). Within each type there are modes of cognitive processing styles or thinking dispositions (Stanovich, 2009) which can vary continuously according to personality characteristics and cultural factors (Evans and Stanovich, 2013).

Following this view, is it possible that direct perception–action processes operate as a subset of Type 1, fast, automatic processes (following Herschbach, 2015)? In contrast, can socially constructed process be considered a subset of Type 2, slow processes? Three research areas worth considering under this line of thought are:

Research Direction 1 – Investigate How Sense of Place Is Both Directly Perceived (Type 1) and Socially Constructed in a Given Place (Type 2)

Perceived meanings, as we have described above, may play a bigger role in "sense of place" than we typically think. We propose that in any experience in life, sense of place can be associated with immediately perceived place meanings (related to Type 1 cognition) and/or place meanings formed through longer-term processes of social construction (related to Type 2 cognition). For example, the fireplace a couple sits next to after getting married enables the used affordance of warmth and light, plus a cozy atmosphere. Equally, that fireplace can be related to a diverse set of inherent, instrumental, socio-cultural, and identity–expressive meanings (Williams, 2014b), which can be positive and negative in nature (Manzo, 2005). At the time of the wedding they may be related to feelings of romance and love, but if the fireplace was the backdrop for the scene of agreement to divorce it could also be associated with feelings of grief and loss, or if during a winter power outage, simply a pragmatic source of warmth or cooking. It follows from above that direct perceptions can be repeated in behavior.

We also propose that the relationships between direct perceptions and social construction are unlikely to be direct and linear. At small geographic scales, we hypothesize that place attachment will be a property of both immediately perceived and socially constructed place meanings, and that these meanings collectively help guide behavior. To investigate this hypothesis, a fruitful area of enquiry may be to specify physical characteristics of the environment that are perceived positively for a certain set of affordances and are known (at least anecdotally) to be a source of place attachment. Starting with a set of known relationships would help researchers to identify the mechanisms through which Type 1 and Type 2 processes occur.

Understanding the duration of focus of direct perception and social construction is also crucial to this line of enquiry. It is assumed that direct perception is immediate and social construction takes longer, but what are the actual time differences? Quasi-experiments may play an important role in understanding the time differences in cognitions resulting from direct perception and social construction so as to form a more holistic understanding of place.

To date we have avoided the question of how different types of place meanings inform each other at different geographic scales. To understand how sense of place is both perceived and socially constructed, we need to clarify the spatial scale of "place" and thus to what extent an affordance is a "place." Here, we argued that there are parallels between affordances and sense of place when focusing on one's immediate perceivable environment, such as a room, home, street, or small urban park (i.e., fine geographic scales). Yet how do direct perception and social construction occur at coarser geographic scales such as a neighborhood, city, or region? In short, we don't yet know. An important future research direction is to examine whether affordances can be nested or sequenced in ways that enable us to understand direct perception at larger spatial scales. Such research would need to challenge some of the fundamental assumptions of affordance theory concerning how humans directly perceive the environment. For example, researchers would need to consider the potential for a collection of affordances in a place, a network of places in the neighborhood, a set of familiar and unfamiliar neighborhoods in a metropolitan area, etc. We consider this question of the scalability of affordance-based thinking an exciting area of future inquiry.

Research Direction 2 – Explore and Examine Whether Perceived (Type 1) and Socially Constructed (Type 2) Dimensions of Place Relate to One Another When Perceived Meanings Become Unsituated

The previous research direction investigates whether place as a perception–action process and place as a socially constructed process exist concurrently in a given place. But how do they relate? We propose that perceived and socially constructed meanings relate when perceived meanings become unsituated. This may occur through the process of "offline cognition." According to Wilson (2002), humans build up in long-term memory a set of reactions, movements, sensations, perceptions,

feelings which are available for various purposes including cultural ones. In this process, mental structures that originally evolved for perception or action are co-opted and run "off-line," to assist in thinking and knowing (Glenberg, 1997; Wilson, 2002). Just thinking about an object produces states as if the object were actually there, as does perceiving a symbol, such as the name of the person or object (Spackman and Yanchar, 2014). Cognition can therefore become "unsituated." The evidence for offline cognition is widespread. It is included in discussions of mental imagery (including visual, audio, and kinesthetic imagery), working memory, episodic memory, implicit memory, and reasoning and problem-solving [see Wilson (2002) for a review].

No empirical work has tested the potential relationships between perceived and socially constructed meanings using ideas of offline cognition, but we can describe it from a practical perspective at fine geographic scales such as a room. Imagine a room in our home that we have been living in for a long time. We enter and exit that room multiple times on a daily basis and our action is guided by a range of perceptions concerning the size, light, and warmth of that room. Now imagine that we get married in that room. Through processes of social construction, that room is now associated with a range of socio-cultural meanings like love and social connection, and inherent meanings like the ambience of the room on the wedding day. Through processes of offline cognition, these perceived meanings associated with the sights, smells, and sounds of the wedding day become engrained in memory and in language, which provides the pathway through which perceived and socially constructed meanings relate.

We propose that perceived and socially constructed meanings are most likely to conjoin when memories are activated. In future studies, researchers could draw on phenomenological approaches in order to investigate the relationships between different components of living memory. That is, how different types of affordances are contained within (or independent to) inherent, instrumental, socio-cultural, and identity–expressive meanings within a given place and/or across places. Also, researchers could identify which types of affordances become "lost in space," i.e., are rarely associated with different types of socially constructed meanings, but rather are part of our everyday navigation through life.

Research Direction 3 – Explore How Place Attachment Changes Over Different Stages of the Life Course Based upon Dynamic Relationships between Processes of Social Construction and Perception–Action

While research has considered how place attachment varies with respect to length of residence, place disruption, or nostalgia, no studies have considered how the structure of place attachment may change with reference to different forms of place experiences and place meanings across the life course. By bringing together the qualities of sense of place and affordance theories, we propose that *place attachment could be considered as an emergent property of the dynamic sets of meanings associated experiences across the life course*. By this we mean that types of perceived and socially constructed meanings formed during experiences at an early life stage (e.g., during a 6th birthday) are likely to inform the perceived and socially constructed meanings during experiences at a later life stage (e.g., getting married), assuming those experiences occur in the same place. The integration of the affordance perspective and how it relates – for example – to the changes in physical capacities associated with aging (e.g., the ledge we referred to earlier may be a challenging climbing place to a child, but too easy for the adult, and beyond the capacity of the elderly) may prove a very useful framework for understanding changes in attachment through the life course (e.g., Cuba and Hummon, 1993) or among the elderly in particular (Rubinstein and Parmelee, 1992).

We don't know how these immediately perceived and socially constructed place meanings combine within and across time to inform changes in the intensity or structure of place attachment. To establish this process, we require new mechanisms for not only examining how place as a perception–action process and socially constructed process relate at any given point in time (i.e., research area 2), but also how they may relate across significant experiences in a given place. Longitudinal research is needed to establish whether and how the memories associated with given affordances earlier in life inform later experiences in the *same place*.

Certain elements of early place experiences could also be transferrable to new settings, requiring an improved understanding of how perception–action processes and socially constructed meanings relate across time and *different places*. Longitudinal research is also needed to understand how the affordances perceived in one place early in life are held in memories to inform the affordances and social constructions of other places later in life.

Understanding place attachment as an emergent property of a complex system also has major implications for the assessment of the relationships between place attachment and pro-environmental behavior. If place attachment is an emergent property of both perception–action and socially constructed processes which are changing across one's time in place then such phenomena cannot be fully understood using traditional linear cause and effect models, as often applied in place research when understanding place as a locus of attachment. Rather, we encourage a new approach to the assessment of pro-environmental behavior which is based on non-linear, complex dynamics. Such dynamics are already the source of intense investigation through areas such as social learning (Cheng and Mattor, 2010), complexity science, and sustainability transitions (Andersson, 2014) and co-production of knowledge (Armitage et al., 2011; Tengö et al., 2014; Reyers et al., 2015), and initial thinking has occurred in the sense of place realm as well (Stedman, 2016; Masterson et al., 2017). We urge a more spatial and relational view of these dynamics recognizing how individual minds and bodies and constituted within places that are both perceived and socially constructed, and how both direct perception and abstractions can lead to formation and change in behavior across places and time.

Implications of Fast and Slow Processes for the Design and Management of Urban Landscapes

If urban settings are repositories for a range of socially constructed and perceived meanings (Research Direction 1) then these settings need to be designed with both fast and slow cognitive processes in mind and thus multiple layers of place meaning. By layers we mean planning, designing, and implementing new forms of architecture in urban landscapes that cater for clusters of different types of immediately perceived and socially constructed place meanings, including functional, affective, and symbolic. These clusters could be tailored to different user groups so as to address important elements of environmental justice (Raymond et al., 2016).

Stemming from Research Direction 2, it may be possible for urban environments to be designed with affordances that immediately evoke different forms of place meanings. Such urban designs may have multiple important uses for highly mobile individuals or migrants seeking to integrate into new communities rapidly. Certain types of affordances could be created in urban environments to bridge place meanings between their place of origin and their new (sometimes temporary) place of residence. For example, by creating "open spaces" which enable new migrants to shape and reshape affordances in that setting through art, craft, and music, informed by place meanings and memories from their place of origin. However, we acknowledge that designing urban environments for a diversity of meanings can lead to the potential for conflicts between different interest groups, which also needs to be managed (Stedman, 1999).

Accepting place attachment as an emergent property (Research Direction 3) requires urban planners to take account of both short-term and long-term processes of cognition when designing cities. For example, forecasting how citizens' experiences in a given setting could inform future experiences (and associated immediately perceived and socially constructed meanings), as opposed to designing solely for immediate, functional uses. This strategy would also suggest that city planners recognize that the end goal may not be to "increase place attachment" *per se*, but rather create settings that cater for a diversity of experiences and place meanings, each informing diverse (and sometimes oscillating) trajectories of place attachment across time. It also requires planners to recognize that initiatives for encouraging "sense of place" among different ethnic and migrant groups may achieve fast results in some areas (e.g., providing a playground so that children have the opportunity to play in their local environment), but have slow results in other areas (e.g., building the social capital so that individuals feel they belong in that place).

CONCLUSION

In this paper, we urged a systematic consideration of how both slow and fast processes of cognition inform sense of place scholarship. We asserted that sense of place scholarship has been conservative, non-dynamic, and principally focused on aspects of place meaning that unfold over time through a process of social construction. Theory development has largely excluded the role of immediate sensory and direct perception–action processes in meaning making, otherwise referred to as immediately perceived place meanings, but instead focused on place meanings formed through longer-term processes of social construction. In response, we suggest how affordance theory could overcome a number of blind spots in sense of place scholarship and then suggest research directions for empirically justifying how place as perception–action processes (a subset of Type 1 thinking in the dual-process model) and place as socially constructed processes (a subset of Type 2 thinking) relate to each other across place experiences and time. Reconceptualizing sense of place as fast *and* slow presents opportunities to consider how immediate perceptual processes can contribute to longer-term processes of social construction and vice versa. It also paves the way to addressing one of the most contentious aspects of sense of place scholarship and wider psychology: how processes of intellectual abstraction and computation based on interactionist worldviews can be united with immediate sensory experience based on transactional worldviews to better account for not only for place meanings and place attachment, but also environmental behavior across the life course.

AUTHOR CONTRIBUTIONS

CR reviewed the literature and developed the key arguments for the paper, also wrote most sections of the paper with additions from MK and RS. MK provided insightful contributions to the affordance theory section of the paper, and to the future directions and management implications sections. RS provided insightful contributions regarding the argumentation and framing of the paper, and also provided key theoretical insights into sense of place, and the discussion section of the paper.

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Restorative Qualities of and Preference for Natural and Urban Soundscapes

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Psychological restoration in urban agglomerations has become a growing challenge. Although scientific proof of the significance of nature is irrefutable, an increase in built-up areas has led to a decrease in urban greenery. Thus, a growing need for restorativeness in urban surroundings has emerged. To investigate whether positively evaluated sonic environments, represented by natural and urban sounds, have comparable restorative qualities we conducted two studies. The aim of the first (Study 1) was to explore the restorative qualities of positively assessed natural and urban sounds. Participants (N = 88) were asked to listen and to rate 22 recordings (each 1 min long) either from natural or urban environments. In the second (Study 2) we investigated whether positively evaluated sonic environments (natural and urban), demand for restoration (feeling relaxed or fatigued) and company (being alone or with a friend) affect the restorative qualities of natural and urban soundscapes. After reading assigned scenarios (feeling relaxed or fatigued; being alone or with a friend), participants (N = 120) were asked to imagine a walk in presented sonic environments and to complete forms (one for each sonic environment) concerning the restorative qualities of given soundscapes (natural and urban). Top five recordings of natural and urban sonic environments were selected from Study 1 and combined into a 154-s soundtrack, to provide a background for the imagined walks in both settings. Our findings confirmed that natural sounds are perceived more favorably than urban recordings. Even when only the most positively assessed soundscapes were compared, nature was still perceived as being more restorative than urban areas. Company of a friend was found to be more beneficial in the urban surroundings, particularly when there was no need for restoration.

Keywords: restoration, restorative qualities, sounds, sonic environment, natural soundscapes, urban soundscapes, preference

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INTRODUCTION

A recent report of the United Nations (2015) predicts that sixty-six percent of the world population will reside in urban areas by the year 2050. As progressive urbanization seems inevitable, it is essential to seek restorativeness in urban surroundings. Surprisingly, despite researchers' growing interests in the affordances of various environments, relatively little is known about the restorative qualities of urban areas. Even less explored is the potential of positively assessed urban sounds, which are omnipresent and accompany citizens in their everyday routines.

Research has shown that people's encounters with natural environments translate into numerous psychological benefits such as improved cognitive functions (Tennessen and Cimprich, 1995; Hartig et al., 2003; Berto, 2005; Berman et al., 2008, 2012; Faber Taylor and Kuo, 2009; Kaplan and Berman, 2010), lessened anger (Cackowski and Nasar, 2003; Kweon et al., 2008), boosted positive affective states (Berman et al., 2008, 2012; van den Berg and Custers, 2011) and reduced stress (Ulrich et al., 1991; Parsons et al., 1998; Wells and Evans, 2003; Kweon et al., 2008; van den Berg et al., 2010; van den Berg and Custers, 2011; Ward Thompson et al., 2012; Hartig et al., 2014).

Urban environments' positive contributions, meanwhile, have remained obscure, attracting less scholarly attention. Nevertheless, findings from settings such as museums (Kaplan et al., 1993; Packer, 2008), monasteries (Ouellette et al., 2005), or houses of worship (Herzog et al., 2010) have highlighted the positive aspects of man-made surroundings and confirmed that urban environments may also afford mental recovery. In addition, participation in cultural life (e.g., going to the cinema, theater, or concerts) was found to be positively related to perceived health and well-being (Johansson et al., 2001), and attending sporting events and cultural activities was associated with high life satisfaction and good health (Leadbetter and O'Connor, 2013). Due to the fact that well-being and life satisfaction appear to be related to mental recovery (Sonnentag and Fritz, 2015), there is a distinct possibility that urban facilities, in particular those associated with sport and culture, can also contribute to restoration.

Two complementary approaches explain mechanisms behind the restorative effects of environments, the Attention Restoration Theory (ART; Kaplan and Kaplan, 1989; Kaplan, 1995), and the Stress Recovery Theory (SRT; Ulrich, 1983; Ulrich et al., 1991). Although both refer mostly to nature, it has been confirmed that they apply also to the urban surrounding (Kaplan et al., 1993; Ouellette et al., 2005; Herzog et al., 2010).

In line with the former approach (ART) to achieve a restorative effect, an environment should have the ability to reconcile individual desires and goals with environmental demands ('compatibility'), be perceived as coherent and of substantial scope ('extent'), create a sense of psychological distance from the problems of everyday life ('being away'), and induce 'fascination' (Kaplan and Kaplan, 1989; Kaplan, 1995). In some built environments additional factors play a role. For example, 'spirituality' is characteristic for places that serve religious purposes, such as monasteries (Ouellette et al., 2005) or houses or worship (Herzog et al., 2010), while 'comfort,' related to the original property of 'compatibility' (Kaplan et al., 1993), defines places such as museums. Other features, meanwhile, may be imperceptible, as was the case with 'compatibility' in a study by Herzog et al. (2010). Interestingly, these properties can also be linked. 'Beauty,' for example, can be described as a combination of 'fascination,' 'extent,' and 'aesthetics' (Ouellette et al., 2005; Herzog et al., 2010).

The Attention Restoration Theory (Kaplan and Kaplan, 1989; Kaplan, 1995) holds that recovery from mental fatigue occurs through the restoration of depleted cognitive resources. Kaplan (1995) distinguishes two types of attention: stimuli-driven involuntary attention, which does not require mental effort, and directed attention, which is responsible for intentional actions and everyday behaviors. Involuntary attention, due to its bottom-up mechanism (Berman et al., 2008), provides psychological restoration, as attention is automatically captured by fascinating stimuli (Beute, 2014), whereas directed attention requires more conscious control, and when depleted, leads to deterioration of cognitive functions and, subsequently, to a reduction in the ability to adapt to daily demands (Kaplan and Kaplan, 2003).

In line with Stress Recovery Theory (Ulrich, 1983; Ulrich et al., 1991), apart from coping with mental fatigue, restoration can also be explained in terms of the physiological reaction to stress (Ulrich, 1983; Ulrich et al., 1991). Particularly relevant seems the importance of positive affective reactions, which according to Ulrich et al. (1991, p. 224), are "comprised of likening and moderate to high interest, should motivate and sustain prolonged attention/intake, should produce higher levels of positive feelings, reduce negatively toned or stress related feelings such as fear and anger, and suppress stressful or extraneous thoughts (Ulrich, 1981, 1983)."

A vast amount of literature attests to people's preferences for natural settings. Nonetheless, these findings might be to some extent affected by the selection of urban stimuli. Despite Ulrich's emphasis on positive affective reaction (Ulrich et al., 1991), in previous works, urban surroundings have often been represented either by unattractive images of industrial zones (Purcell et al., 2001), streets and buildings (Purcell et al., 2001; Joye et al., 2013), which are usually accompanied by automobile traffic (Emfield and Neider, 2014), or by unpleasant audio stimuli such as office noise (Jahncke et al., 2015), sounds of busy intersections, construction site clamor (Medvedev et al., 2015), traffic noise (Gidlöf-Gunnarsson and Öhrström, 2007; Alvarsson et al., 2010), or Time's Square's cacophony of conversations, cars, and honks (Emfield and Neider, 2014).

Moreover, conclusions on people's preference for natural or urban environments have mostly relied on visual stimuli (Herzog et al., 1997; Purcell et al., 2001; Staats et al., 2003; Staats and Hartig, 2004; Nordh et al., 2009; Joye et al., 2013; Stevens, 2014; Conniff and Craig, 2016). Scarce evidence shows, however, that sonic stimuli, such as positively assessed bird songs or sounds of water may also contribute to psychological restoration (Ratcliffe et al., 2013).

As argued by Ulrich (1983), as well as Conniff and Craig (2016), concentrating exclusively on a visual sensory channel limits our understanding of often complex environments, because photography can depict a given setting only fragmentarily (Nordh et al., 2009). Sound, by contrast, can contribute to a more holistic interpretation of a given surrounding, because of its own restorative potential (Alvarsson et al., 2010; Abbott et al., 2016). The impact of the audio stimuli on the assessment of the environment is reflected in the studies investigating a reciprocal relationship between sound and vision. It has been revealed that natural sounds can positively influence perception of images portraying natural or man-made settings (Carles et al., 1999; Hedblom et al., 2014), whereas deterioration in the sonic environment reduces the evaluation of the surroundings (Carles et al., 1999). Likewise,

vision can modify the perception of the audio stimuli (Viollon and Lavandier, 1997; as cited in Carles et al., 1999).

Whereas visual and multimodal approaches have been discussed quite frequently, the relationship between positive evaluation of urban sounds and their restorative qualities have been given much less attention. Therefore, the purpose of this paper is to explore the restorative potential of urban soundscapes. In a pair of studies, we want to verify whether restorative qualities of natural and urban sounds are comparable. In Study 1 we aim to explore people's preference for recorded natural vs. urban sounds and their restorative qualities. The objective of Study 2 is to investigate whether the demand for restoration and company of others play a role in the perception of urban sounds' restorative qualities.

STUDY 1

In line with the abundant existing literature on visual stimuli, we expected that, in general, natural sounds would be evaluated more positively than urban sounds (Hypothesis 1). We also hypothesized that natural sonic environments will be rated as more restorative than urban sonic environments (Hypothesis 2). Additionally, due to the nature of the urban sonic environment, which is usually louder and noisier than nature, we predicted that sensitivity to sounds would play a role in the assessment of the recordings. We expected that the higher the sensitivity to sounds, the less positive the evaluation of the urban sounds would be (Hypothesis 3). We also aimed to select the most positively assessed sounds of both sonic environments.

Method

Participants

Eighty-eight students from the SWPS University of Social Sciences and Humanities (78% women), aged 19–44 years ($M = 26.74$, $SD = 6.82$), were recruited for the study through an advertisement placed in the university's building and on its website. All gave informed consent after the short introduction to the study. They were rewarded with credit points and had a chance to win a lottery gift worth, on average, 5$. The study was approved by the ethics committee of the authors' faculty.

Materials and Measures

Sounds

High-quality (16 bit, 44.1 kHz) samples representing 22 natural environments and 22 urban environments (**Table 1**) were binaurally recorded by a sound recordist. The presence of people was minimized wherever possible while taking these samples so that the focus could be on the environmental sounds. However, there were some exceptions, such as a café, swimming pool, ice rink and parade, where people's voices could be heard in the background. The audio levels were normalized; each 1-min recording was scaled following Medvedev et al.'s (2015) example to an average sound level of 64 dB SPL, and saved as a WAV file.

Evaluation of the sounds

To assess how positive and/or negative each recording was perceived to be, participants used the Evaluative Space Grid (Larsen et al., 2009). The responses were given on a 5 × 5 grid (25 cells) presented on the paper form. On the *x*-axis, ranging from 'Not at all' (0) to 'Extremely' (4), participants were asked how positive they felt about the stimulus, whereas on the *y*-axis, also ranging from 'Not at all' (0) to 'Extremely' (4), they were asked how negative they felt about the stimulus. The answers were then averaged. The negative evaluation was not analyzed in this study.

Sensitivity to sounds

Participants' sensitivity to sounds was measured using the Hyperacusis Questionnaire (Khalfa et al., 2002). On this measure, consisting of 14 questions (e.g., 'Are you particularly sensitive to or bothered by street noise?'), the responses were given on a 5-point scale, ranging form 'No' (0) to 'Yes, a lot' (4) and then averaged. Three additional questions concerning the experience of being exposed to noise ('Are you or have you been exposed to noise?', tolerance to noise ('Do you tolerate noise less well as compared to a few years ago?') and eventual hearing problems ('Have you ever had hearing problems? If so, of what kind?') were responded to by choosing 'Yes' (1) or 'No' (0).

According to Khalfa et al. (2002), the mean total score for the questionnaire is 15 ± 6.7, and a result above 28 (out of the maximum score of 42) may be an indicator of auditory hypersensitivity. In our research the Cronbach's alpha for the scale was 0.76.

Restorative qualities of sounds

Each sound's restorative quality was assessed with four items inspired by the properties of the Attention Restoration Theory (Kaplan and Kaplan, 1989; Kaplan, 1995): being away ('How often this sonic environment can facilitate a sense of mental detachment from the problems of everyday life?'), fascination ('How often this sonic environment can induce fascination/interest?'), compatibility ('How often this sonic environment can encourage you to find yourself in this environment?') and extent ('How often this sonic environment can offer many opportunities to act in such area?'). The answers were given on a 5-point scale ranging from: 'Never' (1) to 'Very often' (5) for questions concerning properties of being away and compatibility, and from 'Very often' (1) to

TABLE 1 | Sounds used in Study 1.

Natural environment
Blackbird in a clearing, Blackcap in the woods, Corncrake at a pond, Crows, Deer in the rut, Forest (boar and birds), Frogs at a pond, Great reed warbler, Howling wolves, Larks and barred warbler, Meadow in the spring (many birds species), Night in the woods (eagle-owls and wind), Nightingale, Ravens, River, Robin at a river, Sea, Seagulls on a windy day, Summer night (crickets and birds), Swarm of insects, Thunderstorm, Wren at a stream
Urban environment
Airport (airplane landing), Street (ambulance), Old town (barrel organ), Café, Amusement park (carousel), Church bells, Concert (orchestra tuning and applause), Construction site, Fireworks display, Highway, Ice rink (people skating), Lawn mower, Parade (brass orchestra), Road work (pneumatic hammer), Fire department (siren), Street noise, Subway (empty subway car), Swimming Pool, Traffic jam (with car horns), Train, Video arcade, Wind chimes

'Never' (5) for questions concerning properties of fascination and extent. To ease the calculations, the responses were later recoded (from 0 for 'Never' to 4 for 'Very often') and averaged. Cronbach's alpha for the scale was 0.93 (for all natural sounds' restorative qualities) and 0.84 (for all urban sounds restorative qualities). For the top five sounds of both environments, Cronbach's alpha was also calculated and was 0.89 (for natural recordings) and 0.81 (for urban recordings). Additionally, we asked participants whether they recognized the presented recording ('Yes' or 'No') and, if the answer was affirmative, to identify the given sound (an open question).

Procedure

Each participant took part in the study individually. After a brief instruction on the procedure, participants were randomly assigned to the natural or urban condition. Subsequently, they listened to and evaluated 22 recordings from natural or urban environments (depending on the condition), played via closed-back headphones (they had the opportunity to adjust the sound volume according to their needs). After each recording, participants rated how positive and negative they felt about the stimulus using the Evaluated Space Grid (Larsen et al., 2009). Then, they were asked whether they recognized the sound and evaluated each sound's restorative quality. A 22 × 22 Latin square in a Williams design (Latin Squares – Williams Design, n.d.) was used to eliminate order effect. The time needed to complete each questionnaire before the next recording was played was adjusted to each participant's individual needs. After all recordings were played, participants completed the Hyperacusis Questionnaire (HQ) and basic socio-demographic data. The study lasted around 40 min on average.

Results

Evaluation of All Sonic Environments

We found a significant difference in the evaluation of all recordings, Welch's $F(1,55.12) = 23.88$, $p < 0.001$, est. $\omega^2 = 0.21$. As predicted (Hypothesis 1), the natural sounds were perceived more positively ($M = 2.12$, $SD = 0.65$) than the recordings from the urban environments ($M = 1.55$, $SD = 0.33$). In line with expectations (Hypothesis 2), they were also rated as being more restorative ($M = 8.63$, $SD = 1.44$) than urban recordings ($M = 6.67$, $SD = 1.01$), $F(1,81) = 52.39$, $p < 0.001$, $\eta^2 = 0.39$. Further analysis revealed that evaluation of the sounds was positively correlated with their perceived restorative qualities, both for the natural, $r = 0.78$, $p < 0.001$, and urban, $r = 0.52$, $p < 0.001$, sonic environments.

Participants had no major problems identifying the sounds. The most recognizable sounds of the natural environment turned out to be: a blackcap in the woods (100% recognition), crows (100%), howling wolves (100%), insects (100%), the sea (100%), seagulls on a windy day (100%), a thunderstorm (100%), a wren at a stream (100%); the least recognizable were the recordings of a boar (64%) and a deer in the rut (66%). It should be noted that the knowledge of bird species was not required. As for the urban environment, the most recognizable sounds were: an airplane landing (100%), an ambulance (100%), a café (100%), church bells (100%), a fireworks display (100%), a parade (100%), and a traffic jam (100%), whereas the least recognizable were: an ice rink (71%) and a subway (57%). Interestingly, not all who declared sound recognition identified the recordings appropriately (e.g., the deer was taken for marine mammals).

The mean total score for the Hyperacusis Questionnaire (Khalfa et al., 2002) was 15.78 ($SD = 6.41$). Only 3.41% of participants met the criteria of hypersensitivity to sounds (results above 28). Still, positive correlation between participants' sensitivity to sounds and the positive evaluation of the natural sounds was found, $r = 0.42$, $p < 0.01$. Surprisingly, an increase in sensitivity to sounds turned out to be correlated with a more positive assessment of the natural sounds. Contrary to our expectations (Hypothesis 3), the correlation between sonic urban environments and sensitivity to sounds was non-significant, $r = -0.20$, $p = 0.19$.

Most Positively Evaluated Sonic Environments (Natural and Urban)

On the basis of the means of all sounds used in this study (Supplementary Table 1), the five most positively assessed recordings (**Table 2**) from each environment were selected. The chosen recordings in natural settings were: a robin at a river, a wren at a stream, a blackbird in a clearing, the sea, and a blackcap in the woods. The chosen recordings in urban settings were: a concert (an orchestra tuning and applause), a fireworks display, an old town sound (a barrel organ), an amusement park (a carousel), and a café.

A significant difference was found between the evaluations of the sonic environments, $U = 640.00$, $p < 0.01$. Again, natural sounds were perceived more positively ($Mdn = 3.40$) than urban recordings ($Mdn = 3.00$). Furthermore, natural sonic environments were rated as being more restorative ($M = 12.12$, $SD = 1.90$) than urban recordings ($M = 11.17$, $SD = 1.82$), $F(1,86) = 5.71$, $p < 0.05$, $\eta^2 = 0.06$. As was previously discovered, the evaluation of the sounds was found to be correlated with perceived restorative qualities of the top five natural sounds, $r_s = 0.80$, $p < 0.001$, and for the top five urban recordings, $r_s = 0.61$, $p < 0.001$.

The relationship between a participant's sensitivity to sounds and the evaluations of the sonic environments was also examined. Neither the correlation between auditory sensitivity and natural sound assessments ($r_s = 0.28$, $p = 0.06$) nor the correlation between auditory sensitivity and urban sound assessments ($r_s = -0.19$, $p = 0.23$) was significant, possibly suggesting that sensitivity to sounds did not influence the evaluations of positive sonic environments.

TABLE 2 | The most positively assessed sounds of natural and urban environments in Study 1 (mean values, standard deviations).

Natural environment	*M*	*SD*	Urban environment	*M*	*SD*
Robin at a river	3.48	0.82	Concert	3.59	0.62
Wren at a stream	3.43	0.93	Fireworks display	2.95	1.06
Blackbird in a clearing	3.14	1.00	Old town	2.80	0.95
Sea	3.09	0.88	Amusement park	2.77	0.99
Blackcap in the woods	3.02	1.05	Café	2.77	1.16

Discussion

As expected, our study confirmed that natural environments, represented by sound stimuli, are perceived more favorably than urban surroundings. This is quite intuitive, as it could have been predicted that negatively perceived natural sounds, such as a crow's call (Ratcliffe et al., 2013), are still less disturbing than some intrusive urban sounds (e.g., recording of a pneumatic hammer). We found, however, that even positive assessment of the urban sounds cannot equalize the difference in how both environments are perceived.

The high percentage of sound identification shows that both sonic environments were familiar to participants, so there may be a different explanation of these results, other than distinct familiarity with the soundscapes. It is possible, for example, that people find urban surroundings more heterogeneous than nature and that participants' individual preferences toward the given settings (even when sonic) are reflected in the study. Our findings seem to confirm that. Whereas natural sounds were almost unanimously assessed positively (in particular birdsongs and water-related soundscapes), the ratings of urban recordings varied. It is likely that some participants found the sonic atmosphere of the urban area as a model example of the environments conducive to recreation and social life, while others described the same setting as undesirable: fatiguing, too noisy, or even aesthetically unappealing.

In line with our assumptions, natural recordings were also perceived as being more restorative than urban soundscapes, both for all and for the top five sounds from natural and urban environments. It was also confirmed that evaluations of the sounds were positively correlated with their perceived restorative qualities, especially in the natural sonic environment.

Surprisingly, sensitivity to sounds did not affect the perception of urban sounds, neither for all recordings nor for the top five. It did, however, influence the assessment of all natural sounds. These results may indicate that, despite preferring natural recordings, people who are sensitive to sounds has become highly accustomed to urban soundscapes. The most positively assessed sounds, meanwhile, are not intrusive, so their origin does not matter.

To further explore the relationship between positive evaluation and restorativeness, we decided to conduct another study, in which we wanted to more thoroughly examine soundscapes' restorative qualities. Due to the fact that sensitivity to sounds did not turn out to significantly influence the perception of urban soundscapes and considering that we had already selected the most positively assessed sounds of both sonic environments (taking sensitivity to sounds into account), we decided to exclude sensitivity to sounds from further research. Instead we decided to concentrate on additional factors that can influence soundscapes' restorative qualities – company and the demand for restoration.

STUDY 2

In Study 2, we further investigated whether positively evaluated urban surroundings can afford psychological restoration comparable to natural settings. For this purpose we replicated the study by Staats and Hartig (2004), in which participants were asked to imagine themselves in a given environment during an imagined walk with a friend or alone. Instead of visual presentation of environments, we used positively assessed sound stimuli.

We were interested in whether a presence in a given setting, even when imagined, can affect its perceived restorative quality. As a sonic background for the imagined walk we chose the most positively evaluated recordings from Study 1. Based on the results from Study 1, we expected that there would be a significant difference between natural and urban soundscapes' restorative qualities (Hypothesis 1).

Additionally, inspired by Staats and Hartig (2004), we decided to verify how company and the demand for restoration (feeling attentionally fatigued or relaxed) interplay with positively assessed soundscapes from natural and urban environments. We expected that participants would experience more restoration being in company, both in the natural (Hypothesis 2a) and in the urban (Hypothesis 2b) soundscapes. We also predicted that demand for restoration would affect the evaluation of restorative qualities: it was expected that participants from the attentionally fatigued condition would rate an imagined walk in the natural soundscapes as being more restorative than an imagined walk in the urban sonic environment (Hypothesis 3a), whereas participants from the relaxed condition, due to the use of stimuli representing positively assessed soundscapes, would rate an imagined walk in the urban soundscapes as being more restorative than an imagined walk in the natural sonic environment (Hypothesis 3b). It was also predicted that there would be a difference in the evaluation of the imagined walk in the natural and the urban soundscapes (Hypothesis 4).

In addition, we wanted to determine whether and how a sense of security influences the restorative qualities of positively perceived sonic environments. We assumed that the urban soundscapes would invoke a greater sense of security than the natural soundscapes (Hypothesis 5). It was also expected that those who imagine themselves walking with a friend would feel more secure than those who imagine themselves walking in solitude, both in the natural (Hypothesis 6a) and the urban (Hypothesis 6b) soundscapes. Moreover, we predicted that a sense of security would have an indirect effect on restorative qualities both in the natural (Hypothesis 7a) and the urban (Hypothesis 7b) sonic environments through company. Likewise, we expected that a positive evaluation of an imagined walk would have an indirect effect on restorative qualities in the natural (Hypothesis 8a) and the urban (Hypothesis 8b) soundscapes through company.

Method

Participants

One hundred and twenty participants (78% women) aged 18 to 51 years ($M = 25.41$, $SD = 8.38$) took part in the study. All were students of the SWPS University of Social Sciences and Humanities who responded positively to the announcement about this research that was placed in the university's building and

on its website. Each participant signed the informed consent form that outlined the procedure's steps, and was rewarded with credit points and a chance to win a lottery gift worth, on average, 5$. The study was approved by the ethics committee of the authors' faculty.

Materials and Measures

Sound recordings

The most-positively assessed sounds from Study 1 (**Table 2**) were used: five natural (a robin at a river, a wren at a stream, a blackbird in a clearing, the sea, and a blackcap in the woods), and five urban recordings (a concert, a fireworks display, a barrel organ, a carousel, and a café). However, this time, to facilitate the listening procedure, each sound was shortened to 30 s, as advised by participants of Study 1, and then combined with others (with 1-s transitions) into a single 154-s soundtrack to provide a background for the imagined walks in the natural and urban settings. Each sound in the compilation represented one place on the 1-h walking route, which, depending on the participant's imagination, could have been either visited or just passed by.

Scenarios

Questionnaires and scenarios used in this study were based on translations of the items and scenarios described by Staats and Hartig (2004).

Demand for restoration scenario. Two alternative scenarios of demand for restoration were created. In a random manner, participants were asked either to imagine themselves being attentionally fatigued (one half of participants) or completely relaxed (the other half). In the former, participants were instructed to visualize a state of tiredness at the end of a semester, when problems with concentration and negative emotions occur. In the latter, participants were instructed to imagine a state of relaxation after the summer holidays, when feelings of restoration, energy, and preparedness to concentrate on learning occur. The demand for restoration scenario remained unchanged throughout the course of the study.

Company scenario. Two versions of a story were prepared. In both, participants were asked to imagine themselves strolling for an hour in the environment, which was represented by the sounds they were about to hear (natural or urban). In one version, the participants were instructed to imagine a lonely walk, without anyone they knew. In the other, they were to imagine walking with someone close to them, for example, with a friend. Again, participants were randomly assigned to one of these two scenarios, and the scenario remained unchanged throughout the study.

Manipulation checks

Manipulation checks consisted of eight items measuring affective state (feeling irritated, tired, exhausted, mentally drained) and attention depletion (ability to make a decision, concentrate, predict consequences of a complex situation, focus attention during a long lecture). Participants indicated to what extent they agreed or disagreed with each sentence using a scale from 'Completely not' (1) to 'Very much' (7). The scale for attention depletion was reversed, and the mean across all eight items was calculated. The Cronbach's alpha for manipulation checks was 0.93.

Restorative qualities of the imagined soundwalks

Participants rated the restorative qualities of an hour-long walk in sonic environments (natural and urban), assuming they were either attentionally fatigued or relaxed. They were asked 19 questions, based on the work of Staats et al. (2003), about the benefits of an hour-long walk in the given soundscapes. The items concentrated on psychological restoration (e.g., 'Experience of restoration' or 'Regain an ability to concentrate'), reflection (e.g., 'Thinking about important matters' or 'View things from a new perspective'), and social stimulation (e.g., 'Seeing many different people' or 'Noticing many different things surrounding you'). The answers were measured on a Likert-type scale ranging from 'Most unlikely' (1) to 'Extremely likely' (7) and then averaged. Cronbach's alpha was similar: 0.87 for natural soundscapes, and 0.88 for urban soundscapes.

Additionally, a similar set of items was used to assess the pleasantness of an imagined walk, with answers ranging from 'Very unpleasant' (1) to 'Very pleasant' (7), however, the results were not analyzed in this study.

Sense of security

Participants' sense of security in natural and urban soundscapes was measured. They rated how secure they felt in the given sonic environment on a 7-point scale from 'Completely not' (1) to 'To a very high degree' (7).

Evaluation of the imagined soundwalks

The imagined soundwalks were evaluated using additional rating instruments. Participants were asked to indicate how attractive, nice, positive, and enjoyable an hour-long walk in a given sonic environment would be. Each of the four answers was given on a Likert-type scale ranging from 'Completely not' (1) to 'To a very high degree'(7). The means were calculated separately for both soundscapes. Cronbach's alpha was, respectively, 0.87 for the evaluation of the walk in natural soundscapes, and 0.89 for the evaluation of the walk in urban soundscapes.

Control measures

For each sonic environment, two additional questions were asked: one about the familiarity of the soundscapes and one about the representativeness of its positively assessed sounds. Answers were given on a Likert-type scale ranging from 'Not at all' (1) to 'Very' (5). Additionally, the question about familiarity of the state of attentional fatigue or relaxation (depending on condition) was added. This answer was also given on a 5-point scale ranging from 'Not at all' (1) to 'Very' (5). An open question for comments and opinions about the research was included. Demographic data such as age and gender were also collected.

Procedure

We followed the procedure used by Staats and Hartig (2004), with the exception that the photographic slides illustrating classic natural and urban settings (e.g., forest scenes, shopping streets) were replaced with audio stimuli, representing only positively assessed sonic environments from Study 1.

Participants, randomly assigned to conditions ($n = 30$ per group), were seated in the middle of a room in front of a pair of sound speakers; individually or in small groups (up to 6 people). After detailed instruction, they read about the demand for a restoration scenario of feeling relaxed or attentionally fatigued and completed the first questionnaire composed of manipulation checks and items measuring pleasantness of an imagined hour-long walk. Next, they read another short text – a company scenario of being alone or with a friend and the first group of environmental sounds (natural or urban) were played, the order of which was balanced: one half of participants heard the set of urban recordings, while the other half heard the set of natural sounds. Each set of soundscapes was presented twice: the first time when the participants were to imagine themselves passing five different locations during an imagined hour-long walk according to prior scenarios, and the second time to refresh their memories and to accompany the questionnaires about the evaluation of the imagined walks and their restorative qualities. The whole procedure was repeated with the other set of sounds, and another questionnaire with identical questions was used. The overall session time averaged 30 min. The scheme of the procedure used in the study is presented in **Figure 1**.

Results

In this section we first present the results of manipulation checks and preliminary analyses. Then we report the effects of the restorative qualities of the imagined soundwalks. Later in the text we discuss the evaluation of the imagined soundwalks and the influence of sense of security on the obtained results.

Manipulation Checks and Preliminary Analyses

We verified whether participants indeed met the given condition of demand for restoration after reading the assigned scenarios. As assumed, those instructed to imagine themselves in a state of attentional fatigue indicated being more fatigued ($M = 4.87$, $SD = 0.80$) than those instructed to imagine themselves relaxed ($M = 2.16$, $SD = 0.69$), $t(118) = -19.91$, $p < 0.001$. The difference in familiarity between the conditions was not significant, $t(118) = -1.30$, $p = 0.20$: participants were familiar with their assigned states of being attentionally fatigued ($M = 4.50$, $SD = 0.73$) or relaxed ($M = 4.33$, $SD = 0.68$).

The natural sonic environment was perceived as more familiar to participants ($M = 4.63$, $SD = 0.71$) than the urban sonic environment ($M = 4.28$, $SD = 0.90$), $t(119) = 3.39$, $p < 0.01$, and recordings of the positively assessed natural soundscapes were perceived as more representative ($M = 4.74$, $SD = 0.51$) than those representing positively evaluated urban soundscapes ($M = 3.76$, $SD = 0.96$), $t(119) = -10.55$, $p < 0.001$.

Effects of the Restorative Qualities of the Imagined Soundwalks

A 2 × 2 × 2 mixed ANOVA was carried out to analyze the effects of the restorative qualities of the imagined soundwalks with the type of soundscapes (natural vs. urban) as a within-subjects variable and company (alone vs. with a friend) and demand for restoration (feeling attentionally fatigued vs. relaxed) as between-subjects variables.

As assumed (Hypothesis 1), the results yielded a significant main effect of soundscapes' restorative qualities, $F(1,116) = 84.37$, $p < 0.001$, $\eta_p^2 = 0.42$ revealing that participants preferred an imagined walk in the natural soundscapes ($M = 5.38$, $SD = 0.68$) over an imagined walk in the urban soundscapes ($M = 4.61$, $SD = 0.82$).

The main effect of company was statistically significant, $F(1,116) = 5.56$, $p < 0.05$, $\eta_p^2 = 0.05$. Participants rated sonic environments as being more restorative when they imagined themselves in the company of a friend. However, simple effects analysis revealed that the difference between being in company ($M = 4.77$, $SD = 0.74$) or alone ($M = 4.44$, $SD = 0.87$) was significant only for the urban soundscapes, as predicted by Hypothesis 2b, $t(118) = 2.24$, $p < 0.05$. Contrary to our expectations concerning the natural soundscapes (Hypothesis 2a), the difference between being with a friend or alone was insignificant, $t(118) = 1.34$, $p = 0.18$.

The main effect of the demand for restoration condition (being attentionally fatigued or relaxed) was not statistically significant $F(1,116) = 0.91$, $p = 0.34$ nor was the interaction between company and demand for restoration, $F(1,116) = 0.88$, $p = 0.35$.

The interaction between demand for restoration (feeling attentionally fatigued or relaxed) and the restorative qualities of sonic environments was non-significant, marginally above conventional p-level, $F(1,116) = 3.69$, $p = 0.057$. Contrary to our assumptions, demand for restoration did not influence the restorative qualities for neither attentionally fatigued (Hypothesis 3a) nor relaxed participants (Hypothesis 3b).

Still, a significant three-way interaction (**Figure 2**) was found between the demand for restoration, company, and the restorative qualities of sonic environments, $F(1,116) = 4.31$, $p < 0.05$, $\eta_p^2 = 0.04$.

Relaxed participants preferred company over being alone both in the natural ($M = 5.56$, $SD = 0.54$ vs. $M = 5.47$, $SD = 0.63$) and in the urban soundscapes, ($M = 4.88$, $SD = 0.69$ vs. $M = 4.28$, $SD = 0.82$). However, the difference between being alone or with a friend was significant only for the urban sounds, $t(58) = 3.09$, $p < 0.01$. Attentionally fatigued participants favored company over solitude, but the differences were not significant for neither the natural soundscapes, $t(58) = 1.30$, $p = 0.21$ nor the urban soundscapes, $t(58) = 0.26$, $p = 0.80$.

Evaluation of the Imagined Soundwalks

As predicted in Hypothesis 4, we found a significant difference in the evaluation of the imagined soundwalks, $Z = -8.47$, $p < 0.001$. Participants preferred the walk in the natural soundscapes ($Mdn = 6.50$) over the walk in the urban soundscapes ($Mdn = 5.00$).

Sense of Security

Participants imagining their walks in urban soundscapes were hypothesized to report a greater sense of security than those imagining their walks in natural soundscapes (Hypothesis 5). A significant difference between the two was found, $Z = -6.90$, $p < 0.001$, but in the opposite manner: those imagining walks in

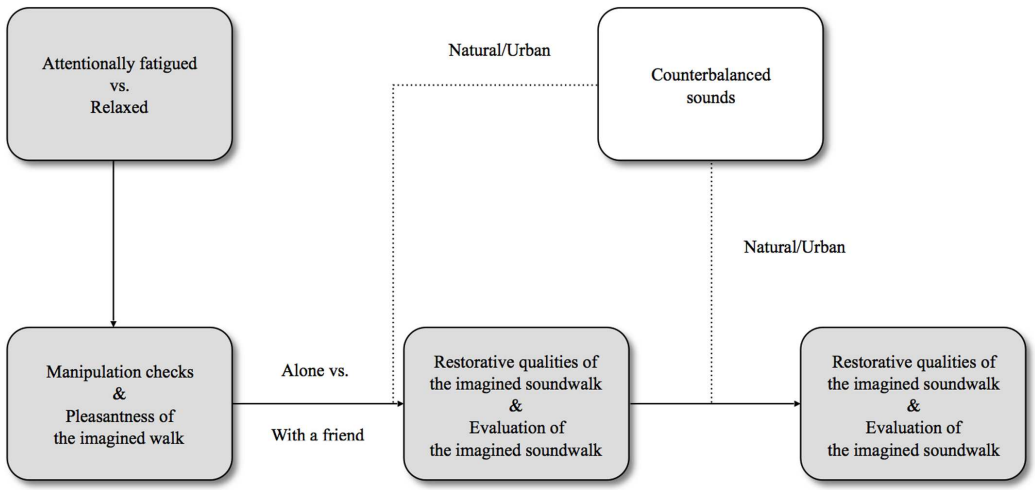

FIGURE 1 | An outline of the research procedure.

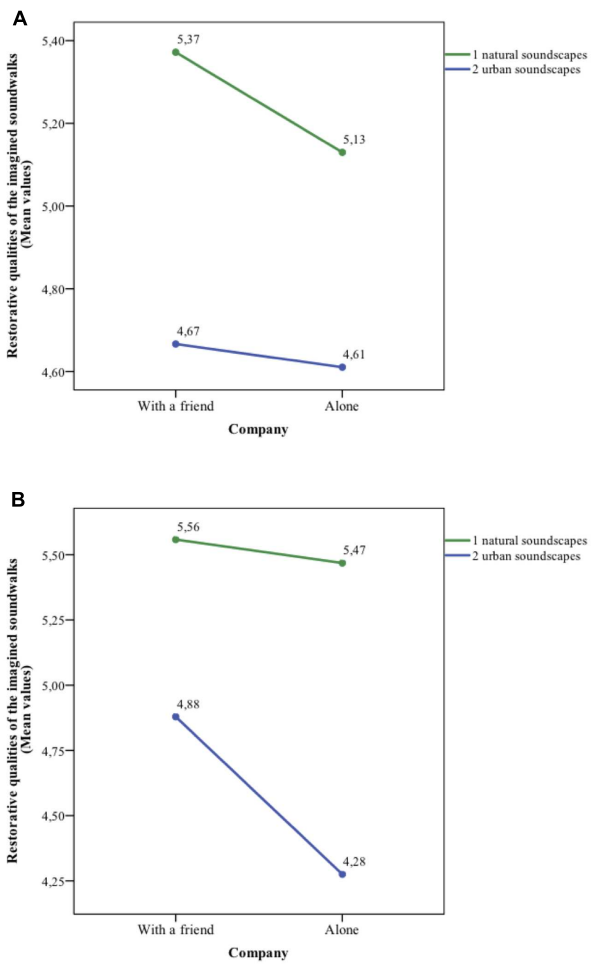

FIGURE 2 | Three-way interaction between the demand for restoration, company and restorative qualities of the imagined soundwalks for attentionally fatigued **(A)**, and relaxed **(B)** participants.

a natural sonic environment felt more secure ($Mdn = 6.00$ vs. $Mdn = 5.00$).

Additionally, participants were assumed to feel more secure in company no matter the sonic environments. According to our expectations (Hypothesis 6a), a significant difference in the assessment of security during the imaginary walk in natural soundscapes was found between those assigned to imagine company ($Mdn = 7.00$) and those assigned to imagine solitary walks ($Mdn = 6.00$), $U = 1302.00$, $p < 0.01$. However, contrary to our predictions (Hypothesis 6b), the appraisal of security in the urban soundscapes was the same ($Mdn = 5.00$) regardless of the company scenario, $U = 1574.50$, $p = 0.22$.

Effect of Company on Restorative Qualities as a Function of a Sense of Security

We examined two mediation models, one for the natural soundscapes (Hypothesis 7a) and one for the urban soundscapes (Hypothesis 7b), in which the relationship between company and the restorative qualities of sonic environments was mediated by a sense of security.

The standardized regression coefficient between company and a sense of security in the natural soundscapes was statistically significant, $b = -0.62$, $SE = 0.21$, $p < 0.01$, as was the standardized regression coefficient between a sense of security in the natural soundscapes and the restorative qualities of the natural sonic environment, $b = 0.17$, $SE = 0.05$, $p < 0.01$. Because two crucial assumptions of mediation were met (Kenny et al., 1998), further analyses were conducted: a bootstrapped estimation with 5000 samples yielded a significant indirect effect of company on natural soundscapes' restorative qualities through a sense of security in the natural sonic environment, $b = -0.10$, $SE = 0.04$, 95% CI $[-0.22, -0.03]$. The mediator accounted for more than half of the total effect, $P_M = 0.62$. Company was not a significant predictor of restorative qualities of the natural soundscapes after introducing the mediator to the model, $b = -0.06$, $SE = 0.12$, $p = 0.61$. As predicted (Hypothesis 7a),

the relationship between company and natural soundscapes' restorative qualities was mediated by a sense of security.

Conversely, for the urban soundscapes, company and a sense of security were not significantly related ($b = -0.31$, $SE = 0.26$, $p = 0.22$). Since the mediation assumptions were not met, further tests were not conducted (Baron and Kenny, 1986). Contrary to our expectations (Hypothesis 7b), the mediating effect of a sense of security in the urban sonic environment on the relationship between company and urban soundscapes' restorative qualities was not confirmed.

Effect of Company on Restorative Qualities as a Function of a Positive Evaluation of the Imagined Soundwalks

Because we were interested in the effect of a positive assessment on the perception of sounds, we also wanted to analyze the influence of a positive evaluation of the imagined walk in a given sonic environment (as an individual component extracted from the general evaluation of the imagined walk) on obtained results. For this reason, we tested two models, again one for the natural (Hypothesis 8a) and one for the urban soundscapes (Hypothesis 8b), in which the relationship between company and soundscapes' restorative qualities was mediated by a positive evaluation of the imagined walk in a given sonic environment.

For the natural soundscapes, the standardized regression coefficient between company and a positive evaluation of the imagined walk in the natural sonic environment was not statistically significant, $b = -0.18$, $SE = 0.14$, $p = 0.18$. As one of the basic mediation assumptions was not met (Baron and Kenny, 1986), further analyses were not conducted. Contrary to our predictions (Hypothesis 8a), the mediating effect of a positive evaluation of the imagined walk in the natural sonic environment on the relationship between company and natural soundscapes' restorative qualities was not confirmed.

By contrast, for the urban soundscapes, the standardized regression coefficient between company and urban soundscapes' restorative qualities was statistically significant, $b = -0.60$, $SE = 0.22$, $p < 0.01$, as was the standardized regression coefficient between a positive evaluation of the imagined walk in the urban soundscapes and the urban soundscapes' restorative qualities, $b = 0.34$, $SE = 0.05$, $p < 0.001$. A bootstrapped estimation with 5000 samples yielded a significant indirect effect of company on the restorative qualities of the urban sonic environment through a positive evaluation of the imagined walk in the urban soundscapes, $b = -0.21$, $SE = 0.08$, 95% CI [−0.38, −0.07]. The mediator could account for more than half of the total effect, $P_M = 0.62$. Company was no longer a significant predictor of urban soundscapes' restorative qualities, $b = -0.12$, $SE = 0.13$, $p = 0.35$. As expected (Hypothesis 8b), the relationship between company and urban soundscapes' restorative qualities was mediated by a positive evaluation of the imagined walk in the urban sonic environment.

Discussion

The main purpose of this study was to explore whether positively assessed urban soundscapes have comparable restorative qualities to natural sounds. We found that both positively assessed sonic environments were perceived as having different restorative qualities. An imaginary walk in the natural soundscapes, including birdsongs and water sounds, was evaluated as being more restorative than an imagined walk in the urban sonic environment, represented by sounds from places such as an old town or an amusement park. These results confirm previous findings about the restorative qualities of natural soundscapes, underlining the importance of greenery in urban surroundings.

It appears that the imagined walk did not change the perception of the urban sonic environment, which was still regarded as being less restorative than nature. It is possible that people do not imagine walking in an urban setting to be as restorative as walking in a natural surrounding. They walk in the city every day, commuting to work or school, often with a purpose and in a hurry. Daily routines are rarely associated with pleasure. A stroll in nature, however, could be perceived as something extraordinary, as a 'being away' experience with no need to rush and with the aim to relax.

The advantage of a natural sonic environment was also confirmed by a more positive evaluation of the imagined walk in nature. It is likely that perceived familiarity and representativeness of sounds affected these findings. We found that the most positively assessed natural recordings were perceived as more familiar and more representative of a given surrounding than the top five urban sounds. These results can be explained by the notion of comfort with the presented type of setting, described previously by Kaplan et al. (1993).

In Study 2, we also explored the roles of the demand for restoration and company. Participants evaluated restorative qualities of sonic environments more favorably when they were assigned to a company condition; however, the result was significant only for the urban soundscapes. Contrary to our expectations, demand for restoration did not influence perceived soundscapes' restorative qualities. Although we suspected that urban sounds could evoke hard fascination not conducive to restoration, this was not confirmed in the obtained results.

In an interaction between restorative qualities of sonic environments, company, and demand for restoration, relaxed participants generally favored being in company, but the difference was significant only in the urban soundscapes; attentionally fatigued participants also preferred company, but the differences between being alone or with a friend were not significant for both sonic environments. These findings suggest that the presence of a close friend is more important when one is in the urban setting.

It is probable that the sample of sounds used in the study partially accounted for the results. Most recordings represented urban environments conducive to meetings (e.g., a café) and visits by relaxed people (e.g., an amusement park). Our findings can therefore highlight the social aspect of an urban environment. Because the urban sounds were associated by participants of Study 1 with fun and social interaction, we can assume that participants preferred to share their experience with someone. It seems that loneliness in the urban environment is more disturbing (e.g., a few prefer be alone in a café). The importance of having company in the urban setting, represented by the urban

soundscapes, was reflected in mediation analysis. It turned out that a positive evaluation of the imagined walk in the urban sonic environment mediated the relationship between company and urban soundscapes' restorative qualities.

Company also increased the sense of security, but we found an interesting contradiction here. Although the urban soundscapes were perceived as less secure, it made no difference to participants whether they had company or not in urban sonic environment, but in the natural soundscapes, perceived as more secure, they preferred to be with someone. Evidently, company of others plays a different role in natural than in urban environments.

In consonance with previous research, in which visual stimuli were used (Staats and Hartig, 2004), mediation analysis confirmed the indirect effect of a sense of security on the relationship between company and the restorative qualities of natural sonic environment. These results might suggest that the urban environment, portrayed by urban sounds, is more predictable (participants know what to expect from the setting) and therefore participants are more likely to explore it alone.

GENERAL DISCUSSION

The combined findings from both studies suggest that natural sounds are perceived by people as being more restorative than urban recordings. This result holds even if only positively assessed urban sounds are used, and when additional factors, such as company or demand for restoration, are considered.

A possible explanation of these findings, which we have not discussed yet, is that natural and urban sounds differ in the extent to which they involve soft or hard fascination. According to Kaplan (1995), these two types of fascination coexist. Soft fascination, characterized by moderate intensity, is experienced in aesthetically pleasant environments, whereas hard fascination is much more intense and appears in more attentionally demanding environments (Heintzman, 2002), such as an exciting NBA match (Chow and Lau, 2015). In our study, natural sounds could have supported restoration by inducing soft fascination in contrast to urban sounds evoking hard fascination. While soft fascination restores concentration, and thus contributes to restoration to a greater extent than hard fascination (Reese and Myers, 2012), it is possible that our findings repeated this pattern. However, it seems that hard and soft fascination can also co-occur. In Study 1, for example, a concert recording, which was the most positively assessed sound of both environments, could have simultaneously induced hard fascination, because of its complexity, and soft fascination, because music is known for its ability to facilitate calm, tranquility and well-being (Krout, 2007; Labbé et al., 2007; Laukka, 2007; Linnemann et al., 2015).

The preference for natural soundscapes might also be explained by the psycho-evolutionary approach. It is believed that "for most of the millions of years during which our species evolved, humans coexisted in a close relationship with the natural environment. Therefore, most adaptations in the human organism, including those of the brain and related behavioral reactions, developed as an evolutionary response to needs imposed by this environment. In contrast, the history of human civilization is relatively short" (Hartig et al., 2011, p. 142). Hence, it is possible that despite the positive valence of urban areas represented by sounds associated with pleasant leisure activities, such as a concert, participants could nonetheless express an innate preference for nature represented by birdsongs and water-related recordings. Notably, because positively assessed urban sounds were mainly linked to recreation and entertainment, these results show that an urban soundscape cannot be equated to noise and its positive aspect should be more broadly acknowledged.

A few limitations of our studies should be mentioned. Because we wanted to depict different locations and use stimuli often used in other research, some of the sounds chosen for Study 1 could have been rated ambivalently or negatively (e.g., crows or road work), thus limiting the selection of potentially positive sounds. As a result, even though we made every effort to provide a variety of sounds, some of the urban facilities or natural habitats, which could have been assessed positively, were not represented (e.g., sports arena).

Moreover, the results obtained in Study 2 could have been partly affected by the role that imagined walking imposed on participants. Although in real life walking in natural surroundings (without additional activities) is a common form of recreation, in urban settings, especially ones similar to those presented in the study (e.g., an amusement park or café), the walk could be additionally associated with other activities accessible in such environments. Thus, for instance, the presence in an amusement park could be related to partaking in the entertainment offered in such places (e.g., taking a carousel ride), because it is rather unlikely to visit such a place just to stroll between attractions. As a result, the predetermined role of 'an observer' instead of the role of 'an active participant' could have resulted in a less positive evaluation of the restorative qualities of the urban soundscapes.

It should also be noted that our findings are limited to one modality (auditory), which may deprive us of some potentially relevant data. Therefore, in the future we would like to take a multimodal approach, which better mimics real-life experience.

In further research on restorative qualities of natural and urban environments, participants should be allowed to perform an attention-exhausting task prior to the beginning of the study. Future research could also investigate whether the presence of a real friend affects the results and whether differences in responses can be found between participants tested individually or in a group.

It is also worthwhile to mention the procedure used in Study 2. We based our scenarios and items on the ones described by Staats and Hartig (2004); however, it would be interesting to modify them, exploring in detail the impact of the evaluation of the environment on its restorative potential or personal preferences for activities and places associated with regeneration. Furthermore, items measuring restorative qualities of a given soundscape/surrounding could also include questions derived from other discovered factors of the ART, such as comfort with a given type of setting (Kaplan et al., 1993) or beauty (Ouellette et al., 2005; Herzog et al., 2010).

Additionally, individual differences between participants should be taken into account. The results found by Meagher (2016) suggest that not only the type of environment, but also personality traits, such as neuroticism, can influence psychological restoration. Future research should also examine the effects of stereotypes on the perception of the natural and urban sonic environments/settings and focus on the restorative qualities of urban surroundings.

Moreover, because a healthier urban biosphere, in which a place for coexistence of natural and artificial worlds would be found, seems to be potentially beneficial for urban residents, it is worthwhile to search for new, effective solutions that could have been implemented on macro (e.g., the WHO Healthy Cities project[1]) and micro scales (e.g., pocket gardens), to promote mental and physical heath within the urban surrounding. The idea that soundscapes, such as the murmur of a stream or birdsong, may change the perception of a given urban environment seems very appealing, as we have not yet fully discovered restorative qualities of sonic environments. Therefore, it would be interesting to further explore the way in which the relationship between sensory modalities (more than one) affects an environment's restorative qualities in a positive (what increases it) or negative (what decreases it) direction. It would also be worthwhile to concentrate more on the mutual penetration between natural and urban environments instead of viewing them as opposites.

CONCLUSION

In sum, our studies provided new knowledge about positively assessed urban sounds and their impact on the perceived restorative qualities of urban areas. Although the obtained results do not favor urban sonic environment, they emphasize the importance of natural soundscapes within an urban surrounding and the role of well-planed urbanized areas, which, with balanced artificial and natural settings, can be more beneficial to urban residents by promoting well-being, improving perceived quality of life and creating new spaces with potential for restoration within urban agglomerations.

[1] For more information about the WHO Healthy Cities project, see de Leeuw (2001).

ETHICS STATEMENT

These studies were carried out in accordance with the recommendations of the ethical guidelines of the faculty's ethics board with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

Research idea and study design: PK and KB. Data collection: PK. Data analysis and paper writing: PK and KB.

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The article by Leadbetter and O'Connor (2013) used in this paper 'contains public sector information licensed under the Open Government Licence v3.0': http://www.nationalarchives.gov.uk/doc/open-government-licence/.

SUPPLEMENTARY MATERIAL

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Affording Sustainability: Adopting a Theory of Affordances as a Guiding Heuristic for Environmental Policy

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Human behavior is an underlying cause for many of the ecological crises faced in the 21st century, and there is no escaping from the fact that widespread behavior change is necessary for socio-ecological systems to take a sustainable turn. Whilst making people and communities behave sustainably is a fundamental objective for environmental policy, behavior change interventions and policies are often implemented from a very limited non-systemic perspective. Environmental policy-makers and psychologists alike often reduce cognition 'to the brain,' focusing only to a minor extent on how everyday environments systemically afford pro-environmental behavior. Symptomatic of this are the widely prevalent attitude–action, value–action or knowledge–action gaps, understood in this paper as the gulfs lying between sustainable thinking and behavior due to lack of affordances. I suggest that by adopting a theory of affordances as a guiding heuristic, environmental policy-makers are better equipped to promote policies that translate sustainable thinking into sustainable behavior, often self-reinforcingly, and have better conceptual tools to nudge our socio–ecological system toward a sustainable turn. Affordance theory, which studies the relations between abilities to perceive and act and environmental features, is shown to provide a systemic framework for analyzing environmental policies and the ecology of human behavior. This facilitates the location and activation of leverage points for systemic policy interventions, which can help socio–ecological systems to learn to adapt to more sustainable habits. Affordance theory is presented to be applicable and pertinent to technically all nested levels of socio–ecological systems from the studies of sustainable objects and households to sustainable urban environments, making it an immensely versatile conceptual policy tool. Finally, affordance theory is also discussed from a participatory perspective. Increasing the fit between local thinking and external behavior possibilities entails a deep understanding of tacit and explicit attitudes, values, knowledge as well as physical and social environments, best gained via inclusive and polycentric policy approaches.

Keywords: ecological psychology, affordance theory, pro-environmental behavior, attitude–action gap, environmental policy, socio–ecological systems, nudging, radical embodied cognitive science

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INTRODUCTION

Human behavior is a common determinant underlying most of the major ecological crises of the 21st century, and there is simply no escaping from the fact that behavior needs to be changed for socio-ecological systems to take a sustainable turn (Steg and Vlek, 2009; Antal and Hukkinen, 2010). Yet whilst making people and communities behave pro-environmentally is one of the

fundamental targets of environmental policy, this foundation is surprisingly often left unspoken, or at least understood from a very limited, non-systemic, perspective. The aim of the present article is to elaborate pro-environmental behavior change policy and intervention analysis by introducing a theory of affordances to the environmental policy community. Affordance theory, which interprets environmental behavior from a dynamical and coupled *systems* or *ecological* approach (Gibson, 1979), is shown to be a promising heuristic for systemic behavior analysis. Particularly, it can help policy-makers locate and make use of 'leverage points,' or places where small changes can lead to large shifts in a system's behavior, for systemic behavior change interventions (Meadows, 1997, 2008; Lockton, 2012). This can help not only individuals, but whole socio–ecological systems to learn to adapt to more sustainable habits.

Affordances are defined in this paper as the 'relations between abilities to perceive and act and features of the environment' (Chemero, 2009, p. 150). As Guagnano et al. (1995) and Jackson (2005) note, such integrative approaches, which take into account the dynamical relations between 'internal' and 'external'[1] behavior antecedents, have traditionally been lacking. I argue therefore that a theory of affordances has a particularly valuable niche to occupy within the multidisciplinary field of environmental policy, since it effectively crosses the artificial divide between internal and external behavior antecedents and studies the dynamical and coupled systems relations between human actors and their (physical and socio-cultural) environment. Moreover, affordance theory invites us to study how this behavior system, as a whole, 'unfolds over time' (Chemero, 2013, p. 149). This, in turn, accounts for a more complete picture of environmental behavior and helps us understand why pro-environmental knowledge, values or attitudes are not alone sufficient to induce behavior change (the attitude–action gap), or why everyday environments fail to make the full use of our internal behavior potential. This is particularly relevant since the overwhelming consensus is that despite many or even most of us having pro-environmental attitudes, we are not behaving sustainably (Blake, 1999; Kollmuss and Agyeman, 2002; Abrahamse et al., 2005; Kennedy et al., 2009; Steg and Vlek, 2009).

In the present text, these mismatches between internal and external behavior antecedents are analyzed in terms of affordances, and it is suggested that by increasing pro-environmental affordances we can facilitate systemic and even self-reinforcing pro-environmental behavior change. Moreover, it is also argued below that an affordance-based approach to behavior change intervention can make the best use of the pre-existing latent pro-environmental behavior potential of both humans (capabilities to act, including attitudes, values, knowledge etc.) and everyday environments. This seems to call for a thorough understanding of latent behavior potentials of local populations, suggesting that affordance-based governance should be polycentric (or decentralized), inclusive and participatory, reducing local helplessness and increasing social acceptability.

The crux of this article is therefore to make a case for adopting a theory of affordances as a guiding heuristic for environmental policy. With a heuristic, I mean a fast instrumental and conceptual tool which facilitates 'exploring and conceptualizing' pro-environmental behavior, also helping us to 'identify points of policy intervention' (Jackson, 2005, vi). A successful heuristic facilitates quick decision-making and helps avoid costly errors. By adopting a theory of affordances as a guiding heuristic, I argue that policy-makers and scholars are better equipped to systemically analyze the ecology of pro-environmental behavior, understand the dynamics between its internal and external antecedents, as well as design appropriate policy interventions.

Adopting the definition from Steg and Vlek (2009, p. 309), environmental behavior is defined in this paper as 'all types of behavior that change the availability of materials or energy from the environment or alter the structure and dynamics of ecosystems or the biosphere.' Pro-environmental behavior (abbreviated hereafter as PEB), correspondingly, 'refers to behavior that harms the environment as little as possible, or even benefits the environment' (ibid.). The question of what exactly counts as pro-environmental and what does not is not problematized further within the scope of this paper. However, it is worth emphasizing that harming the environment as 'little as possible' is not necessarily *pro*-environmental and that pro-environmental behavior in one domain or context might emerge as unsustainable in another.

The body of this article is divided into three main sections. Firstly, in section "The Attitude–Action Gap, or Why We Don't 'Walk the Talk'" the attitude–action gap and its relevance to environmental policy is briefly discussed. Particularly, I suggest that, all too often, pro-environmental behavior research has limited its focal variables to either internal (e.g., values, attitudes, personal norms, habits, and knowledge) or external (e.g., physical infrastructure, economic factors, and institutions) ones (see Jackson, 2005 for an overview). I argue that to overcome the barriers between pro-environmental motivations and behavior, we must understand how our everyday environments provide or constrain the actualization of our pro-environmental internal factors. This requires the simultaneous and dynamical inspection of both internal and external behavior antecedents, as well as particular focus on how these dynamics evolve over time (Chemero, 2013). In section "A Theory of Affordances," drawing particularly on ecological psychology (e.g., Gibson, 1979) and recent advances in radical embodied cognitive science (e.g., Chemero, 2009), I argue that a theory of affordances provides an effective heuristic framework for studying these coupled and dynamical human–environment behavior systems. In section "Affording Sustainability" I discuss the policy-relevance and potential applications of affordance theory, where affordances can be utilized as leverage points to induce systemic behavior change. In section "Affording Sustainability" I also include a brief meta-empirical survey of how affordance-like ideas have

[1]I acknowledge here, at the very beginning of this text, that the use of the terms 'internal' and 'external' imply a dichotomy that, ontologically speaking, simply does not exist (it is a 'false dichotomy'; Gibson, 1979). Indeed, this paper is devoted to show that they are not dichotomous, and are instead mutually implicative and systemically relative (there is no internal without external). However, due to linguistic insufficiencies I maintain that a cautious upholding of this dichotomy is necessary for pragmatic purposes.

been implemented in environmental policy and psychology, and discuss how intentional adoption of a theory of affordances can hasten the arrival at well-functioning policies at various nested systemic levels. Section "Conclusion" concludes the article.

THE ATTITUDE–ACTION GAP, OR WHY WE DON'T 'WALK THE TALK'

It is widely accepted amongst those studying pro-environmental behavior (PEB) that a significant gap lies between possessed values, knowledge and attitudes and behavior (Blake, 1999; Kollmuss and Agyeman, 2002; Abrahamse et al., 2005; Jackson, 2005; Kennedy et al., 2009; Steg and Vlek, 2009). In other words, an attitude–action gap, a knowledge–action gap or a value–action gap exists between internal human factors and behavior patterns. For practical purposes, I from here on refer to this discrepancy between internal factors (such as attitudes, values, knowledge, personal norms, intentions and emotions) and behavior simply as the attitude–action gap, humbly acknowledging that this does a disservice to the great body of research focused on studying the relationships between these individual internal factors and pro-environmental behavior (see Kollmuss and Agyeman, 2002; Abrahamse et al., 2005; Steg and Vlek, 2009 for an overview on the topic).

The attitude–action gap does not imply that internal factors do not have *any* effect on pro-environmental behavior, but rather that a great amount of PEB cannot be explained with internal factors alone. Generally, it seems that internal factors are more likely to lead to change in low-cost (low in time and effort) actions than in high-cost behavior (Kollmuss and Agyeman, 2002; Abrahamse et al., 2005; Steg and Vlek, 2009), although not all research fully supports this (e.g., Hunecke et al., 2001). Moreover, the case seems to be that internal factors seem to correlate more strongly with behavior when they are specific to a certain domain. This is, perhaps, common sense: positive recycling attitudes strongly predict recycling behavior (and not, for example, travel behavior), whilst more generic pro-environmental values do so only to a much lesser extent (Vining and Ebreo, 1992).

The attitude–action gap is, at the root of it, rather intuitive. Many people with pro-environmental intentions will have experienced the uncomfortable feeling of cognitive dissonance when they have taken part in environmentally harmful yet seemingly banal activities such as air travel. Simply, as Vining and Ebreo (1992, p.1604) observe, 'it is easier to be concerned about the environment than it is to act on one's convictions.' This mundane and banal phenomenon, however, takes on direct policy relevance when combined with an urgent need for humans to change their behavior patterns and habits to tackle ongoing ecological crises. We talk the talk, but systemically fail at 'walking the talk' (Kennedy et al., 2009). Since significant portions of national populations are pro-environmentally motivated, translating these latent pro-environmental behavior potentials into action becomes an imperative task for environmental policy. For one example, Kennedy et al. (2009) found that Canadians adhere much more strongly to the 'New Ecological Paradigm' world-view (which states, inter alia, that 'humans and other species are intricately connected') than to the so-called 'Dominant Social Paradigm' ('mankind was created to reign over the earth').

A comprehensive literature review on the attitude–action gap is beyond the scope of this article. Fortunately, such work has already been done, notably by Kollmuss and Agyeman (2002), Abrahamse et al. (2005), Jackson (2005), and Steg and Vlek (2009). Briefly, however, it should be noted that studies on the relations between mental models and behavior have progressed significantly from the oldest and simplest models known as 'rational,' 'linear,' or 'information-deficit' models, which established a direct linear relation between knowledge, values and behavior. More complex and nuanced models have taken into account how attitudes, norms, beliefs, intentions, emotions, affect, altruism, locus of control, self-identity and a large variety of other variables influence pro-environmental behavior, also including sociological factors, situational variables and, to a somewhat limited extent, the structural and physical environment (Steg and Vlek, 2009, p. 314).

I argue, however, that many of these accounts on pro-environmental behavior – important as they are for understanding the complexities of human practices – suffer from a very fundamental a priori assumption, which limit cognition 'to the brain' (Rockwell, 2005). In this paradigm, often implicit in environmental psychology, contextual factors, if considered at all, have usually been 'introduced in the form of subjectively perceived environment,' and not as systemic ecological situations (Hunecke et al., 2001). Moreover, when the effects of external (such as economic) factors on behavior have been studied, it has often been done so with the cost of excluding internal human factors. Integrative approaches, which take to account the dynamical coupling between internal and external behavior variables, have traditionally been scarce (however, see Guagnano et al., 1995; Stern, 2000; Hunecke et al., 2001; Jackson, 2005).

This is, of course, traceable to a long tradition of Cartesian materialistic thinking, often implicit in the psychological and cognitive sciences (Heft, 2001; Rockwell, 2005; Chemero, 2013; Ch. 7 in Reed, 1996). That is, the notion that behavior and cognition are *ecological*, construed dynamically in an ecological system, is most often downplayed in favor of more limited approaches which reduce cognition and behavior to the internal domain (e.g., mental representations). Whilst this might be a pragmatic and even useful limitation at times, treating human cognition as a 'static' entity, ontologically separable from outside variables, can also be wildly misleading (Kurz, 2002, p. 269). What is suggested below is that rather than focusing on single static variables underlying behavior we should take a dynamical stance, such as that provided by a theory of affordances.

Affordance theory originates from the field of empirical and theoretical research known as *ecological psychology*. Ecological psychology draws mainly from perceptual psychologist James J. Gibson's work (most influentially Gibson, 1979), which emphasizes the dynamical and systemic coupled relations between animals and their physical environment. As used in this text, ecological psychology should not be confused with environmental psychology or other strains of research

going by the name of ecological psychology (such as Roger Barker's), although many similarities between these fields exist (see Heft, 2001 for a useful overview). I argue that ecological psychology and its more recent descendants in radical embodied cognition theories (e.g., Chemero, 2003, 2009, 2013 as well as Rockwell, 2005) should be revisited in order to understand more comprehensively the role our everyday and urban environments play in shaping our environmental behavior. This is elaborated in detail in sections "A Theory of Affordances" and "Affording Sustainability" in the form of a theory of affordances.

A few caveats are in place before moving onward. I am not proposing a silver bullet to solve the problem of the attitude–action gap altogether. As Kollmuss and Agyeman (2002, p. 248) rightly note, the gap is 'such a complex one that it cannot be visualized in one single framework or diagram.' This is wholly unsurprising from a systems theoretical point of view, where it is generally understood that no static conceptualization or model can capture the whole complexity of a contingent system (Meadows, 2008). Indeed, to map the complete causality underlying a behavior system is practically impossible, since it would take an astronomical scale (Rockwell, 2005). Accordingly, 'there will always be something of a tension between simplicity and complexity' in modeling behavior, and a 'good conceptual model requires a balance between parsimony and explanatory completeness' (Jackson, 2005, p. 23, vi). Therefore, what is merely suggested below is that a theory of affordances provides us with a pragmatic (see Rockwell, 2005) and adaptable heuristic for understanding and intervening with behavior from a systems perspective. Such a heuristic not only facilitates and hastens the arrival at working policy solutions, but also importantly helps us avoid unintended consequences and making costly mistakes. For now, in section "A Theory of Affordances," however, it is in place to provide a more detailed description of what exactly we mean when talking about a theory of affordances.

A THEORY OF AFFORDANCES

An affordance, in its simplest – yet most philosophically impoverished – definition, refers to the action possibilities provided by objects or environments. Whilst, as is elaborated below, the concept is in fact significantly more nuanced than this, the aforementioned definition of affordances has been widely adapted by, for instance, the design community: 'when used in this sense, the term *affordance* refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could be possibly used' (Norman, 2002, p. 9). It follows then, that a chair provides support and thus *affords*[2] humans with (or 'is for') sitting. Apples afford, among a huge variety of behavior, throwing, eating, baking and cutting. Bananas afford – explaining their huge urban popularity – easy, fast and locally clean eating as well as exportability, since they ripen after picking.

However, a more nuanced treatment of affordances does not consider affordances as *properties* of objects or environments, but rather in terms of ecological situations. As Chemero (2003, 2009) remarks, affordances are functionally meaningful features of whole situations. These whole situations are better defined as fluctuating behavioral fields emerging from brain–body–world interaction (Rockwell, 2005, 2010). Here, the similarity to Lewin's (1951) field theory, a theory positing human behavior as "a function of a dynamical 'field' of internal and external influences," is obvious (Jackson, 2005, p. 26; see also Heft, 2001). Affordances from this more refined perspective are not – contra the popular understanding (see e.g., Kurz, 2002; Norman, 2002) – dispositional properties of things or environments, but rather functionally meaningful 'relations between abilities to perceive and act and features of the environment' (Chemero, 2009, p. 150; c.f. Turvey, 1992). The environment here is to be understood to refer to the whole of the material world, physical, cultural and social environments included. This is the definition of affordances used in the remainder of this text.

Affordances are therefore dynamical and coupled organism–environment relations, hence through and through systemic and ecological (Chemero, 2009). A chair, given the right conditions, affords sitting for an erect bipedal species such as ours, whilst its affordances are wholly different for other species not adapted to walk and sit. Affordances are therefore not 'psychologies of things' (contra Norman, 2002), but rather psychologies of organism–environment relations. Affordance theory posits that active cognitive agents perceive and experience the world in terms of affordances, or functionally meaningful relations with the environment. We do not perceive the world passively as having pre-given objective and action-neutral properties, but rather as active opportunities for action (Ramstead et al., 2016). Our everyday lives are ridden with affordances, and they are continuous, dynamic, reciprocal and evolutionary processes: affordance-sets constantly affect organisms and populations, whilst organisms continuously adapt to and modulate the niches (or sets of affordances) they inhabit (Heft, 2001, xxix; Chemero, 2003, p. 190; Reed, 1996, p. 26).

The ontology of affordances is therefore one which attempts to effectively cross the artificial subject–object divide (Chemero, 2009).[3] This is perhaps best captured by the following oft-cited, yet slightly cryptic, quote by Gibson (1979, p. 129):

[2]The transitive verb *to afford*, in the whole of this text, should be read to imply the meaning 'to make available, give forth, or provide naturally or inevitably' (as defined by the Merriam-Webster dictionary). This should not be confused with the more common definition 'to be able to bear the cost of' something. The noun *affordance* is a neologism coined by ecological psychologist James J. Gibson (see e.g., Gibson, 1979) and, of course, refers merely to the former definition of the verb 'to afford.' To cite Gibson (1979, p. 127) himself, 'The verb *to afford* is found in the dictionary, but the noun *affordance* is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment.'

[3]I suggest that affordances are best interpreted via an anti-Cartesian ontology, which does not separate subjects from objects. Good candidates for such an ontology can be found in early American pragmatism, for instance the works of John Dewey (e.g., Dewey, 1958) and William James (see Heft, 2001). This is no coincidence, since Harry Heft's (Heft, 2001) brilliant exposition on ecological psychology reveals James' radical empiricism's direct influence on James J. Gibson's ecological psychology. Common to these perspectives is the ontological priority of *processes* over *substances*, sometimes labeled 'process metaphysics' or 'process philosophy' (Rescher, 1996, 2000). For an introduction to process philosophy see the work of Nicholas Rescher (Rescher, 1996, 2000), and for an interpretation of process philosophy in the context of environmental policy, see Kaaronen (in press).

> 'an affordance is neither an objective property nor a subjective property; or both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points bothways, to the environment and to the observer.'

Whilst this might seem unnecessarily muddling and counterintuitive to some – or even violative toward the law of non-contradiction (*viz.* 'neither an objective property nor a subjective property' or 'both if you like') – Gibson's definition contains a valuable insight: when understood ecologically, behavior is not constrained to the perceiver nor to the perceived, but is rather a dynamical and coupled systems relation between the perceiving organism and the environment it inhabits. From this perspective, it is distasteful to reduce cognitive systems to the brain (or even body), but cognition and behavior rather emerge over time from a 'dynamical brain–body–world nexus' (Rockwell, 2005; Anderson et al., 2012; Hutto and Myin, 2012). Hence affordances imply a degree of extended cognition: the perceived world is not construed by the brain or mind, but rather emerges from the interaction between a nervous system, a body capable of perceiving and an environment which affords perception (via, for example, latent information in the form of structured ambient light in the environment) (Gibson, 1979; Reed, 1996; Chemero, 2003, 2009; Rockwell, 2005, 2010; Anderson et al., 2012). Affordance theory implies that meaning is not construed by the brain alone (by any means of 'mental gymnastics'), nor is it merely a social construct, but rather is latent in the environment and (directly) perceivable in organism–environment interactions (see the 'radical embodied cognitive science' of Chemero, 2003, 2009). In contrast to inferential theories of perception, where 'meanings arise inside animals, based on their interactions with the physical environment,' affordance theory suggests that 'the animal simply gathers information from a meaning-laden environment' to actualize some function (Chemero, 2003, p. 181; see also Gibson, 1979, p. 238–263). Meaning, cognition, perception, and thus also behavior, are thoroughly ecological. Hence, of course, *ecological* psychology.

Importantly, as Gibson's quote above implies, affordances are not idealistic (in the ontological sense), and despite their hardly tangible nature, affordances are indeed real, perceivable and empirically observable (Chemero, 2003, 2009; Heft, 2003; c.f. Kurz, 2002 who, among others, claims affordances are mere subjective perceptions). Chemero (2003, p. 187) suggests that for us to understand affordances we should consider the 'taller-than' in the statement 'Shaquille is taller than Tony.' The taller-than is neither a property of Shaquille or Tony, yet it is still an empirically observable and real relation in the whole situation. Affordances are equally real. To further elaborate, Chemero (2009, p. 150), drawing on Dennett (1998), likens affordances to the state of being 'lovely': a hippopotamus can continue to have the potential for being lovely even when it is not, at that moment, observed by another organism. In other words, the hippopotamus' physical structure has latent *potential* to be lovely for a *potential* observer, even if the affordance of 'being lovely' is only actualized when complemented by another organism which has the abilities to perceive and experience its latent loveliness, given that the right conditions are met. Affordances are, as Chemero (2003, p. 193) notes with dry wit, 'lovely.'

Our everyday lives make use of innumerable affordances even when we are not conscious of them (I would argue that we mostly are not), and affordances do not require us to be able to consciously locate them. Take for instance Polanyi's (1958/1974, 1966/2009) well-known example that we can, without effort, recognize familiar faces without being able to explicate how we achieve this (i.e., familiar faces afford recognition).[4] A similar tacit use of affordances is illustrated by the so-called 'gaze heuristic,' by which humans (and, it seems, dogs) can catch flying objects unconsciously (and without any mental gymnastics such as trajectory calculation) by simply fixing their gaze on the object, starting to run, and adjusting running speed so that the angle of the gaze remains constant (see the 'ecological rationalism' of Todd and Gigerenzer, 2012). The 'catchability' affordance of an object is, therefore, specifically an active organism–environment relation. Moreover, to tacitly recognize affordances is no trick unique to humans; all organisms are evolutionarily adapted to their ecological niche and can make sense of the affordances within it. Charles Darwin, who made less famous advances in animal perception, noted how earthworms very delicately adapt to the affordances within their ecological niche (see Reed, 1996, p. 20–28; Darwin did not, of course, use the term 'affordance'). We do not need to consciously recognize affordances to make use of them – certainly earthworms do not, at least not to our human standards of consciousness. However, we *can* knowingly identify and recognize affordances sufficiently for us to modulate them, as will be discussed in section "Affording Sustainability."

In this section I have asserted that organism–environment relations are coupled and dynamical systems. For our purposes, this means that human cognition and behavior are, on an ontological level, formed simultaneously, continuously and dynamically from both internal (organismic) and external (environmental) behavior potential. Moreover, affordance theory implies that we not only study the way external and internal factors cause changes in behavior, but rather 'the way the system as a whole unfolds over time' (Chemero, 2013, p. 149). **Figure 1** illustrates this as a coupled and dynamical feedback system. The rationale for modeling environmentally significant behavior in such a non-linear fashion, with potential for positive feedback (this is returned to in the following section), stems from affordance theory's recent resurgence in radical embodied cognitive science, which attempts to describe psychology by combining 'non-linear dynamical modeling with ideas about the nature of the mind' (Chemero, 2013, p. 145; see also Rockwell,

[4]Interestingly, Polanyi's philosophy of tacit knowing seems to have, to some extent, influenced Gibson (1979, 22, 260–261). Drawing on Polanyi, Gibson notes that knowledge can be said to be both *tacit* and *explicit*, but that there has to be a tacit 'awareness of the world' before it can be explicated ('put into words'); 'perceiving precedes predicating'. Gibson continues: 'However, skilled an explicator one may become one will always, I believe, see more than one can say'. See also Kaaronen (in press) for discussion on sustainability, M. Polanyi and affordances.

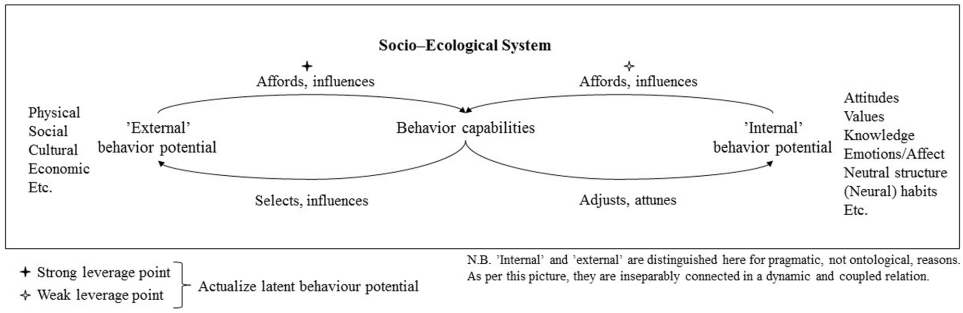

FIGURE 1 | The dynamical and ecological behavior system.

2005 and Chemero, 2009). This is necessary since, as Chemero (2013, p. 148) continues, it 'is only for convenience (and from habit) that we think of the organism and environment as separate; in fact, they are best thought of as forming just one non-decomposable system.'

Here we can identify a processual scheme dynamically interconnecting 'internal factors,' 'behavior capabilities' (e.g., socio–physical abilities to act) and 'external factors.' Importantly, this behavioral process is not linear, but all events (arrows) of the process are interconnected and active simultaneously and constantly. To paraphrase Gibson (1979, p. 240), behavior is a flux and not a sequence – a continuous evolutionary act which is ceaseless and unbroken. Behavioral systems are 'processual' and not discrete (in terms of process philosopher Rescher, 1996, 2000) or 'loopy,' and not 'linear' (as per enactivists Hutto and Myin, 2012: 6 or Varela et al., 1991). The ecological behavior system is dynamical (it evolves continuously) and coupled (its constitutive parts are interconnected, and a change in one variable results in changes in the others). This situation model in **Figure 1** represents, essentially, a self-organizing coupled dynamical system where 'the river molds the banks and the banks guide the river' (Bateson, 2000, p. 83). Whilst **Figure 1** presents internal and external factors as collections of variables, we could also choose this model to analyze dynamics between specific internal and external variables. Note also that whilst affordances are generally taken to refer to merely the arrow connecting external factors to abilities, I have also chosen to use the verb 'afford' to connect internal behavior potential with abilities. After all, the latent structure of internal factors affords individuals with behavioral abilities, even if not always to the same force as the structure of external factors. This figure is returned to with practical examples in the following sections.

I argue below that the notion that our everyday worlds are infused, often unknowingly to us, with innumerable affordances, takes on a very political nature. Whilst affordance theory is generally considered a realistic or naturalistic description of organism–environment relations, it can, and arguably should, also be politicized. What kinds of affordances do we reinforce, foster and inhibit, and how is this reflected in everyday behavior patterns? More precisely, how (if at all) do the most prevalent features in our socio–ecological system afford pro-environmental behavior, and are available affordances equal for different populations? Affordance theory presents us a framework for studying the ecology of human behavior, and particularly for focusing on how our everyday and urban environments systemically nudge individuals and local populations to behave in environmentally significant patterns and habits. A better understanding of local behavior potentials (internal and external) and their dynamics over time can facilitate the design of urban and everyday environments which help to actualize these potentials, resulting at best in self-reinforcing systemic learning patterns. This would suggest for local, decentralized (or polycentric) and even participatory governance, where policy-designers are more specifically attuned to local behavior potentials and capabilities. An imperative question arises here for those involved with environmental policy. How do we, as a society and culture, as individuals, as local communities, as policy-makers, *afford* sustainability? These issues are elaborated in the following sections.

AFFORDING SUSTAINABILITY

Having outlined the conceptual aspects of a theory of affordances, it is now time to consider its policy-relevance. I have suggested above that environmental policy-makers should adopt affordance theory as a guiding heuristic for policy development, particularly to understand the attitude–action gap in environmental behavior and target policy interventions to induce systemic behavior change. An efficient and coherent heuristic is more than a semantic advantage; a good heuristic model can shape the way in which we intuitively perceive the world and therefore promptly aid policy- and decision-makers in identifying points for policy intervention, hastening the arrival at working-as-intended policies and helping to avoid costly (in time, effort and money) mistakes (Jackson, 2005).

Since affordance theory provides us with a through-and-through systemic understanding of environmentally significant behavior, focusing on the dynamics between internal and external behavior antecedents, it helps us locate systemic leverage points (Meadows, 1997, 2008; Lockton, 2012) for policy intervention. Leverage points are here to be understood as 'places in the system where a small change could lead to large shift' in the system's behavior (Meadows, 2008, p. 146). Since environmental

behavior is a coupled and dynamical system which evolves over time (see **Figure 1**), by making use of leverage points policy-makers have the capacity to help this system learn to behave more sustainably. This is in Bateson's (2000) terms *deutero-learning* (learning to learn), in other words inducing second-order change to the system to complement the usual first-order trial and error (environmental behavior as usual). By understanding and leveraging these feedback loops, we can, again quoting Bateson (2000, p. 274), 'not only solve particular problems but also form *habits* which we apply to the solution of *classes* of problems.' A central task for environmental policy-makers and scholars is therefore to help our socio–ecological system – not just its individual constituents – to learn to behave more sustainably. What follows is an attempt to describe such systemic learning.

To understand the attitude–action gap in terms of a theory of affordances, we should begin with asking why our everyday niches *do not* afford sustainable behavior. Here Norman's (2002) insights from cognitive science and design are of direct relevance for environmental policy. Norman (2002, p. 51) suggests that two 'Gulfs' separate internal mental states from being complemented by external physical ones, namely the Gulf of Execution and the Gulf of Evaluation.

The first of these gulfs is the Gulf of Execution, which exists when the actions provided by a system do not match those intended by a person, or when a system does not allow a person to execute the intended actions directly and without significant effort (Norman, 2002). In the case of the attitude–action gap then, this would equal to a person with high pro-environmental intentions (let us signify this here with INT+, for internal factors) yet with low action possibilities provided by their ecological niche (EXT−, for external factors).

The second gulf Norman (2002, p. 51) specifies is the Gulf of Evaluation. The Gulf of Evaluation exists when a system does not provide physical representations that can be directly perceived and interpreted in terms of intentions and expectations of a perceiver. In other words, the Gulf of Evaluation exists during lack of functionally meaningful feedback. For this Gulf to be crossed, the amount of effort that a person must exert to 'interpret the physical state of the system' must be low and the person must be able to determine how well their expectations and intentions are met. Systems should provide information that is easy to acquire and interpret, and match the way in which the person perceives the system. Because 'people generally do not know which and whose behaviors significantly affect resource use,' or at least such knowledge is bound to be vague and filled with misunderstandings, feedback is important from an educational point of view, giving instructions for future behavior (Steg and Vlek, 2009, p. 310). A system intended to overcome the attitude–action gap must therefore not only provide simple and comparative feedback, but also provide functionally meaningful 'feedforward' ('how to act from here on') (Lockton, 2012).

Consider now, drawing back on **Figure 1**, the attitude–action gap in terms of dynamical and coupled human–environment relations, or affordances. If a population's pro-environmental internal set (values, knowledge, attitudes etc.) is high (INT+) and we are witnessing a lack of behavior, the heuristic answer per a theory of affordances would be that the niche does not provide sufficient affordances for the actualization of the internal sustainability potential (thus EXT−). Most likely, this is due to insufficient action possibilities (Gulf of Execution) and feedback (Gulf of Evaluation).

Now, consider that by policy means we cross the Gulfs of Execution (make the system afford physical actions) and Evaluation (make the system provide feedback/feedforward). In other words, we alter our niche to have better capacities for actualizing our latent pro-environmental potential, thus increasing sustainable affordances. This would particularly entail intervening with the strong leverage point in **Figure 1** ('External' behavior potential → Behavior capabilities, or altering the material aspects of the environment). Now we have a coupled feedback loop of INT+ and EXT+. With the increase of affordances in our niche (via EXT+), the latent potential of INT+ can be actualized. That is not to say that intervening with the weak leverage point (see **Figure 1**) is unnecessary here, since abilities to utilize any external factors also have to be taught and learned – the case is merely that without the strong leverage point being activated (e.g., recycling being physically possible) no amount of weak leveraging will suffice.

A case example demonstrating such a positive sustainable feedback loop between internal and external factors would be a couple, call them Alfa and Beta, both possessing high pro-environmental attitudes and knowledge (INT+), and thus high latent potential for recycling, living in a suburban environment without easily accessible recycling systems (EXT− due to a Gulf of Execution; e.g., inconvenient drop-off recycling locations). Note also that their waste disposal system provides no feedback or feedforward as to how they are acting or how they should act (EXT−). To remind Alfa and Beta (say, via information campaigning) about their unsustainable action is unlikely to substantially change behavior, and it might at worst result in Alfa and Beta experiencing cognitive dissonance and thus blocking the dissonant information or delegating responsibility elsewhere (by means of self-justification).[5] Now, imagine a local environmental policy-maker, after surveying the local populations' environmental perceptions and identifying latent pro-recycling attitudes, deploys each household in the suburb with easily accessible curbside recycling systems (crossing the Gulf of Execution).

Alfa and Beta now have affordance for recycling (EXT+ and INT+). Moreover, since it is now convenient for them to recycle, the very act of recycling is likely to strengthen their pro-environmental identities and attitudes. One explanatory theory for this is the theory of cognitive dissonance, which suggests that humans have a tendency of adjusting attitudes to conform to behavior patterns (Cooper, 2007). This increase in internal behavior potential makes it possible now for Alfa and Beta to further adjust their ecological niche and fit their everyday environments with less wasteful affordances (e.g., by altering

[5]In fairness, it should be acknowledged that cognitive dissonance could, at best, result in Alfa and Beta going through excess measures to recycle (i.e., adjust behavior to match values), although it is arguably more likely that they take the 'path of least resistance'. As Cooper (2007, 8) notes, 'the relative ease of changing one's attitudes rather than one's behavior has made dissonance more relevant to attitudes than to any other concept.'

the prevalence of certain products and appliances). This again reinforces their pro-environmental identities, and so on. Whilst the recycling example is a mundane one (and arguably a minor factor in the global ecological crisis), it is one of the more researched fields of PEB and therefore serves the purpose here to illustrate such cyclic systemic learning patterns. Steg and Vlek (2009, p. 312) note, accordingly with the logic of **Figure 1**, that the 'introduction of recycling facilities may result in more positive attitudes toward recycling (e.g., because it is more convenient), and positive attitudes may in turn result in higher recycling levels.'[6] Vining and Ebreo (1992, p.1604) research on recycling similarly concludes (inter alia) that increased recycling opportunities (implementation of curbside recycling) not only significantly increased recycling behavior but also led to an increase in positive 'global environmental' and 'specific recycling' attitudes, thus 'strengthening already positive environmental attitudes.' Guagnano et al.'s (1995) study also concluded that having a curbside bin increased pro-environmental recycling behavior (by reducing barriers between latent pro-recycling attitudes and action) and, importantly, awareness of the social and environmental consequences of recycling. Moreover, a similar feedback loop (or 'positive interactive cycle') has also been found by Kyttä (2003, p. 98, Kyttä, 2004) in studies on child-environment relationships: a child-friendly environment 'allows a positive interactive cycle to develop between a child and the environment' where 'actualized affordances for their part motivate the child to move around more in the environment, which creates more possibilities for new affordances to become actualized.'

Basically, we have here the potential for systemic leveraging, where by actualizing a sufficient number of pro-environmental affordances (by intervening with the strong and weak leverage points of **Figure 1**) we can reinforce the pro-environmental identities and motivations of populations, which again further spurs PEB and potentially even further spontaneous pro-environmental modulation of everyday environments. In such a case we can imagine the behavior system in **Figure 1** running smoothly, and to an extent self-reinforcingly, evolving over time toward more sustainable habits. For Reed (1996), the whole notion of culture arises from this kind of bootstrapping, where the agglomeration and proliferation of certain types of affordances forms a 'field of promoted action,' which spurs new practices, ideas/inventions and socio-cultural interactions. This is also known as the 'ratchet-effect,' or the notion that human socio-technological culture accumulates (often irreversible) modifications over time (Tomasello, 1999; Tennie et al., 2009). This 'cultural ratchet' of cumulative learning, of course, also involves the social dimensions of teaching, social imitation and norm conforming (Tennie et al., 2009). We are no longer dealing here with individual organism–environment relations, but rather a 'rich landscape of affordances' (Rietveld and Kiverstein, 2014) which promotes certain social practices (see Shove et al., 2012) and reinforces what Ramstead et al. (2016) have recently called 'shared expectations' or 'local ontologies' of a population (behaving in ways which others expect one to behave). These shared expectations and local ontologies are embodied at various levels from brain networks, cultural artifacts and constructed environments, which further reinforce enculturated practices (ibid.).

For instance, when enough people are incentivized to recycle and the built environment supports this behavior (i.e., recycling is systemically afforded), it becomes a normalized social and cultural practice, or a cultural affordance, where we expect others to expect us to recycle (see section "Object-Level Affordances" for a case example). A cultural affordance in this context refers to the possibilities for action which depend on the skillful leveraging of 'explicit or implicit expectations, norms, conventions, and cooperative social practices' (see Ramstead et al., 2016, 3; although more specifically, Ramstead et al. call this a 'conventional' cultural affordance). The principal lesson here for those involved with environmental policies is therefore that by actualizing, or locating and activating in large enough numbers what I have called systemic leverage points, the recycling case being only one of innumerable possibilities, we not only promote individual sustainable behaviors but also reinforce the emergence of sustainable pro-environmental sociocultural practices and hasten the transition toward a more sustainable culture. This implies that we are essentially helping our socio–ecological system to learn more sustainable habits. A central task for those involved with environmental policies therefore emerges as the need to redesign our ecological 'niche,' or 'designer environment' (Ramstead et al., 2016), so that its rich landscape of affordances systematically promotes pro-environmental behavior. In such an ecological niche, pro-environmental behavior would emerge in many respects as the path of least resistance and the default form of life.

That is not to say that these positively reinforcing feedback loops would go on forever, since they would eventually settle down to, or oscillate around, some relatively steady state, depending on the availability of affordances, or be disrupted by external forces. Moreover, a single feedback loop might not spill over to other PEB domains (e.g., from recycling to increased bicycling), or at least current research is very dubious as to whether or not this is the case: spillover effects have been reported to be both positive (PEB in one domain leads to a PEB in another) and negative, where, quite concerningly, PEB in one domain rebounds as a lack of PEB in another (Truelove et al., 2014). The case seems to be, though, according to Truelove et al.'s (2014, p. 132) meta-empirical review, that "those who engage in a PEB because their environmental identity has been activated will be likely to exhibit positive spillover because the participants' role will get reinforced and strengthened as the result of the initial decision." Contrarily, external coercing of PEB might have a converse effect. This suggests that we should particularly make our everyday environments afford sustainable actions that reinforce *pre-existing* latent pro-environmental internal factors,

[6]This is similar to the concept 'virtuous circle' (or 'foot-in-the-door') in social psychology. For example, children who perceive themselves as being generous because of a previous act of (even haphazard) generosity are more likely to continue to behave generously (Tavris and Aronson, 2015). This is predicted by the theory of cognitive dissonance: when someone behaves in a certain manner, they are likely to afterward self-justify the previous behavior in order to maintain consonance (Festinger, 1957). Sustainable behavior can lead to sustainable thinking (and vice versa) in a 'virtuous circle' or sustainable feedback loop.

making us perceive that we are (knowingly and willingly) acting in consonance with our pro-environmental identities and not enforced or coerced by external authorities to do so.[7] This is a relevant observation for environmental policies, where behavior interventions should particularly be implemented in domains where significant latent pro-environmental behavior potential (e.g., attitudes or knowledge) exist. Here, the provision of material environments which afford PEB has higher potential to lead to spillover effects and positive feedback loops in PEB. Moreover, since pro-environmental internal factors are, in many respects, pre-existing unutilized resources (as exemplified by the attitude–action gap), their actualization is also a cost-effective way of inducing pro-environmental behavior and habits.

Making the best use of affordances as leverage points is a fascinating opportunity for those involved in environmental policy and behavior interventions, although any applications must be preceded by a thorough understanding of system dynamics. Simplistic 'if-you-build-it-they-will-come' or 'one size fits all' policy approaches are insufficient for identifying leverage points (see Ostrom, 2010 for criticism on such top-down approaches), since affordances are transactional. To make the full use of these self-reinforcing feedback loops and sociocultural ratcheting processes, we need to understand *which* external structures complement a *certain* population's set of internal factors. This calls for local, decentralized and perhaps even participatory policy approaches, where local behavior potentials (internal and external) are thoroughly charted before the implementation of behavior change strategies. This also a political reasoning for not defining affordances as uniform 'properties' of things or environments, since physical environments can afford environmentally significant behavior patterns very unequally. Affordance theory takes on a very political nature here, and must be particularly sensitive toward socioeconomic factors and behavior capabilities. Firstly, individuals might have variety in their ability to utilize affordances and transform resources into valuable activities. Second, the distribution of environmentally significant affordances might be fundamentally unequal between local populations and socio-economic groups (see the 'capability approach' of, e.g., Sen, 1995 for similar arguments). For instance, targeting costly information campaigns or 'blaming strategies' at non-recycling low-income families might be unfairly patronizing if recycling affordances are scarce to begin with (Jackson, 2005, p. 54). Moreover, 'fetishizing' actions such as recycling – to which less fortunate populations might have less affordances – at the expense of letting 'political minefields' such as air travel off the hook is certainly questionable on moral and political grounds (see Capstick et al., 2015).

Therefore, affordance theory seems to quite naturally call for polycentric (Ostrom, 2010), local and inclusive governance which understands the behavior potentials (internal and external) of local populations and encourages, facilitates and guides local populations to act accordingly with their latent pro-environmental attitudes. Indeed, participatory problem solving of this kind has also been claimed to reduce helplessness (since it helps people understand and explore problems) and thus induce sustained and long-term pro-environmental behavior (Kaplan, 2000; see Jackson, 2005).

Applied Affordances

I have stated above that socio–ecological systems, everyday environments included, are thoroughly infused with affordances. To comprehend the full potential of affordances in environmentally significant decision-making, it is worth explicating how diverse the analysis and leveraging of affordances can be. Here, scalability and adaptability are what truly make a theory of affordances stand out from other theoretical models.[8] Since affordances are systemic relations, an affordance is a scalable heuristic applicable to whatever system we are interested in observing. We can therefore choose to analyze affordances from a nested order of systems (Gibson, 1979, see also Ostrom, 2005). This systemic nature of affordance theory makes it an incredibly versatile analytical tool, basically applicable to any area of interest of environmental policy. Consider, for example, how we could choose to study affordances related to (1) objects and everyday items, (2) households (3) urban environments or (4) socioeconomic systems, and how this can inform us about potential leverage points for environmental policy intervention. These adaptations of affordances are briefly discussed below with affordance-relative case studies.

Object-Level Affordances

Physical objects are perhaps the most intuitive of affordance-relatable entities. As was the case in this article, introductions to affordance theory usually begin with imagining what functions objects afford for humans. It comes then as no surprise that affordances of objects have been studied with quite some detail, particularly by the design community. For instance, in recent years several authors have published under the umbrella-term of 'design for sustainable behavior,' which (often drawing on the work of Norman) study how objects afford pro-environmental behavior and how variables such as understandability, ease of use and functional meaningfulness affect sustainable product use (see e.g., Lockton et al., 2008; Bhamra et al., 2011; Lockton, 2012; Selvefors, 2017). Often, though, affordances are in this context generally defined merely as properties of objects, a conception against which I have argued in this text (in favor of affordances as systemic animal–environment relations, see section "A Theory of Affordances").

[7] A complicating factor here is that it seems that high-cost PEB is more likely to promote positive spillover PEB than low-cost behavior (Truelove et al., 2014). This makes sense from a cognitive dissonance perspective: when a person is highly invested in one practice, they are likely to self-justify other similar behavior (Cooper, 2007; Tavris and Aronson, 2015). The question for policy-makers remains: how can people be supported to act in consonance with action they perceive as high-cost?

[8] From other theoretical frameworks possibly relatable to affordance theory, I can think of at least Giddens (1984) structuration theory, Lewin's (1951) field theory, Sen's (1995) capability approach, practice theory (e.g., Bourdieu, 1990 and Shove et al., 2012), Paul Stern and colleague's (Guagnano et al., 1995; Stern, 2000) attitude–behavior–context model, nudge theory from behavioral economics (Thaler and Sunstein, 2008) as well as the whole discourse on ecosystem services (see e.g., Danley and Widmark, 2016).

A great example of objects affording sustainability can be found in the Finnish bottle deposit-refund system, where each bottle or can sold is placed with a deposit ranging from 10 to 40 cents added to the beverage's retail price (PALPA, 2017). The system gives consumers monetary incentive to recycle, since the deposit is refunded when bottles and cans are returned to stores and kiosks. The bottles afford a visual prompt for recycling (overcoming the Gulf of Evaluation), and recycling points are abundant (crossing the Gulf of Execution, since each store that sells deposit-items is required to also receive them).

Technically speaking, it is not the bottles and cans alone which afford recycling here, but rather both the objects and the whole recycling system they are embedded in. However, it is clear that 'recycling' has become a prominent affordance (functional meaning) which consumers perceive when encountering a bottle or can in the Finnish culture. The deposit system has been hugely successful, with the recycling rate of bottles and cans ranging from 89 to 98%. Arguably, a point has also been reached where the recycling system reinforces shared expectations and social practices (in other terms, recycling has become a social or cultural affordance), whereby deviations from this norm are considered unacceptable (circa 90% of the population sample self-reportedly always/often recycle bottles and cans; Blom et al., 2010). However, I suspect the pro-environmental affordance-potential is not used to its full capacity in this case, since feedback from recycling mainly concerns monetary benefits, and to a much lesser extent environmental welfare.

Household Affordances

Abrahamse et al. (2007) acknowledge in their study on energy consumption behavior, households are responsible for a highly significant portion of greenhouse gas emissions, and domestic environments should therefore be considered an important target group for behavior change interventions. The authors (Abrahamse et al., 2007, p. 266) note that whilst knowledge itself predicts pro-environmental behavior rather poorly, tailored information and feedback as well as feedforward (in the form of goal setting) can be effective strategies for encouraging energy conservation. This is particularly the case with continuous electronic feedback, made possible by digitalized energy systems. In Abrahamse et al.'s (2007) study, experimental groups were given access to an online website with information on energy consumption and related ecological problems, along with a list of tailored energy-saving measures and an online tool which could calculate relevant and practical energy-saving means. Basically, the tool gave simple and comparative feedback and feedforward on how to reach the intended goal of 5% energy consumption reduction. The 5-month long intervention resulted (among a variety of other interesting findings) in the experimental groups lowering their direct (gas, electricity and fuel) energy consumption by 8.3% as opposed to the control group, whose direct energy consumption increased by 0.4% (although indirect energy consumption was not affected nearly as strongly as direct energy use).

This would suggest, although the authors do not discuss the results in terms of affordances, that when household energy systems are designed to afford sustainable behavior (in this case, by crossing the Gulf of Evaluation), they have the potential to significantly strengthen pro-environmental behavior patterns. Importantly, as opposed to a control group, the intervention also resulted in heightened energy conservation knowledge within the experimental groups, signaling potential for a sustainable feedback loop, where not only heightened explicit knowledge but also tacitly acquired practical 'know-how' would further increase the ability to adopt more sustainable consumption habits (see Darby, 2006). Affordance theory also implies that the intervention would have likely been even more effective had the Gulf of Execution and Evaluation been crossed more efficiently: instead of using a website (which must be accessed with significant intent) the information could be ready-to-hand[9] at a constantly visible location within the household (e.g., an interactive LCD-screen). With the dawn of smart energy systems in digitalized domestic environments, such high pro-environmental affordance systems could become mainstream in the near future. This is potentially a big step forward from current electric billing, which affords sustainable energy consumption behavior particularly poorly due to technical and rare (e.g., quarter-yearly) feedback and lack of prompts regarding how to change behavior.

Urban Affordances

Marcus et al. (2016) explicitly discuss affordances in the context of urban design. The authors note that 'most approaches to sustainable urbanism still share the conception of the humans–environment relations that characterized modernism' and therefore do not emphasize the dynamical systemic properties of urban environments. Instead, affordances could form the core of a 'new epistemological framework of the human–environment relation in sustainable urbanism' (Marcus et al., 2016, Abstract, 440). Against the backdrop of the Cartesian human–environment dualism implicit in much of urban design, we should rather advocate a dynamical and interactive two-way understanding of the relations between humans and the urban environment. Marcus et al. (2016, p. 445), in fact, go as far as recognizing that 'cities, as the physical objects we generally envision them to be, are also cognitive objects, that is, they are not something only out there but also a type of extensions of the human mind.' As noted above, such 'extended cognition' follows naturally from a dynamical systems understanding of affordances (Chemero, 2003, 2009; Rockwell, 2005; Anderson et al., 2012).

The transactional nature of affordances suggests that, when designing urban environments, local attitudes and interests should also be charted in an inclusive and even participatory

[9]The Heideggerian notion of ready-to-handedness (see Heidegger, 1927/1978) is often implicit in ecological psychology (see e.g., Chemero, 2013). Being 'ready-to-hand,' very briefly, implies that an object 'is for' (or affords) the achieving of some function without the need for theorizing or other analytical activities. For those familiar with behavioral economics, particularly nudge theory (Thaler and Sunstein, 2008) and Kahneman's (2011) dual system approach, there is something inherently System 1 (fast, automatic behavioral processes) in ready-to-handedness.

process. In other words, affordances "cannot be imposed by expertise themselves but need to consider the 'meanings' of the local community" and "cannot be implemented as abstract 'demands' but have to cognitively engage and motivate people, even if on a low key" (Marcus et al., 2016, p. 443). Kurz (2002, p. 273) supports this idea by noting that financial rebates on public transport systems are not sufficient if, for example, people are more attuned to the social status their private vehicles afford them with. Interestingly, Kurz's notions on public transport are supported by a study by Hunecke et al. (2001), which suggests that an additive 'economy-plus-moral' (subway fare plus normative ecological orientation, i.e., external plus internal) formula best determines public transport travel choice in urban environments. As discussed extensively above, environments do not afford pro-environmental behavior alone, but always in relation to human abilities and motivations.

Marcus et al. (2016, p. 446) also cite their previous work (Giusti et al., 2014) to highlight the importance of green urban affordances. The provision of green affordances (accessibility to urban nature in Stockholm) for preschool children was shown to lead to increased ecological knowledge and impact awareness, as well as strengthened emotional connection with nature. These internal factors, again, could be termed as further latent potential for pro-environmental behavior. In this respect, urban environments can ratchet cognitive processes: by redesigning urban environments to reinforce sustainable affordances (e.g., accessibility to nature), we can promote a wealth of pro-environmental identities and habits, which may over time reinforce the transition toward a culture of sustainability.

In fact, the notion of the affordance could be extended to include a whole socioeconomic system. This goes far beyond the scope of this article, but (e.g., Sen's, 1995) capability approach has elaborated a very similar idea, where abstractions such as 'equality' and 'freedom' are assessed as the actual capabilities (which relate to both individual physical abilities, or 'functionings', and the system's distribution of action opportunities) of human-beings. In other words, even concepts such as freedom, justice, equality can be assessed in terms of functionally meaningful human–environment relations (where the environment, of course, includes social, cultural and economic determinants).

CONCLUSION

> 'There is only one world, however, diverse, and all animals live in it, although we human animals have altered it to suit ourselves. We have done so wastefully, thoughtlessly, and, if we do not mend our ways, fatally' (Gibson, 1979, p. 130).

Affordance theory, as presented in this paper, studies the dynamics of organism–environment systems and their evolution over time. In this context, internal and external behavior antecedents should not only be studied as interdependent entities, but as a single, non-decomposable, evolutionary system (**Figure 1**). In this respect, affordance theory particularly helps us understand the ecology of environmentally significant behavior. It has been proposed in this paper that those involved with environmental policies adopt affordance theory as a guiding heuristic for the design and implementation of pro-environmental behavior change interventions. Several reasons exist to as why this should be the case:

(1) Affordances can be understood to represent leverage points for systemic behavior change interventions, since their actualization can lead to large and self-reinforcing shifts in environmentally significant behavior. Affordance theory, as a dynamical systems approach, can therefore guide us to conceptualize and identify leverage points which can help individuals and socio–ecological systems to learn more persistent sustainable habits. This second-order change (helping the system learn) not only solves particular individual problems, but also forms habits which apply to the solution of classes of problems (Bateson, 2000, p. 274).
(2) By identifying and activating pro-environmentally significant affordances in large enough numbers, we can induce positive feedback loops (**Figure 1**), where, for instance, changes in the material environment reinforce pro-environmental identities and promote pro-environmental sociocultural practices (which again can lead to further modulation of the socio-material environment, and so on). The reinforcement of these feedback loops can further serve to normalize pro-environmental habits as socio-culturally and materially embodied practices.
(3) Affordance theory, as an ecological approach to behavior analysis, helps us conceptualize and understand the lack of fit between internal and external behavior antecedents. Focus in policy interventions should be particularly directed to domains where mismatches between internal and external factors exist. One exemplary case is the widely prevalent attitude–action gap, where latent pro-environmental internal factors pre-exist but are not yet actualized due to lack of affordances. The actualization of pre-existing pro-environmental internal factors is also more likely to lead to positive spillover effects than other interventions (Truelove et al., 2014), making it a particularly important leverage point.
(4) Affordance theory is a particularly useful and versatile conceptual framework for policy interventions, since it is, due to its systemic and nested nature, applicable to practically any environmentally relevant policy-arena from the sustainable design of objects and households to urban environments.

This, I believe, presents us with a conceptual framework for a systemic *mending of our ways* (in reference to Gibson above) toward a sustainable future, where pro-environmental behavior would emerge as a default path of least resistance and form of life. Moreover, affordance theory has the potential to be a participatory approach at that. A thorough understanding of latent local behavior potential seems to call for participatory and decentralized policy-making, with heightened understanding of locally embedded meanings and local environments. This also has the potential to increase the social and political acceptability

of behavior change interventions (which 'nudge' interventions, in particular, have struggled with, see e.g., Hukkinen, 2016) and reduce helplessness in local populations. Whilst this mending of our ways is by no means an easy task (and much is left to be studied in how pro-environmental feedback loops can be practically implemented) and not perhaps the radical systemic change some commenters seem to call for (see e.g., Capstick et al., 2015), there are reasons to be optimistic that little strokes fell great oaks. After all, any organism–environment system is necessarily infused with affordances, and by mending affordances toward a self-reinforcing, less wasteful and thoughtless, direction there is hope that our socio–ecological system will ultimately take a sustainable turn.

AUTHOR CONTRIBUTIONS

RK made sole contribution to the conception and design of the work. RK drafted the work and revised it critically for important intellectual content. RK agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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A Framework to Assess Where and How Children Connect to Nature

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The design of the green infrastructure in urban areas largely ignores how people's relation to nature, or human-nature connection (HNC), can be nurtured. One practical reason for this is the lack of a framework to guide the assessment of where people, and more importantly children, experience significant nature situations and establish nature routines. This paper develops such a framework. We employed a mixed-method approach to understand what qualities of nature situations connect children to nature (RQ1), what constitutes children's HNC (RQ2), and how significant nature situations and children's HNC relate to each other over time (RQ3). We first interviewed professionals in the field of connecting children to nature ($N = 26$), performed inductive thematic analysis of these interviews, and then further examined the inductive findings by surveying specialists ($N = 275$). We identified 16 qualities of significant nature situations (e.g., "awe," "engagement of senses," "involvement of mentors") and 10 abilities that constitute children's HNC (e.g., "feeling comfortable in natural spaces," "feeling attached to natural spaces," "taking care of nature"). We elaborated three principles to answer our research questions: (1) significant nature situations are various and with differing consequences for children's HNC; (2) children's HNC is a complex embodied ability; (3) children's HNC progresses over time through diverse nature routines. Together, these findings form the Assessment framework for Children's Human Nature Situations (ACHUNAS). ACHUNAS is a comprehensive framework that outlines what to quantify or qualify when assessing "child-nature connecting" environments. It guides the assessment of where and how children connect to nature, stimulating both the design of nature-connecting human habitats as well as pedagogical approaches to HNC.

Keywords: assessment framework, child-nature-connectedness, human-nature connection, significant nature situations, nature routines, sustainable urban design, environmental education, mix-method approach

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INTRODUCTION

Academic discourse is increasingly focused on how people see themselves in relation to nature (Ives et al., 2017). In the last few decades, academic interest in human-nature connection, or HNC, has spread from evolutionary explanations (Kellert and Wilson, 1993), to psychological constructs like ecological identity (Naess, 1973), nature relatedness (Nisbet et al., 2008) and inclusion with nature (Schultz, 2002), and across the scholarships of environmental and conservation psychology (Saunders and Myers, 2003; Gifford and Nilsson, 2014; Zylstra et al., 2014), landscape management

(Lewicka, 2011; Meyfroidt, 2013), biological conservation (Miller, 2006; Simaika and Samways, 2010), and more recently urban design (Andersson et al., 2014; Marcus et al., 2016; Colding and Barthel, 2017). Despite the heterogeneity of approaches, this body of literature consistently reports two trends. First, a set of values and beliefs facilitates pro-environmental choices and behaviors (Black et al., 1985; Guagnano et al., 1995; Stern, 2000; Hunecke et al., 2001; Thogersen, 2005; Kaiser et al., 2011). Second, a deep-seated HNC is nurtured by direct nature interaction during childhood (Chawla, 1998, 1999; Kahn, 2002; Evans et al., 2007; Hsu, 2009) and is remarkably stable in adulthood (Kaiser et al., 2014). These two trends highlight the importance of early nature experiences in shaping psychological traits of HNC, and suggest that HNC has a role to play in the transgenerational establishment of sustainable futures (Matsuba et al., 2012; Conrad, 2017).

Approaches to sustainability science that analyze social-ecological systems have broadly discussed a shared societal mindset of connection to nature (Folke, 2006; Folke et al., 2011; Díaz et al., 2015; Fischer et al., 2015). In this line of research, social and ecological dynamics are conceptualized as components of a single integrated system in which structure, goals, and overall trajectory are shaped by society's mindset (Meadows, 2008). The encompassing concept of HNC has, therefore, been considered the strongest leverage point to transform or transition a social-ecological system toward a desirable, resilient, and sustainable future (Abson et al., 2017). It follows from all the considerations above that direct experiences of nature during childhood are fundamental moments of sustainable enculturation, with long-lasting consequences for sustainable social-ecological systems. Considering how the physical living environment of humankind, i.e., the human habitat, provides nature experiences for children is therefore a crucial step toward reaching sustainable developmental goals.

In 2014, 54 percent of humankind lived in cities, and by 2050, 66 percent of the world's population is projected to be urban (United Nations, 2014). Cities are, and increasingly will be, the most common human habitat. The urban green infrastructure, or its absence, will, therefore, be the leading background of children's direct experiences of nature. In this built landscape children will experience what nature is, what it is made of, how it works, and eventually create expectations for what nature should be in the future (Kahn, 2002). So, the obvious question to ask is: "is the urban nature designed to nurture children's HNC?" The short answer is no. Contrary to the standards advocated by the UN New Urban Agenda of "universal access to safe, inclusive and accessible, green and public spaces" (General Assembly, 2015, 22) the urbanization process largely ignores the design of nature experiences with measured penalties for public health (Lederbogen et al., 2011; Bratman et al., 2012; Hartig and Kahn, 2016), personal development (Chawla, 2015; de Keijzer et al., 2016), and the emotions, attitudes, and behaviors that define HNC (Giusti et al., 2014; Soga and Gaston, 2016). The absence of nature experiences in the human habitat is so severe that is also referred to as "extinction of experience" (Pyle, 1993) and it is an active concern in environmental education (Finch, 2008), environmental conservation (Miller, 2005; Samways, 2007; Simaika and Samways, 2010) and public health alike (Soga and Gaston, 2016). Overall, the urban space is far from being a human habitat that promotes a connection between its inhabitants and nature.

Two interlinked obstacles that hinder the design of "nature-connecting" human habitats come from an ontological separation between mind and body in modern urban design (Metzger, 2013). First, the dominant model of urban design is characterized by the top-down implementation of body functions, such as housing, working, recreation and transportation (Le Corbusier, 1943; Cities European Council of Town Planners, 1998). However, this linear and compartmentalized approach to urban living fails when challenged to address social and psychological requirements such as livability or HNC (Gehl, 2010; Portugali, 2011; Marcus et al., 2016). Modern urban design does not structure the relation between humans and environments beyond its material facets (Marcus et al., 2016; Samuelsson et al., 2017). Second, there are no tools to identify if the green infrastructure connects people to nature or not, nor to quantify or qualify where "extinction of experience" happens. There are indeed no standard criteria or guidelines to assess or categorize an environment as more or less "nature-connecting." As a consequence, there is no possibility to even conceive what "connecting" environments could be or should look like in the design process. Questions like "where do people connect to nature?" and "what kind of 'connecting' nature experiences are missing from cities?" are fundamental to design green infrastructure that connects people nature, but they cannot be answered yet. The overarching purpose of this paper is to address this shortcoming.

In this paper we aim to develop a practical framework that defines criteria and guidelines that allow users to assess if an environment connects children to nature or not. We have been inspired by Heft's (1988) seminal work, in which he identified sets of suitable relations between children's behaviors and outdoor environments that have been consequently used to assess if an environment is more or less "child-friendly" (Kyttä, 2002, 2006). In support of this aim identify which sets of relations can categorize an environment as more or less "child-nature-connecting." Classifying an environment as more or less child-friendly relies on quantifying or qualifying an environment using lists of behavioral and social criteria that are suitable for children. As of yet, a similar list of criteria to assess environments that nurture children's HNC does not exist. This paper fills this gap. Rephrasing the definition of the "obesogenicity" property of an environment (Swinburn et al., 1999), we define here "child-nature-connectedness" as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting human-nature connection in individuals or populations of children." In other words, the properties that allow a social-ecological system to connect children to nature. The goal of this paper is, therefore, not to provide a tool that prescribes *how* to measure child-nature-connecting environments, but a framework that outlines the list of criteria of *what* ought to be measured. We note that in order to provide a useful framework any list of criteria should be sufficiently comprehensive of all relations

that indicate children's HNC; transferable across different children and cultures; and of practical use for practitioners and researchers to identify where and how children connect with nature. Thus, we develop and test the framework for these properties to initiate the design of nature-connecting human habitats and inform educational programs that aspire to connect children to nature.

In the next section, we present the theoretical overview of HNC and the "child-nature-connecting" property of environment. We provide an overview of the concepts used and the three research questions in section Overview of Concepts and Research Questions. We then outline the methodology of this mixed-methods investigation, which involves an initial qualitative and inductive phase that informs a quantitative and testing phase. We then present the results and critically discuss them in relation to the goal of the paper.

AN EMBODIED APPROACH TO HUMAN-NATURE CONNECTION AND CHILD-NATURE-CONNECTEDNESS

Despite an exponential growth in research on HNC in the last decade epistemological and ontological differences prevent the development of an instrument to assess child-nature-connectedness of environments using the existing literature. For example, HNC has been experimentally studied as an independent attribute of the mind, qualitatively observed and described through nature experiences elsewhere, and also investigated as a relationship between people and specific geographical locations (Ives et al., 2017). These co-existing bodies of literature are somewhat complementary, but unsuitable for comparison or integration with each other because of their fundamentally different epistemological traditions (Ives et al., 2017). For instance, "connectedness to nature" (Schultz, 2002; Mayer and Frantz, 2004), "nature relatedness" (Nisbet et al., 2008), and "environmental identity" (Clayton, 2003) are central conceptualizations of HNC in environmental psychology, but they can be difficult to unify with evolutionary conceptualizations of HNC (Kellert and Wilson, 1993; Beery et al., 2015) or theories of sustainability transformation (Manfredo et al., 2014; Abson et al., 2017). Additionally, the ontological nature of such literature presents further challenges to identify the important criteria of child-nature-connectedness.

Despite a variety of research approaches in HNC, the majority of studies operationalize a disembodied ontology of HNC, in which contextual factors are independent and often dismissed objects of investigation. An indication of the widespread use of such disembodied ontologies is that even though most studies specifically evaluate some form of personal HNC, the vast majority do not define what kind of nature people tend to connect to (Ives et al., 2017). Existing research has mostly investigated HNC as cognitive abstractions and attitudinal attributes, using an experimental approach that mostly ignores the role of people's body, culture, and environmental context (Gifford, 2014; Zylstra et al., 2014; Restall and Conrad, 2015; Lumber et al., 2017). Different disembodied conceptualizations of psychological HNC (Mayer and Frantz, 2004; Perrin and Benassi, 2009) have indeed been shown to be overlapping (Tam, 2013; Restall and Conrad, 2015) and with limited assessment capacity in real-world situations (Duffy and Verges, 2010; Ernst and Theimer, 2011; Bruni et al., 2015). Some have suggested that this limited capacity for real-world assessments derives from socio-physical de-contextualization (Duffy and Verges, 2010; Meyfroidt, 2013; Beery and Wolf-Watz, 2014; Restall and Conrad, 2015). A distinctive example of how de-contextualization affects real-world assessments is from two studies that used the same experimental design and methodology to assess "connectedness to nature" in two different locations and attributed opposite results to climate differences (Verges and Duffy, 2010; Bruni et al., 2012). The existing empirical evidence produced by disembodied conceptualizations of HNC and experimental approaches is often a deductive testing of theoretically-prompted concepts, and, therefore, has limited usefulness to construct a practical framework of assessment, which we aim to develop in this paper.

Limitations of disembodied operationalizations of HNC can be also found in environmental education. Since its inception with the Tbilisi declaration in 1977, a key goal of environmental education has been "to search for a new ethic based on respect for nature" (UNESCO, 1978, 28). However, the disembodied separation between body and mind assumed in environmental education has favored curricula that abound in ecological knowledge, but ignores practical skills and social circumstances (Hungerford et al., 1980). Despite environmental knowledge being widely available and promoted, children's experiences in nature has never been so rare (Soga and Gaston, 2016) and the ecological crisis never been so obvious. Environmental educators such as Nazir and Pedretti (2016) also recognized these limitations when they write:

> "*For some time now, researchers and practitioners in the field of environmental education have been recommending a shift away from a focus on cognitive knowing about the environment toward raising peoples' environmental consciousness in deep and substantive ways (see, e.g., Gough, 1987; Gruenewald, 2004; Kahn, 2008; Bowers, 2009; Wals and Dillon, 2013). Bai and Romanycia (2013, 105) suggest that environmental consciousness raising is really about [. . .] making ecological principles into habits of mind, body and heart [. . .] creating spaces for multiple, meaningful interactions to take place (Wals and Dillon, 2013) and providing contextual embodied experiences (Greenwood, 2013)" (p. 288, 301).*

To overcome the limitations shown above and investigate the criteria needed to assess child-nature-connectedness we then reject an ontological separation between mind and body and operationalize a relational, or transactional (Altman and Rogoff, 1987), approach based on affordance theory (Gibson, 1979) called embodied ecosystem (Raymond et al., 2017). The theory of affordances is a relational approach to human perception and behavior posited by Gibson (1979) that is defined by the relations that exist between humans' abilities and the features of the environment (Chemero, 2009). Traditionally, affordances have been assessed from a functional standpoint while ignoring

the emotional dimensions that act as the motivational basis for action (Kyttä, 2003). A renowned example of this is Heft's (1988) list of children-outdoor relations mentioned above that inspired this research. However, *"Gibson hardly wanted to divide the world up into material, social, or cultural worlds, as he was against all division of environmental experience"* (Kyttä, 2002, 76) and in recent times we have seen attempts to include emotional (Roe and Aspinall, 2011) and social affordances (Kyttä, 2006) in assessment models of human-environment relations (Kyttä, 2006; Broberg et al., 2013). One of the latest formulations of affordance-based theory is the concept of embodied ecosystem, which highlights the relational values of ecosystems that dynamically emerge by the sets of relations existing between mind, body, culture, and environment (Raymond et al., 2017). By adopting the concept of embodied ecosystem in this research we move away from the identification of single measures of HNC abstractions. This ontological choice allows us to fully embrace the complexity of HNC, grasp the diversity of "connecting" nature experiences that might influence it, and appreciate how the relations between children's HNC and nature experiences jointly unfold across temporal, environmental, and cultural contexts.

OVERVIEW OF CONCEPTS AND RESEARCH QUESTIONS

We use the term *significant nature situations* (SNS) here, instead of "connecting" nature experiences for two reasons. The first reason is to be coherent with existing literature. *Significant* nature experiences have long been used in the literature to denote those life experiences that "connect" people to nature (Tanner, 1980; Chawla, 1998, 1999, 2006; Stern, 2000). Second, we use *nature situations*, instead of nature experiences, to be consistent with the embodied ontological approach described in section An Embodied Approach to Human-Nature Connection and Child-Nature-Connectedness.

In order to create a framework to assess child-nature-connecting environments, we first need a list of criteria to identify what a significant nature situation is, and distinguish it from a non-significant one. It is self-evident that not all nature situations are equally significant to promote children's HNC. For example, climbing a tree influences children's HNC differently than climbing a cactus. It is, however, unfeasible to use a list of all nature activities that can possibly promote or hamper children's HNC to distinguish a significant nature situation from a non-significant one. Such list would be an endless catalog of all possible interactions with nature, including indoor and virtual ones (Kahn et al., 2009). Instead, we need to identify what are the distinguishing *qualities* reoccurring across different nature situations that connect children to nature. In other words, we first need to identify the *qualities of significant nature situations*. If we assume for example that "enjoyment" is a hypothetical quality of SNS, and that enjoyment can be assessed while a child climbs a tree, then it means that the child is in a nature situation significant for developing her HNC. Also, it is likely that such a nature situation will change how she will perceive climbing trees in the future. Thus, a framework to inform the assessment of significant nature situations has to include qualities of SNS as much as their relation to children's HNC over time. There are, therefore, three crucial components required for an assessment framework: it should identify what the qualities of SNS are; what constitutes children's HNC; and provide an indication of their relation over time. Consequently, we ask the following research questions:

RQ1. What are the qualities of significant nature situations?
RQ2. What constitutes children's human-nature connection?
RQ3. How do qualities of significant nature situations and children's human-nature connection relate to each other over time?

METHODOLOGY

Since the goal of the paper is to define a framework useful to assess child-nature-connectedness of environments we adopted a "sequential exploratory research design for instrument development" (Creswell and Clark, 2007). As in our case, this mixed-method methodology was required to develop and test an instrument of classification that is not yet available (Creswell and Clark, 2007). The empirical work is characterized by two sequential phases. In phase 1 (qualitative), we performed semi-structured interviews with a pool of professionals in the field of connecting children to nature to inductively unveil the qualities of SNS (RQ1), what constitutes children's HNC (RQ2), and how qualities of SNS and children's HNC relate to each other over time (RQ3). In phase 2 (quantitative), we tested the results of phase 1 with an online survey that we distributed among a broader pool of professionals in the field of connecting children to nature. Here, we examined the results for comprehensiveness, transferability, and practicality and further explored the relations between qualities of SNS and children's HNC.

Why a Focus on Professionals' Expertise?

Practitioners that aim to connect children to nature are an international and very heterogeneous group of specialists who have developed the ability to design, perform, and assess nature-based activities for children throughout their professional careers. We chose to focus on these professionals because their practices, outlooks, and educational strategies are directly based upon a holistic understanding of children's HNC. Our research is therefore based on professionals from a diverse number of organizations and from a wide array of countries. Tapping into their expertise ensured comprehensiveness of different approaches and intents, sufficient transferability across children's ages and groups, and practical usability for a wide audience of actors.

Additionally, focus on professional expertise aligned the methodology of this investigation with the relational ontology of embodied ecosystems. Understanding which qualities distinguish significant nature situations from non-significant ones requires the observation of children's HNC as it unfolds in their actions, or changes over long periods of time. Professionals who observe children daily are capable of recognizing these

patterns of change. We therefore relied on decades of professional observations and insights, rather than attempting an inevitably partial and potentially theoretically biased observation ourselves.

Phase 1: Identification of HNC and Qualities of SNS

We used semi-structured interviews to question practitioners ($N = 26$; male = 5; female = 21) in the field of connecting children to nature in two consecutive steps. The first pool of practitioners ($N = 11$) was chosen to represent a wide range of professional competencies and complementary conceptualizations of children's HNC. A second set of practitioners ($N = 15$) was selected from within a Swedish organization of nature preschools ("I Ur och Skur") whose outdoor-focused pedagogical approach has contributed to increase interest and attachment to nature in young children through direct nature interaction since 1983 (Westerlund et al., 2016). With this second pool of interviewees (see Svane, 2017 for full report) we questioned, clarified, and deepened previously acquired information. All interviewed practitioners had between 5 and 40 ($M = 18$) years of expertise in the field so we refer to them in the paper as "professionals." All interviewees provided informed consent prior to the interview. The interviews lasted 50 min on average and followed interview guidelines that covered the three main areas of interest identified by the RQs: what constitutes a "connecting" nature experience for children, what the traits of a connected child are, how children's HNC changes over time. The interviews were recorded, transcribed, and coded using Atlas.ti. Inductive coding was performed for all interviews following the systematic process for thematic analysis described by Braun and Clarke (2006).

The resulting themes denoting qualities of SNS (RQ1), children's HNC (RQ2), and their relationship over time (RQ3) were discussed between researchers and interpreted according to the objectives and the relational approach of the paper. We differentiated between themes when they were critically dissimilar and aggregated them when their differences were only of terminological nature. For example, when resulting themes were positive or negative manifestations of the same concept we aggregated them into an overarching theme. When the resulting themes were overlapping we highlighted their diversity whereas for nested themes we retained the most general. These inductive results were used to formulate the criteria of the assessment framework, which were then examined further by additional professionals using an online survey in phase 2.

Phase 2: Examining Phase 1 Results for Comprehensiveness, Transferability, and Practicality

The online survey was developed following the process identified by Artino et al. (2014) to design high-quality survey scales. With the survey, we tested the criteria obtained from phase 1 and examined their comprehensiveness, transferability, and practicality. The survey was composed of four pages. The first page provided information about the study and survey, and ensured that all respondents gave informed consent for us to anonymously utilize the results for research purposes. The second page asked professionals for some descriptive information (e.g., number of years of professional experience in the field, the age of the children they work with). The third page addressed relevance and comprehensiveness of the constituents of children's HNC obtained in phase 1. First, participants were asked if each constituent indicated some form of children's HNC using a five-point Likert scale from "strongly disagree" to "strongly agree." Professionals were then asked how comprehensive the list of *all* possible constituents of children's HNC was, and subsequently asked to rank all the constituents from the one children learn first to the one children learn last (hereinafter called *ordering exercise*). The fourth page examined the practicality and potential transferability of these constituents across a multitude of actors. In this exercise, we asked respondents to choose one constituent of children's HNC, to state a nature activity they perform in their everyday work to significantly nurture that constituent, and then to assess the reported significant nature activity rating how important each quality of SNS obtained in phase 1 was on a five-point Likert scale ranging from "not important" to "essential" (hereinafter called *assessment exercise*). Professionals were then asked to perform the same assessment exercise for another constituent of children's HNC, and were allowed to further perform it a third time.

We chose the number of questions (14 were compulsory) in the survey to be practical and simultaneously adequately comprehensive to capture the complex essence of children's SNS and HNC. We favored simple English vocabulary to suit the intended international audience of professionals working with children's HNC. Prior to releasing the survey, we conducted expert validation with four colleagues for content validity; eight cognitive interviews with additional professionals in the field for response process validity; and performed two phases of pilot testing (Artino et al., 2014). These practices ensured that the professionals responding to the survey understood and interpreted the final version of the questions and items correctly. The survey was individually emailed to professionals in the field of connecting children to nature in several countries. In addition, we also asked participants for further contacts.

We used R software for the analysis of the data. Specifically, the package *stats* and *likert* for the statistical analysis, the *daisy* function with Gower's coefficient for the analyses of dissimilarity, and the *agnes* and *hclust* functions of the package *cluster* for hierarchical clustering and dendrogram construction.

RESULTS

Descriptive Analysis of Survey Respondents

The 275 respondents of the survey were from more than 200 different organizations. These organizations included primary, secondary and high schools, forest and gardening schools,

national parks, local and national organizations of environmental conservation, municipalities, and international organizations devoted to the cause of connecting children to nature. These organizations and schools were located in Sweden, Finland, Netherlands, US, England, Australia, Canada, Colombia, New Zealand, Scotland, Wales, Spain, Norway, Northern Ireland, Belgium, Mexico, Malaysia, India, Indonesia, Austria, Estonia, and Portugal. Only the data from respondents that had stated that connecting children to nature is either "very important" ($N = 57$) or "essential" ($N = 218$) for their profession were analyzed. This resulted in the removal of only 7 respondents suggesting that the survey was correctly targeted. Of all respondents 93% had at least 3 years of professional experience in the field of connecting children to nature ($M = 15.5$, Mdn = 12, max = 50, $SD = 11$), so, as with the interviewees in phase 1, we considered the respondents of the survey "professionals" in the field. Additionally, their heterogeneous professional competencies and institutions covered the full-spectrum of potential insights into what SNS are. Most professionals worked with several age groups at the same time. Only few respondents (13%) worked with the age group "0 to 1 years old," 37% worked with "2 to 3 years old," most of them (80%) worked with the age group "4 to 7 years old," while 53% worked with "8 to 11 years old," and 34% worked with "12 to 18 years old."

The results from the interviews and survey are presented below alongside each other according to the research question they jointly explored and tested.

RQ1: What Are the Qualities of Significant Nature Situations?

From the inductive analysis of interviews with professionals we obtained a list of qualities that characterizes a nature situation with the potential to connect children to nature; that is, we identified the qualities of SNS. Hence, a SNS for children is characterized by one or more of the qualities listed in **Table 1**.

During the assessment exercise in the survey, professionals reported 399 significant nature activities. These significant nature activities were often as simple as "pond dipping," "lighting a fire," "bug hunting" and "playing in the forest and parks," but sometimes they were more complex; for example, "group sessions to talk about the permaculture ethics of earth care, people care and fair share" and "growing a vegetable garden using children's ideas." All qualities of SNS were considered *very important* and *essential* to assess at least some of the 399 significant nature activities that the professionals reported (**Figure 1**). Of all respondents, 67% found the list of qualities of SNS *very comprehensive*, 7% *fully comprehensive* whereas no respondent found the list *not comprehensive*.

In order to appreciate the differences and similarities in how qualities of SNS were used to assess significant nature activities we calculated a dissimilarity matrix using Gower's coefficients (min = 0.26, Mdn = 0.36, $M = 0.36$, max = 0.52) and subsequently performed hierarchical clustering. The dendrogram (agglomerative coefficient = 0.30) and clustering of the qualities of SNS at this level showed six separated clusters (**Figure 2**). Significant nature activities characterized by "thought-provocation," "awe," and "surprise," were clustered together and named *"environmental epiphanies"*; nature activities characterized by "intimacy," "mindfulness," and "self-restoration" were clustered together and named *"restorative experiences"*; nature activities characterized by "creative expression," "physical activity," "challenge," "engagement of senses," and "child-driven" were clustered together and named *"nature free play"*; nature activities characterized by "involvement of mentors," "structure/information," and "social/cultural endorsement" were clustered together and named *"nature school."* The hierarchical clustering showed that "entertainment" and "involvement of animals" were categorically different qualities that seemed to have intrinsic value and were independently clustered as "*entertaining*" and "*animal engaging.*"

RQ2: What Constitutes Children's HNC?

The main themes emerged from the inductive analysis of the interviews showed that professionals recognized HNC as an ability that children manifest when they perform certain actions or show certain emotions. This was particularly evident when professionals compared children who had been taking part in nature activities for a long time with children that had just begun. We selected few illustrative quotes to exemplify this point.

> "*We have one group that we have been working with for quite a long time, and [. . .] then I have started with a new group, and then this thing is very clear [. . .] they don't all have this feeling about how to think, or like: 'before I start climbing this little mountain, I need to look where to go. I can't just go this way because it will be too steep, I need to go around'."*

> *"A couple of the. . . stark differences we notice in our children [. . .] it takes them about 2 weeks on average to open up to the idea that they can also get dirty and wash up after, and it becomes something that's not quite so scary for them."*

> *"The ones who have been through this, they are quicker and faster and. . . they move differently. And that's the same when we go ice-skating or skiing, that the ones who have done this from when they were little, they have something in their body that makes it easier for them."*

The main themes obtained from the inductive analysis of the interviews form a list of abilities that, according to the professionals, were clear indicators of children's HNC (**Table 2**). We called these indicators *abilities of human-nature connection*. Hence, a child more or less connected to nature is characterized by one or more of the abilities of HNC listed in **Table 2**.

Across all abilities of HNC, at least 79% of survey respondents *agreed* or *strongly agreed* that the abilities shown indicated some form of HNC in children, whereas *disagreement* ranged from 5 to 8% (**Figure 3**). Furthermore, only 0.7% of the respondents stated that the list of abilities of HNC was *not comprehensive*, whereas all others stated that the list of abilities of HNC was either *slightly* (5%), *moderately (24%)*, *very* (63%), or *fully comprehensive* (7%).

TABLE 1 | List of qualities of significant nature situations with associated brief descriptions.

Qualities of SNS	Brief description
Entertainment	Nature situations that are fun, joyful, amusing, or enjoyable.
Thought-provocation	Nature situations that create new ways of conceiving human-nature interaction.
Intimacy	Nature situations that are private or intimate and allow a personal experience with nature.
Awe	Nature situations that are amazing, of overwhelming attraction, or mesmerizing, that create a "wow effect."
Mindfulness	Nature situations that grasp children's focus and alertness, that make children "be in the flow."
Surprise	Nature situations that are unpredictable or unexpected. In these nature situations children's line of thought is interrupted, and nature draws their attention.
Creative expression	Nature situations that involve arts, myths, stories, music, or role-play.
Physical activity	Nature situations that require body movement or any form of physical activity.
Engagement of senses	Nature situations that activate children's senses (smell, touch, hearing, etc.)
Involvement of mentors	Nature situations that involve persons, such as teachers, experts or relatives, who are capable of inspiring, encouraging, or leading the nature experience for the child.
Involvement of animals	Nature situations that involve interaction with animals.
Social/cultural endorsement	Nature situations that involve positive peer pressure, support from significant others, social acceptance, or cultural reinforcement.
Structure/instructions	Nature situations characterized by a set of rules that define the frame within which the child can act.
Child-driven	Nature situations that are chosen by the child, child-initiated (children autonomously decide when to begin the nature activity), and open-ended (children autonomously decide when to conclude the nature activity).
Challenge	Nature situations in which children overcome psychologically or physically adverse conditions, such as fear or cold.
Self-restoration	Nature situations of psychological, physical, or social relief. For example, relief from stress, fatigue, or gender stereotypes.

The descriptions presented here were also available to the respondents of the survey. The table can be read as, "A significant nature situation is characterized by (quality of SNS)."

RQ3: How Do Qualities of Significant Nature Situations and Children's Human-Nature Connection Relate to Each Other Over Time?

The inductive analysis of professionals' interviews and survey exercises showed that qualities of SNS relate to children's abilities of HNC through two interrelated dynamics of change: *routinization* and *progression*.

Routinization fosters the development of children's HNC *within* abilities of HNC. It happens through reoccurring nature activities with similar qualities of SNS, but possibly across different socio-environmental situations. That is, the set of relations existing between different spatial natural features, social circumstances, and children's abilities generates qualities of SNS that develop certain abilities of HNC in depth. We selected few illustrative quotes from the interviews to exemplify the dynamic of routinization.

> *"It is practice that gives them that skill. […] With the skiing for example, they can go downhill a hundred times and fall a hundred times. And the 101st time, they stand the whole hill down."*

> *"3 things that make nature play impactful: right kind of play, right kind of place, and the right kind of re-play […] is this frequency thing […] basically that it needs to happen, not necessarily everyday, but frequently."*

Progression is the development of children's HNC *across* abilities of HNC. That is, the set of relations existing between different spatial natural features, social circumstances, and existing children's abilities generates qualities of SNS that allow children to develop abilities of HNC that they did not have before and broaden the development of their HNC; we selected few illustrative quotes from the interviews to exemplify the dynamic of progression.

> "*Also, to build a positive feeling for nature you need to establish this sense of comfort already in young [children]- Being comfortable that you're able to, or dare to, carry your own backpack for example. That is sort of the first step. And then as you get a little bit older- To be able to walk a bit further away, maybe to another place."*

> *"First; you have to get accustomed to nature somehow, explore and discover, before you can play. […] Then you can start becoming interested in… Well, maybe practicing your agility by jumping from rocks or climbing tree logs or something."*

> *"[In a new place], you have to sort of start over, from this first phase [i.e., being comfortable]."*

In order to fully appreciate the progression of children's abilities of HNC, we use a weighted average to rank the results from the ordering exercise in the survey. "Feeling comfortable in natural spaces" was found to be the first ability of HNC that children learn and "being one with nature" the last one (**Figure 4**). We also calculated a dissimilarity matrix on the results of the ordering exercise (min = 0.20, Mdn = 0.37, M = 0.41, max = 0.75), on which we performed hierarchical clustering to understand if the progression of abilities of HNC had clusters of development. Both the weighted averages and the dendrogram (agglomerative coefficient = 0.44) showed three clear clusters of abilities of HNC (**Figure 4**). The first cluster was defined by children's abilities of "feeling comfortable in natural spaces" and "being curious about nature," so we termed it *"being IN nature."* The second cluster is defined by children's abilities of "acting in natural spaces," "feeling attached to natural spaces," "reading natural spaces,"

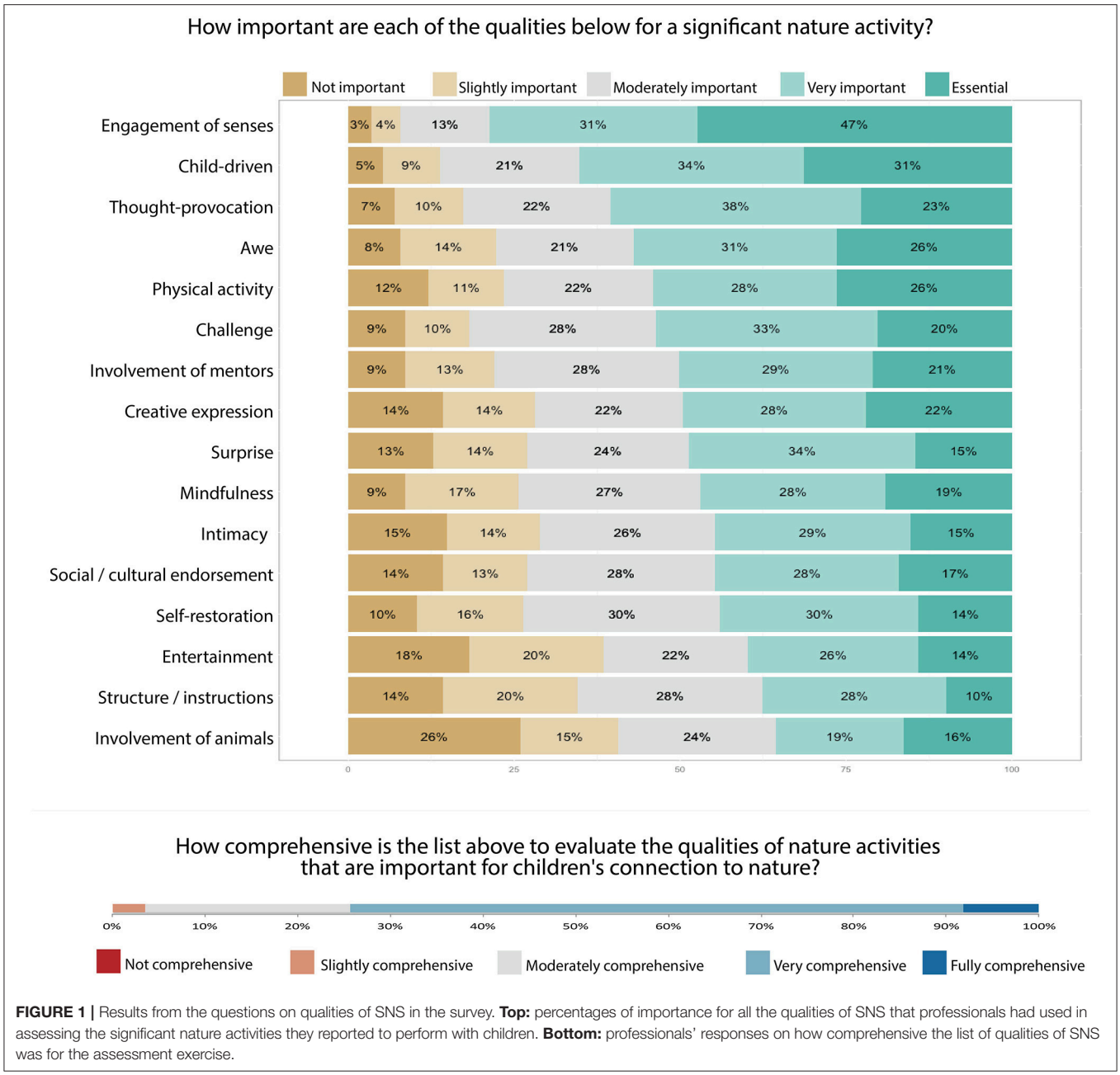

FIGURE 1 | Results from the questions on qualities of SNS in the survey. **Top:** percentages of importance for all the qualities of SNS that professionals had used in assessing the significant nature activities they reported to perform with children. **Bottom:** professionals' responses on how comprehensive the list of qualities of SNS was for the assessment exercise.

"knowing about nature," and "recalling memories with nature," so we termed it *"being WITH nature."* The last cluster is defined by children's abilities of "caring about nature", "taking care of nature," and "being one with nature," so we termed this cluster *"being FOR nature."*

The dynamics between the qualities of SNS and children's abilities of HNC have been further explored using the results of the assessment exercise performed in the survey. This showed that in order to teach children specific abilities of HNC, professionals used nature activities that had different configurations of qualities of SNS (**Figure 5**). For example, professionals that intended to teach children to be capable of *"being IN nature"* performed nature activities that were mostly "child-driven," characterized by high "engagement of senses", "awe," "physical activity," but with little "structure/instructions." Conversely, professionals who aimed to teach children to be capable of *"being FOR nature"* performed nature activities that were more characterized by "thought-provocation," "social/cultural endorsement" and "structure/instructions" and less by "physical activity" or "entertainment."

One-way ANOVA tests were conducted to compare the statistical influence of qualities of SNS on the three phases of HNC progression: *"being IN nature,"* *"being WITH nature,"* and *"being FOR nature."* The results showed that many qualities of

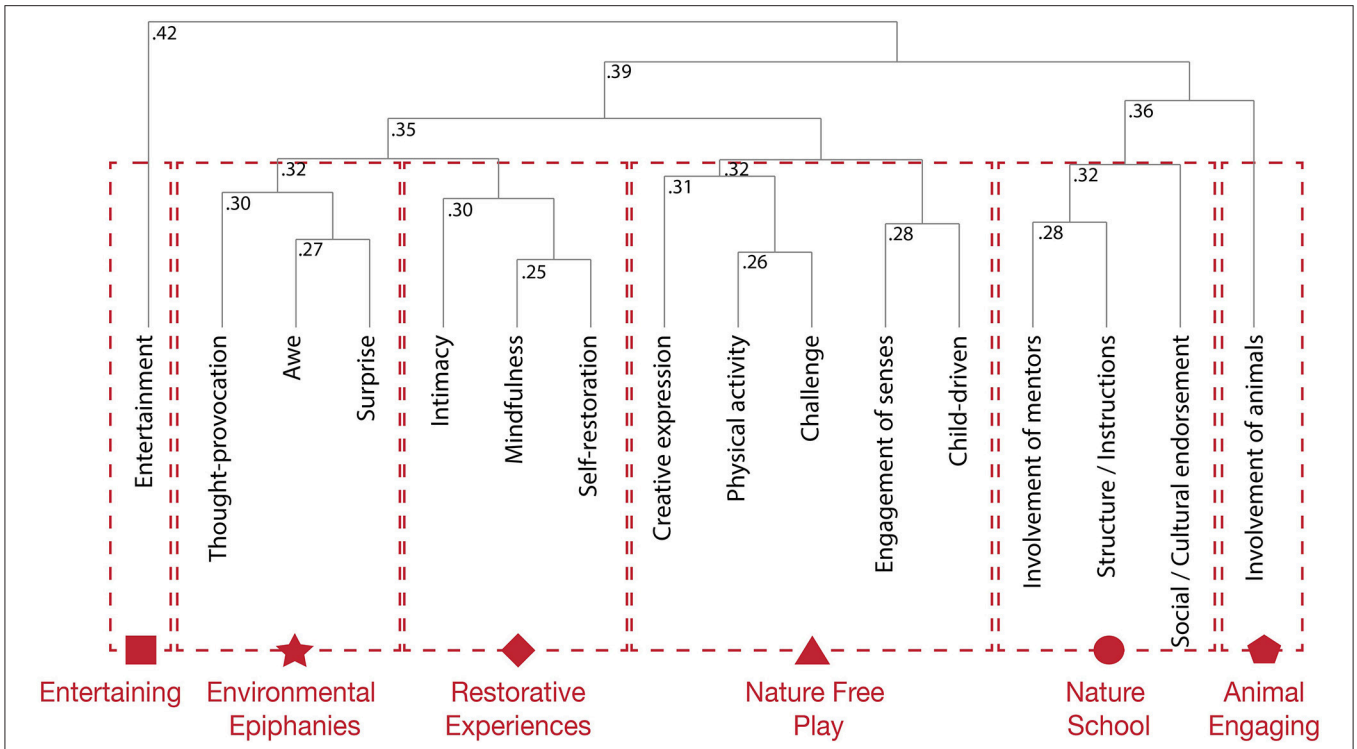

FIGURE 2 | Dendogram obtained from the hierarchical analysis of dissimilarity of qualities of SNS using Gower's coefficient with height coefficients. The clusters of "entertainment" and "involvement of animals" had been independently clustered as "entertaining" and "animal engaging." The remaining qualities of SNS were clustered into four different macro categories of nature situations: environmental epiphanies, restorative experiences, nature free play, and nature school.

TABLE 2 | List of abilities of human-nature connection with the associated brief descriptions.

Abilities of HNC	Brief description
Feeling comfortable in natural spaces	The child demonstrates ease in natural spaces and feels comfortable with natural elements in the outdoors (e.g., dirt, mud, rain, or the sun).
Reading natural spaces	The child is able to see the possibilities for action in natural spaces that are not purposefully designed by man.
Acting in natural spaces	The child is able to perform activities in nature, for example, nature playing, camping, or outdoor sports in nature.
Feeling attached to natural spaces	The child shows a sense of belonging to specific natural spaces, to which they feel part of.
Knowing about nature	The child demonstrates knowledge of animals, plants, and ecological dynamics.
Being curious about nature	The child shows interest and motivation in exploring nature.
Recalling memories with nature	The child is able to recall past nature experiences and tell stories of lived experiences with nature.
Taking care of nature	The child is able to be responsible for nature and feels empowered to act for the wellbeing of nature.
Caring about nature	The child is able to feel care, concern, sensitivity, empathy, and respect for nature.
Being one with nature	The child is able to identify with nature and has a sense of profound personal attachment to nature that can be described as spiritual. Love for nature, humbleness in relation to nature, and assuming to be a small part of the immensity of nature are manifestations of this ability.

The descriptions presented here were also available to the respondents of the survey. The table can be read as, "A child connected to nature is capable of (abilities of HNC)."

SNS were statistically different for different phases of abilities of HNC; that is, "entertainment" [$F_{(2,396)} = 6.811$, $p = 0.001$], "thought-provocation" [$F_{(2,396)} = 4.665$, $p = 0.009$], "intimacy" [$F_{(2,396)} = 3.85$, $p = 0.02$), "awe" [$F_{(2,396)} = 3.841$, $p = 0.02$], "surprise" [$F_{(2,396)} = 8.384$, $p = 0.0002$], "physical activity" [$F_{(2,396)} = 0.467$, $p = 0.004$], "social/cultural endorsement" [$F_{(2,396)} = 6.218$, $p = 0.002$], "structure/instructions" [$F_{(2,396)} = 6.628$, $p = 0.001$], "engagement of senses" [$F_{(2,396)} = 3.261$, $p = 0.04$] and "child-driven" [$F_{(2,396)} = 5.916$, $p = 0.003$]. For these qualities of SNS, Tukey *post-hoc* tests showed that there were significant differences between teaching children to be *in* or *with* nature and being *for* nature (**Table 3**). For instance, nature activities used in teaching children to be *for* nature were significantly less characterized by the qualities of SNS of "entertainment," "physical activity," and "child-driven," but more defined by "thought-provocation," "structure/instruction," and

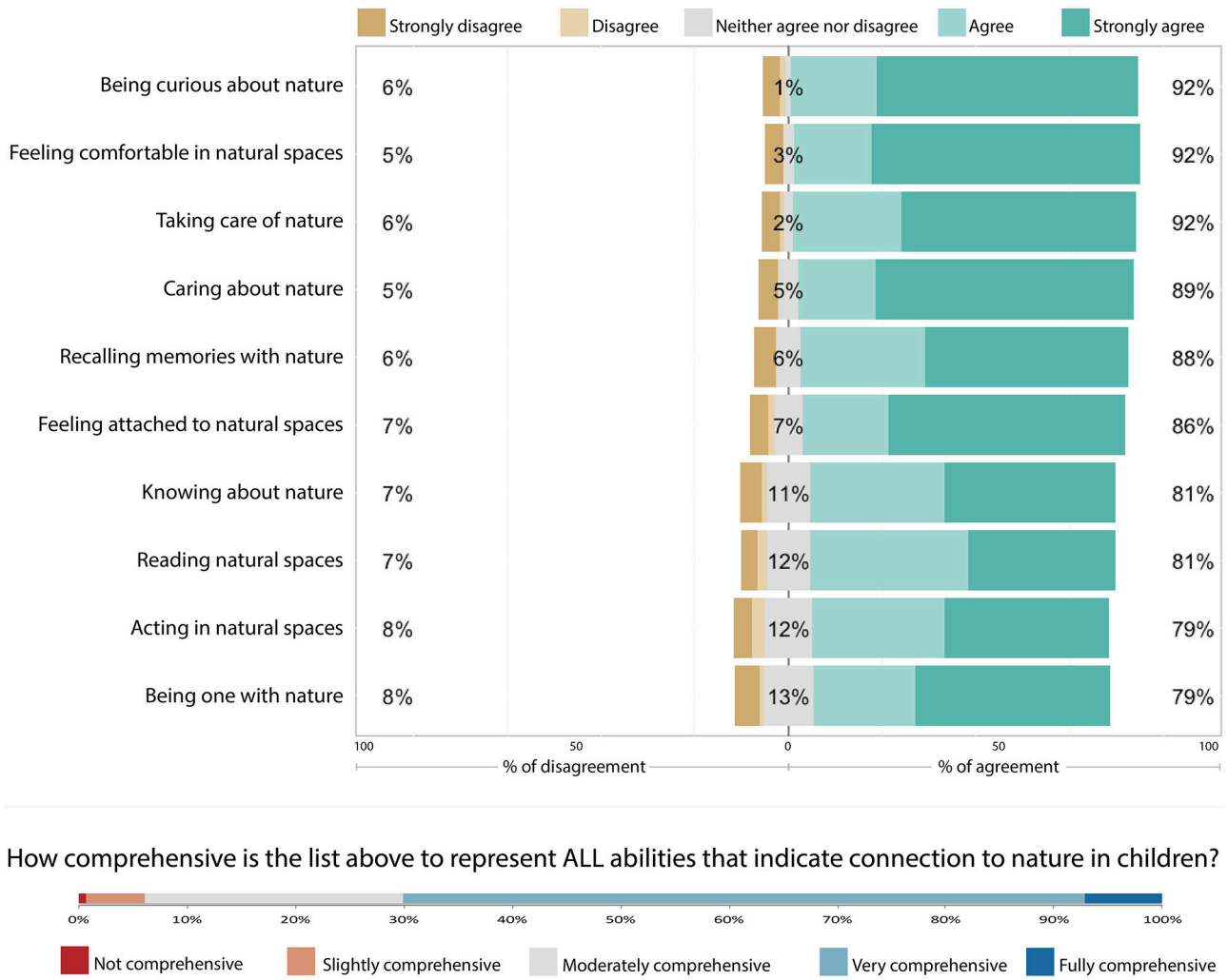

FIGURE 3 | Results from the questions on abilities of HNC in the survey. **Top:** how much professionals agreed that the list of abilities of human-nature connection indicated children's HNC. **Bottom:** professionals' responses on how comprehensive the list of was to represent all abilities that indicate children's HNC.

"social/cultural endorsement." Calculating Cohen's d on such differences also showed that the effect sizes were above average for educational research ($d > 0.4$) (Hattie, 2008) meaning that certain qualities of SNS were considerably more, and some less, important to nurture specific phases of HNC progression.

DISCUSSING ACHUNAS: A FRAMEWORK TO ASSESS WHERE AND HOW CHILDREN CONNECT WITH NATURE

The results shown in this paper form the Assessment framework for Children's Human Nature Situations (ACHUNAS) (**Figure 6**). ACHUNAS is composed of the list of qualities of SNS (**Table 1**); the list of children's abilities of HNC (**Table 2**); and three guiding principles (see section Guiding Principles of ACHUNAS). The lists of qualities of SNS and abilities of HNC outline *what* to assess to quantify or qualify the child-nature-connecting property of an environment, without defining *how* to perform the assessment itself. In line with transactional research, ACHUNAS avoids the rigid standardization of measurements across settings, and it solely highlights patterns of regularities across SNS and children's HNC (Altman and Rogoff, 1987). ACHUNAS is intended to be a flexible framework that allows practitioners and researchers to choose the assessment strategies, goals, and methods appropriate to their socio-environmental context. To allow the greatest flexibility while maintain integrity, three guiding principles are included as part of the framework. These principles give the boundaries of what SNS are, what children's HNC is, and how they relate to each other over time and are included as part of the framework. Together, the lists of qualities of SNS and abilities of HNC, and the three

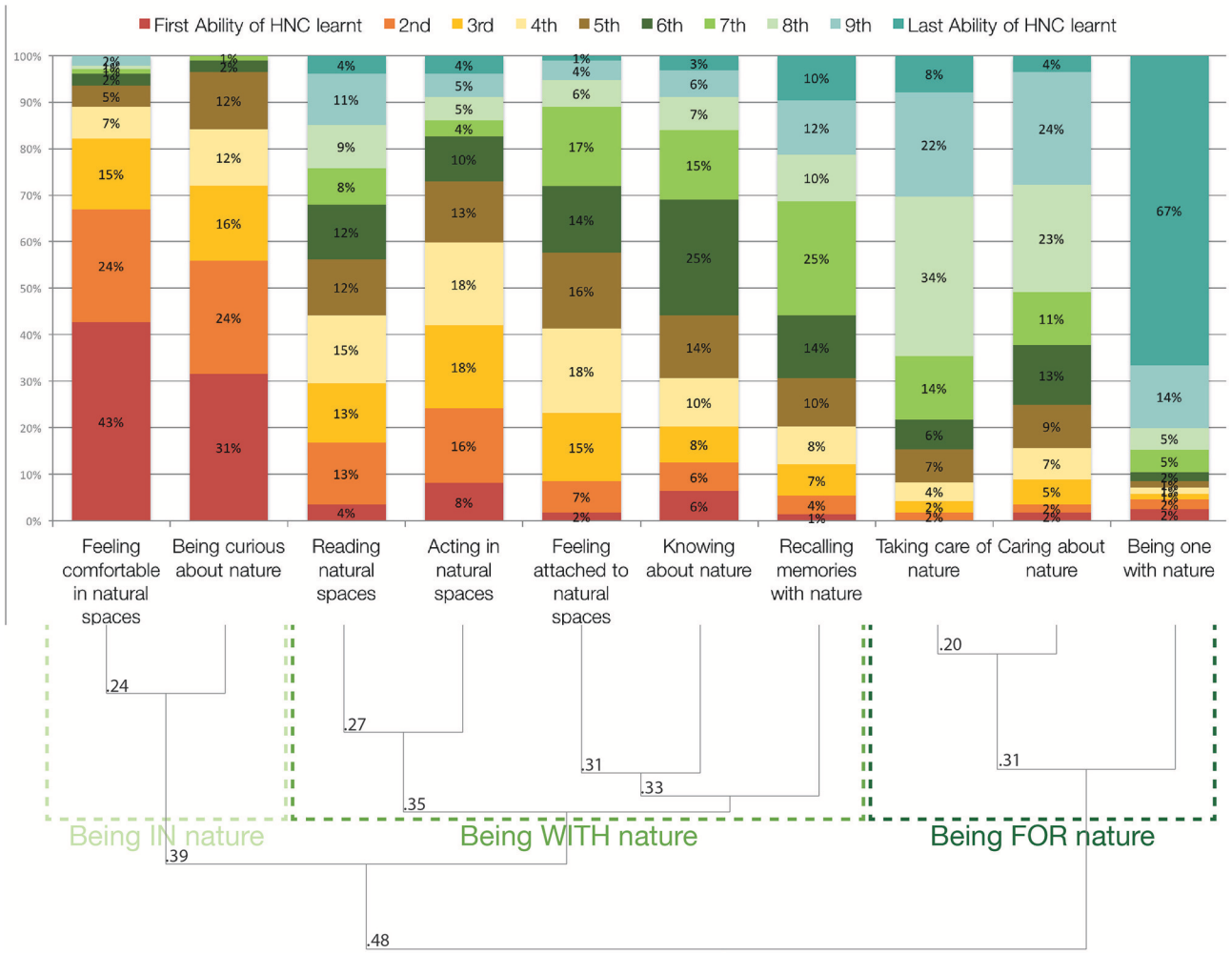

FIGURE 4 | Results from the ordering exercise in the survey showing the progression of abilities of HNC in time. **Top:** each stacked column shows the percentages of professionals that placed as first, second, third, etc., or last each learnt ability of HNC. **Bottom:** the upside-down dendogram obtained from the hierarchical analysis of dissimilarity with height coefficients. The three obtained phases of HNC progression are also shown: being IN Nature, being WITH nature, and being FOR nature.

guiding principles form a comprehensive, transferable, and practical framework to guide the assessment of child-nature-connecting environments. Thus, ACHUNAS does not prescribe a set of methods to apply for a specific assessment, but it is a framework that outlines the criteria to apply when assessing child-nature-connectedness. ACHUNAS sets the framework to guide the assessment of where and how children connect to nature, but it does not impose a standard set of tools to measure child-nature-connectedness across all socio-environmental contexts.

Guiding Principles of ACHUNAS

This paper identified *three* crucial questions to address the problem of assessing child-nature-connectedness of environments: "what are the qualities of significant nature situations?" (RQ1), "what constitutes children's human-nature connection?" (RQ2), and "how do qualities of significant nature situations and children's human-nature connection relate to each other over time?" (RQ3). Below, we discuss the results that answer each of these questions with a principle. The *three* resulting principles set the boundaries of the assessment framework and guide how it should be interpreted and operationalized in the future.

Principle 1: Significant Nature Situations Are Various and with Differing Consequences for Children's HNC

Professionals identified sixteen qualities that make a nature situation significant for children's HNC (**Table 1**). Nature situations can be significant for children's HNC simply because they are entertaining, because they involve a personal engagement with animals, or because children feel free to

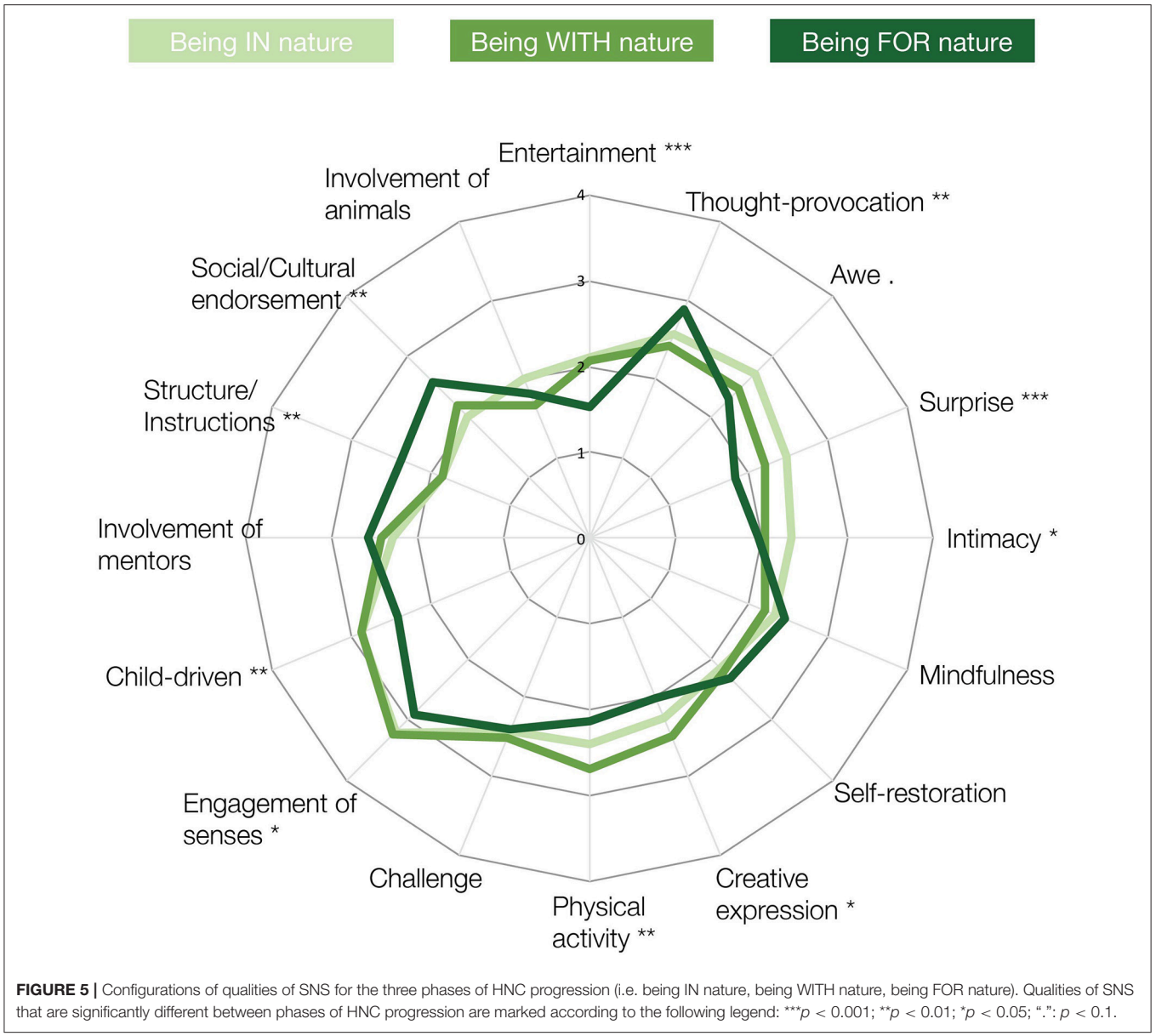

FIGURE 5 | Configurations of qualities of SNS for the three phases of HNC progression (i.e. being IN nature, being WITH nature, being FOR nature). Qualities of SNS that are significantly different between phases of HNC progression are marked according to the following legend: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; ".": $p < 0.1$.

engage in physical or artistic activities that activate their senses. However, it is most likely that several qualities of SNS co-occur in one significant nature situation. The configurations of qualities of SNS produced by the hierarchical clustering have shown the potential co-existence of six different kinds of SNS similar to some that have already been recognized in academia (**Figure 2**). Thought-provoking, awesome, and surprising SNS constituting *"environmental epiphanies"* are identified in the literature as "'aha' moments [...] that shift the fundamental self-nature relationship" (Vining and Merrick, 2012, 1). Intimate, mindful, and self-restoring SNS constituting *"restorative experiences"* have a long academic history (Hartig et al., 1991; Kaplan, 1995) and are for example considered fundamental for healthy urban living (Hartig and Kahn, 2016). SNS characterized by "involvement of mentors," "structure/information," and "social/cultural endorsement" are equally recognized in environmental education (Nazir and Pedretti, 2016). Consequently, assessing the child-nature-connectedness property of environments implies assessing a variety of different SNS.

It is important to note that the diversity of SNS comes with a diversity of implications for children's HNC. Different configurations of qualities of SNS require and nurture children's HNC differently. Results from the survey have shown that the nature activities that professionals performed to teach children to care, take care, and be one with nature (i.e., to be FOR nature) are characterized by configurations of qualities of SNS that are statistically different from the other phases of HNC progression (see **Figure 5**, **Table 3**). As different qualities of SNS

TABLE 3 | Results of Tukey *post-hoc* test and Cohen's d for the qualities of SNS that were significantly different between the three phases of HNC progression (i.e., being IN nature, being WITH nature, being FOR nature).

Qualities of SNS	Being IN nature	Being WITH nature	Being IN nature	Being FOR nature	Being WITH nature	Being FOR nature
	$M_{in} \pm SD_{in}$ $N_{in} = 144$	$M_{with} \pm SD_{with}$ $N_{with} = 162$	$M_{in} \pm SD_{in}$ $N_{in} = 144$	$M_{for} \pm SD_{for}$ $N_{for} = 93$	$M_{with} \pm SD_{with}$ $N_{with} = 162$	$M_{for} \pm SD_{for}$ $N_{for} = 93$
Entertainment	2.1 ± 1.37	2.06 ± 1.26	2.1 ± 1.37	1.52 ± 1.26	2.06 ± 1.26	1.52 ± 1.26
			$CI_{0.95} = -0.7, -0.17^{**}$ $d = -0.44$		$CI_{0.95} = -0.69, -0.17^{**}$ $d = -0.043$	
Thought-provocation	2.58 ± 1.2	2.42 ± 1.16	2.58 ± 1.2	2.88 ± 1.02	2.42 ± 1.16	2.88 ± 1.02
					$CI_{0.95} = 0.16, 0.67^{**}$ $d = 0.41$	
Awe	2.72 ± 1.2	2.46 ± 1.16	2.72 ± 1.2	2.29 ± 1.3	2.46 ± 1.16	2.29 ± 1.3
			$CI_{0.95} = -0.61, -0.08^{*}$ $d = -0.35$			
Intimacy	2.36 ± 1.16	2.05 ± 1.36	2.36 ± 1.16	1.96 ± 1.3	2.05 ± 1.36	1.96 ± 1.3
			$CI_{0.95} = -0.59, -0.07^{*}$ $d = -0.33$			
Surprise	2.48 ± 1.18	2.22 ± 1.17	2.48 ± 1.18	1.83 ± 1.35	2.22 ± 1.17	1.83 ± 1.35
			$CI_{0.95} = -0.79, -0.26^{***}$ $d = -0.52$		$CI_{0.95} = -0.57, -0.06^{*}$ $d = -0.32$	
Physical activity	2.4 ± 1.3	2.69 ± 1.33	2.4 ± 1.3	2.13 ± 1.27	2.69 ± 1.33	2.13 ± 1.27
					$CI_{0.95} = -0.69, -0.17^{**}$ $d = -0.43$	
Engagement of senses	3.2 ± 0.97	3.23 ± 1.09	3.2 ± 0.97	2.9 ± 1.05	3.23 ± 1.09	2.9 ± 1.05
					$CI_{0.95} = -0.56, -0.05^{*}$ $d = -0.31$	
Social/Cultural endorsement	2.01 ± 1.32	2.19 ± 1.24	2.01 ± 1.32	2.58 ± 1.15	2.19 ± 1.24	2.58 ± 1.15
			$CI_{0.95} = 0.19, 0.72^{***}$ $d = -0.45$		$CI_{0.95} = 0.07, 0.58^{*}$ $d = -0.32$	
Structure/Instructions	1.86 ± 1.23	1.86 ± 1.21	1.86 ± 1.23	2.38 ± 1.09	1.86 ± 1.21	2.38 ± 1.09
			$CI_{0.95} = 0.18, 0.71^{***}$ $d = 0.44$		$CI_{0.95} = 0.19, 0.70^{*}$ $d = 0.45$	
Child-driven	2.88 ± 1.1	2.87 ± 1.12	2.88 ± 1.1	2.42 ± 1.16	2.87 ± 1.12	2.42 ± 1.16
			$CI_{0.95} = -0.67, -0.15^{**}$ $d = -0.41$		$CI_{0.95} = -0.65, -0.14^{**}$ $d = -0.40$	

Cells with significant results ($p < 0.05$) with effect size $d > 0.40$ are highlighted. Legend for significance levels: $^{*}p \leq 0.05$; $^{**}p \leq 0.01$; $^{***}p \leq 0.001$.

are used to promote different abilities of HNC it follows that some configurations of qualities of SNS are more important than others in developing certain abilities of HNC. During the assessment of where and how children connect to nature it is, therefore, important to remember that SNS are various and with differing consequences for HNC.

Principle 2: Children's Human-Nature Connection Is a Complex Embodied Ability

The professionals interviewed described HNC as a constellation of abilities of the mind and body that children learn. For example, professionals stated that children show HNC when they are "curious about nature"; which is visible in children when they show desire to know about nature as well as when they show the desire to physically explore natural spaces. Most abilities of HNC listed here simultaneously embody both actions and emotions, and are also embodied in particular socio-environmental contexts. During the interviews and in response to the survey, professionals widely remarked that the abilities that shape children's HNC are not only in relation to "nature" as an abstract concept, but they are also importantly related to natural physical spaces. Children's HNC exists when children are capable of *"feeling comfortable in natural spaces," "acting in natural spaces," "reading natural spaces,"* and ultimately *"feeling attached to natural spaces."* These abilities of HNC show that children's HNC is rooted to tangible natural environments, and potentially specific ecological attributes, going beyond an abstract conceptualization of "nature" often used to assess people's relation with nature (Ives et al., 2017). Additionally, children's HNC shows attributes of complexity. The existence of different phases of HNC progression (**Figure 4**) and their differing relations to qualities of SNS (**Figure 5**) suggest that children's HNC as a whole cannot be solely understood as the sum of their individual abilities of HNC. Different configurations of abilities of HNC seem to play an important role in characterizing children's HNC as a whole. The second guiding principle to support the use of ACHUNAS is, therefore, that children's HNC is a complex embodied ability.

This principle answers the call of many in environmental psychology to integrate extra-psychological factors in models that aim to determine pro-environmental behaviors (Gifford, 2014; Gifford and Nilsson, 2014; Steg et al., 2014). Unlike previous academic work that presents mono-dimensional or disembodied understandings of the relationship that exists between people and nature, this paper demonstrates that professionals conceive children's HNC as a complex set of abilities embodied within mind, body, culture, and the environment. Despite socio-environmental contexts being considered obvious antecedents to encourage or constrain pro-environmental behaviors (Steg et al., 2014) academics have not yet systematically scrutinized their impact in encouraging pro-environmental behaviors (Steg and Vlek, 2009). The relational approach used here to develop ACHUNAS offers an alternative starting point that embraces and values professionals' embodied perspectives of children's HNC.

Principle 3: Children's Human-Nature Connection Progresses Over Time through Diverse Nature Routines

The thematic analysis of professionals' interviews showed that children's HNC progresses dynamically over time through routinization and progression like most other human abilities. In the survey, professionals suggested a model of development for children's HNC that begins with "feeling comfortable in natural spaces" and "being curious about nature," and ends with "caring about nature" and "being one with nature" (**Figure 4**). The related hierarchical clustering showed three consecutive phases of HNC progression: being *in* nature, being *with* nature, and being *for* nature. That means that before being able to feel and act *for* nature (3rd phase) a child has to develop over time the ability to be *in* (1st phase) and *with* nature (2nd phase). In other words, before feeling care or concern for the environment, and before feeling responsible and motivated to act for it, a child has to at least feel at ease and comfortable in the natural elements of the outdoors. Children's ability to just enjoy and being curious about natural spaces is therefore a gateway to more profound forms of human nature relationships, but the progression across such abilities of HNC cannot be considered linear. Since these abilities are embodied in specific socio-environmental contexts, their progression is also context-dependent. As one of the interviewees stated "[In a new place], you have to sort of start over, from this first phase." The three phases of HNC progression can indeed be seen as an indication of multiple states of equilibrium. This also implies that the development of children's HNC is likely to be characterized by potential threshold effects between one phase of HNC progression and another. For instance, only when a child is comfortable in nature in several social-environmental contexts can s/he then begin to know how to read specific environmental features. Abilities of HNC can indeed progress in depth (e.g., a child can be more or less curious about nature) and breadth (e.g., child can be curious about a garden, but not about a forest), and can nurture one another (e.g., a child who can be curious about a natural space might begin to feel attached to it). The third guiding principle to support the use of ACHUNAS is, therefore, that children's HNC does not grow linearly, but it progresses dynamically over time through the routinization of diverse qualities of SNS.

Current literature proposes models of development for HNC that grow linearly in independent and pre-identified psychological traits (Tam, 2013). The amount of time spent in a space is mentioned throughout the literature on sense of place as the most consistent predictor of attachment to it (Lewicka, 2011) and, similarly, the amount of time spent in nature is one of the most significant predictor of emotional affinity toward nature (Kals et al., 1999) and a crucial condition of any changes in children's HNC (Schultz and Tabanico, 2007). However, we are not familiar with any models that have explored how HNC develops and what is required for its progression over time. The development of children's HNC requires the reoccurrence of different qualities of SNS to progress. That is, children's HNC requires diverse nature routines provided by a wide variety of environmental features and by the involvement of diverse actors, collaborators, and institutions. Establishing significant and diverse nature routines responds to concerns in modern environmental education (Chawla and Cushing, 2007; Nazir and Pedretti, 2016), environmental conservation (Miller, 2005; Soga et al., 2015), and sustainable socio-ecological urban design (Colding and Barthel, 2013; Giusti et al., 2014; Marcus et al., 2016; Beery et al., 2017). As one interviewee highlighted: "3 things that make nature play impactful: right kind of play, right kind of place, and the right kind of re-play [...] is this frequency thing."

Use and Usefulness of ACHUNAS

The lists of abilities of HNC and qualities of SNS outline what to *quantify* or *qualify* when assessing child-nature-connecting environments. Similar to the lists of qualities used to assess the "child-friendliness" property of environments (Kyttä, 2006; Broberg et al., 2013), or the ANGELO framework used to assess the "obesogenicity" property of environments (Swinburn et al., 1999; Kirk et al., 2010), ACHUNAS is a framework that outlines a list-based set of criteria with the purpose of assessing the child-nature-connectedness property of environments. The lists of qualities of SNS and abilities of HNC give practitioners and researchers a frame of reference to identify where there are SNS and how they affect children's HNC. Eventually, the criteria proposed in ACHUNAS can be quantified using, for example, Likert scale surveys or other psychometric measurements. This would allow users to *quantify* the degree of "significance" of nature situations. Simultaneously, ACHUNAS is useful to understand what *kind* of SNS exist in the everyday landscapes and routines of children. The diversity of qualities of SNS and abilities of HNC listed provides the possibility to *qualify* the landscape in terms of the kind of SNS provided. For example, the green infrastructure might allow entertaining situations, but not nature situations that are child-driven or involving animals.

The above properties make ACHUNAS useful to assess, first, where significant nature situations are, and, second, how children connect to nature. Below, we give two hypothetical examples of assessments that operationalize ACHUNAS to exemplify its use in assessing child-nature-connecting environments.

Hypothetical Examples of Assessments Using ACHUNAS

ACHUNAS can be used, for example, to assess the extent and type of "extinction of experiences" that many authors also believe undermines children's well-being (Soga and Gaston, 2016; Soga et al., 2016) and interest in nature conservation (Miller, 2005; Samways, 2007; Finch, 2008). Such assessments could be performed by using participatory observations, interviews, or PPGIS methodologies to examine which qualities of SNS exist, and which do not, in the everyday landscape of children. As an example, take an urban park in which children are freely allowed to play. Each item in the lists of qualities of SNS can be independently assessed according to the nature situations that are available in the park (see the assessment example "playing in the park" in **Figure 6**). In this hypothetical example, the evaluator has spent time in the park performing participatory observations of children describing nature activities with high levels of "entertainment," but low levels of "thought-provocation." Overall, the observations show that the nature situations available in this park are mostly characterized by the qualities of "child-driven" and "physical" activities with high "engagement of senses." The evaluator then decides to interview children to understand their ability of "feeling comfortable in natural spaces," "being curious about nature," and so on. Once completed, the assessment provides the evaluator with useful information about what *kind* of nature experiences exist in the park, and, importantly, which ones are missing. In this example, the evaluator might conclude that organized activities and the introduction of animals might further nurture children's ability of "knowing about nature," or "feeling attached to natural spaces." In the above example, ACHUNAS specifies the list of criteria that the evaluator should follow to assess the environment, but the methods to do this (e.g., participatory observations and interviews) are chosen by the evaluator. For a more complete assessment, the evaluator might also consider principle 3 of ACHUNAS (i.e., children's HNC progresses over time through diverse nature routines) and assess how frequently children visit the park and how long they have exposure to nature activities for, or perform the same assessment for all the parks of a neighborhood or a city.

A second example of how ACHUNAS can be used is in the assessment of educational nature activities. This type of implementation would be particularly useful to educational programs connecting children to nature (see the assessment example "gardening" in **Figure 6**). Qualitative and/or quantitative methods such as interviews, observations, and questionnaires could be applied to study the presence and extent of the different qualities of SNS and abilities of HNC. In this hypothetical example, the project aims to teach children how to grow their own food, and researchers use a questionnaire to ask practitioners to rank how important each of the qualities of SNS are when children garden (this example has strong similarities with the assessment exercise performed by professionals in the survey). The final assessment shows that while gardening "thought-provocation" and "social/cultural endorsement" are high, but that "entertainment" is low. By interviewing the children, researchers also find that despite children being able to "take care of nature" their level of ability to "be curious about nature" while gardening is low. Researchers would conclude that gardening, as it is performed by this educational program, is likely to be insufficiently entertaining to nurture children's curiosity about nature. Researchers might then recommend that practitioners introduce an element of play during gardening activities, or to foster children's sense of belonging to the garden by making them choose a name for different sections of the garden. As in the previous example, ACHUNAS provides the lists of qualities of SNS and abilities of HNC which should be assessed, and the researchers select the method in which to do so (e.g., questionnaires and interviews). Using ACHUNAS in this way allows practitioners to develop more holistic and comprehensive nature activities, and it helps to bridge the gap between theory and practice that constitute a major obstacle in current environmental education (Chawla and Cushing, 2007; Finch, 2008; Nazir and Pedretti, 2016).

Comprehensiveness, Transferability, and Practicality

Of the 275 professionals responding to the survey (from more than 200 organizations in 22 countries), 74% considered the list of sixteen qualities of SNS to be "very" or "fully comprehensive" to assess *all* the qualities of nature activities that connect children to nature. During the survey, every single quality of SNS listed was considered "very important" or "essential" to assess a considerable percentage of nature activities that have the potential to connect children to nature; from 35% for "involvement of animals" to 78% for "engagement of senses" (**Figure 1**). The same can be said for the list of abilities that constitute children's HNC. The list of abilities of HNC was found to be at least "somewhat comprehensive" by 99.3% of the professionals responding our survey with the majority of professionals (63%) stating that it was "very comprehensive." Additionally, a large majority of respondents agreed that every single ability of HNC listed indicated some form of connection to nature in children; from 79% agreeing with "being one with nature" to 92% agreeing with "being curious about nature" (**Figure 3**). These results, the mixed-method methodology, and the heterogeneous group of professionals ensure that the lists of qualities of SNS and abilities of HNC generated in this paper are sufficiently comprehensive of all relations that indicate children's HNC, transferable across different children and cultures, and can be practically implemented by practitioners and researchers in order to identify where children's SNS are.

Limitations of ACHUNAS

We identify three limitations of ACHUNAS to assess child-nature-connecting environments. The first limitation is the completeness and generalizability of ACHUNAS. 63% of professionals found the abilities of HNC "very comprehensive" and 67% of them thought the same for qualities of SNS, but only 7% of them found these lists to be "fully comprehensive." This shows that ACHUNAS might not yet integrate all the qualities that can categorize an environment as more or less child-nature-connecting and, therefore, the lists of qualities of SNS and abilities of HNC require formal validation. Further

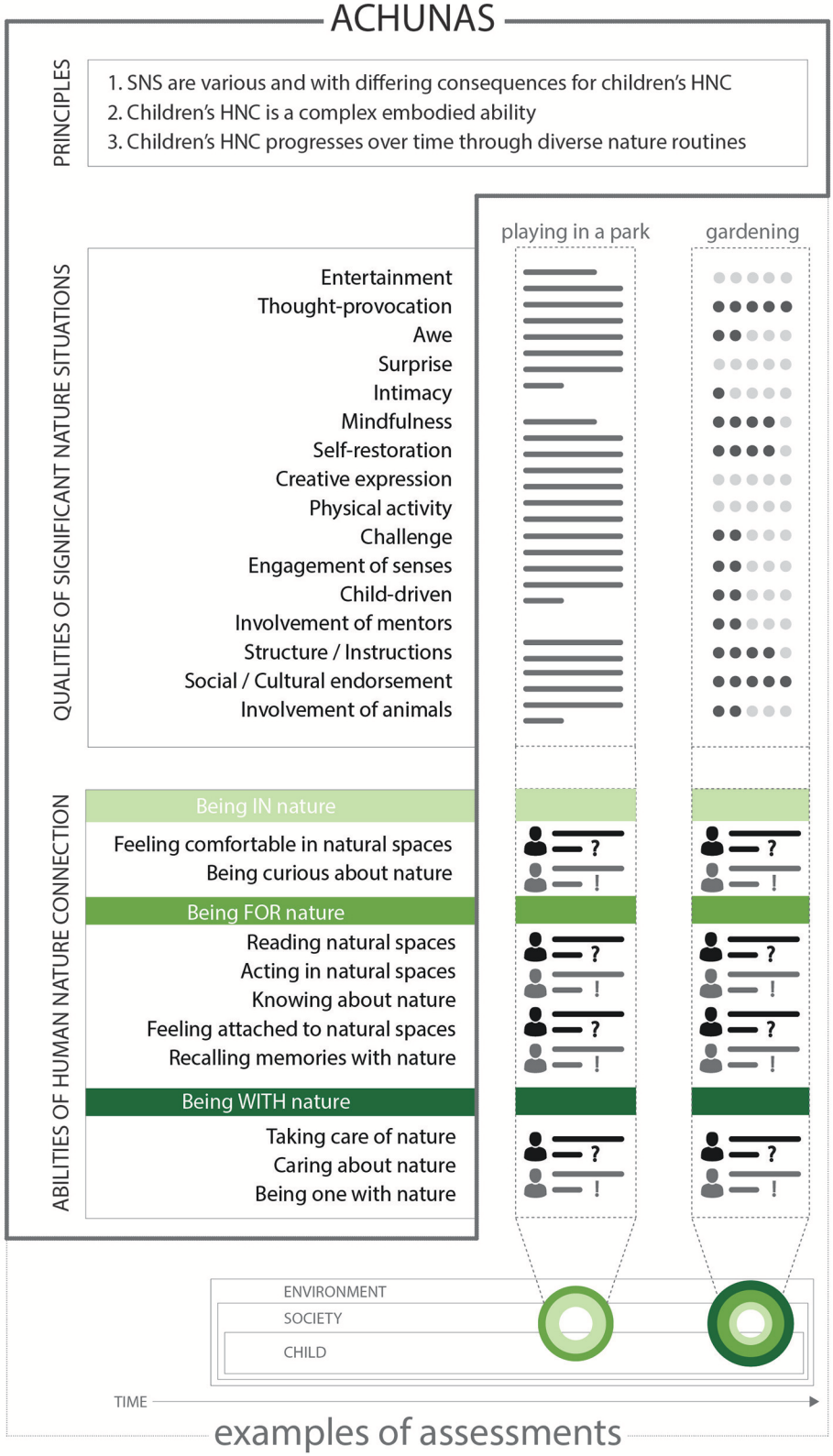

FIGURE 6 | Assessment framework for Children's Human Nature Situations (ACHUNAS). ACHUNAS comprises the list of qualities of SNS, the list of children's abilities of human-nature connection, and three guiding principles. The figure shows the hypothetical assessment of two SNS (playing in the park and gardening) with different configurations of qualities of SNS and abilities of HNC.

research is required to test the lists for convergence or divergence. For generalizability, cross-cultural assessments are needed to understand if certain qualities of SNS and abilities of HNC are more suitable than others to assess specific socio-cultural contexts. Despite having tested ACHUNAS on a very international and heterogeneous group of respondents, the framework lacks the contributions of non-English speaking professionals and the potentially valuable input from indigenous communities.

Second, because of the nature of ACHUNAS, the framework does not suggest which method is the most suitable to assess each item in the lists. ACHUNAS highlights *what* to assess, but it does not provide guidance on *how* to assess child-nature-connectedness. Comparability across assessments that operationalize ACHUNAS with different methodologies might, therefore, be limited. Defining standard operationalizations of ACHUNAS through trandisciplinary collaborations would greatly increase the comparability of results across different socio-environmental contexts.

Third, ACHUNAS is a framework built upon professionals' understanding of children's HNC. The results are therefore a representation of a multitude of adults' perspectives and lack the direct input of children's insights. In order to further improve the validity of ACHUNAS as a framework, interviews of children and self-reporting methodologies performed with children can be implemented to better integrate children's perspectives into the ACHUNAS framework. In pursuing this endeavor, we also see the potential contribution of children with differing socio-demographic backgrounds.

Future Research Directions for Child-Nature-Connecting Environments

We identified three future research directions that have great potential to promote the design of nature-connecting human habitats or to inform educational curricula that promote children's HNC. The most obvious is operationalizing ACHUNAS to assess where and how children connect to nature. Implementing standard operationalizations of ACHUNAS would allow understanding which relations of children's abilities of HNC and socio-environmental features afford qualities of SNS. This would be a further step forward in unveiling the ecological properties that can categorize an environment as more or less child-nature-connecting. Furthermore, such knowledge would be a stepping stone toward the design of nature-connecting human habitats.

A second area of research of fundamental importance is the analysis of interdependencies between qualities of SNS and abilities of HNC. The fundamental unit of analysis in ACHUNAS is at the confluence of children's abilities of HNC, qualities of SNS, and the socio-environmental context. The results shown above already indicated that certain configurations of qualities of SNS significantly relate to certain abilities of HNC (see **Table 3**). However, the current understanding of these linkages are preliminary and they lack temporal dimensions such as frequency or duration. A better understanding of the effects that routinized sets of qualities of SNS have on children's abilities of HNC would better inform the design of nature-connecting human habitats as well as pedagogical curricula that aim to connect children to nature.

Lastly, it is plausible that children's HNC may vary not just in relation to SNS and nature routines, but also with respect to the child's cognitive, emotional, moral, and physical stages of development. Although this has not been the goal of this paper, we recognize that studying the progression of HNC in relation to children's stages of development is a promising area of research that could directly promote comprehensive and holistic curricula to nurture children's HNC. For the sake of facilitating such academic endeavor, we believe that Piaget's stages of development (Piaget, 1960), Vygotsky's theory of Zones of Proximal Development (Chaiklin, 2003), Bronfenbrenner's theory of child development (Bronfenbrenner, 1979), situated and social learning (Lave and Wenger, 1991), and embodied cognition (Chemero, 2009) might be useful theories to investigate some of these unknowns.

Implications for Sustainable Urban Design and Environmental Education

The results of this study have obvious implications for the practice of sustainable urban design and environmental education. It is common for urban green infrastructure to be promoted and developed for biophysical management, e.g., stormwater management, flood control, urban cooling, reduction in carbon emissions etc., but its role in the development of children's HNC has been so far largely ignored. For example, access rights, spatial accessibility, ecological and biological diversity are just some of the variables of the green infrastructure that can promote children's nature routines and their HNC; all of which are already intentionally designed in the human habitat. Whether intentional or incidental, recurring experiences of nature situated in the everyday habitat of children are opportunities to develop their abilities of HNC (Giusti et al., 2014; Marcus et al., 2016; Beery et al., 2017; Samuelsson et al., 2017). Nature-based solutions provide direct benefits for public health, improve living conditions, and build resilience to climate and environmental change (Colding and Barthel, 2013; Hartig and Kahn, 2016). The results of this study show that they can also be considered in sustainable urban design for the transgenerational establishment of sustainable futures.

As environmental educators have already acknowledged, promoting children's HNC also means facilitating frequent nature activities and the results of this study confirm this position (Chawla and Cushing, 2007; Finch, 2008; Nazir and Pedretti, 2016). ACHUNAS offers the possibility to assess the significance of such frequent nature activities, to compare them, to identify which phase of HNC progression children are in, or to better tailor nature activities to suit the intended educational ability of HNC. In so doing, ACHUNAS is a first step toward the assessment of best practices to nurture children's HNC across organizations, cultures, and geographical locations. More broadly, assessing nature activities using ACHUNAS provides a preliminary form of curricula evaluation when the pedagogical goal is to connect children to nature. Conclusive monitoring

methods developed from the ACHUNAS framework would allow reliable comparison within and across programs and the identification of discrepancies between intended and effective outcomes. This is a stepping stone to understand if such programs have potential to nurture future sustainable personal and collective behaviors. In summary, we believe ACHUNAS is a step forward in creating a reliable pedagogical curriculum capable of connecting children to nature.

ACHUNAS is a starting point for cross-fertilization between different disciplines interested in child-nature-connectedness. The academic literature on HNC has been systematically divided into epistemological silos (Ives et al., 2017), but the embodied approach to HNC used for ACHUNAS provides fertile ground to integrate, extend, and apply these different branches of empirical evidence. Several abilities of HNC in ACHUNAS such as "feeling comfortable in," "feeling attached to," "recalling memories in," and "caring about" natural spaces are also founding elements of sense of place literature in human geography (Hernández et al., 2007; Lewicka, 2011). On the other hand, "knowing about nature" and to an extent "being one with it" are recognized components of modern environmental education (Nazir and Pedretti, 2016). The embodied nature of ACHUNAS allows these established disciplinary grounds to be brought together and set side by side with professionals' understanding of children's HNC. The use of ACHUNAS will allow these disciplines to gain further practical application and provide practitioners with the possibility to draw on the solidity of peer-reviewed literature.

CONCLUSION

In this study, through the use of inductive thematic analysis and a practitioner survey we identified and tested three components of an Assessment framework for Children's Human Nature Situations that we called ACHUNAS (**Figure 6**). First, we identified 16 qualities of SNS that characterize a nature situation with the potential to "connect" children to nature. Second, we documented a list of 10 abilities of human-nature connection that expresses the nuances of children's human-nature connection. Third, we defined three principles that frame the applicability of these lists: (1) significant nature situations are various and with differing consequences for children's human-nature connection; (2) children's human-nature connection is a complex embodied ability; and (3) children's human-nature connection progresses over time through diverse nature routines. Together, these findings form a comprehensive framework that outline what to quantify or qualify when assessing "child-nature connecting" environments.

Questions like "where children connect with nature?" and "what kind of nature experiences are missing from cities?" are central to the design of nature-connecting human habitats as much as to the generation of sustainable futures. ACHUNAS is sufficiently comprehensive, transferable, and practical to provide a starting point to answer these questions and to guide the assessment of where and how children connect to nature. It can be operationalized to assess the extent and typology of "extinction of experience" and inspire the design of nature-based human habitats that also connect children and people to nature. Similarly, it can be used to evaluate curricula that aim to connect children to nature, providing useful information to such educational programs. Overall, ACHUNAS is a transdisciplinary framework that allows cross-fertilization and integration of knowledge across different academic disciplines and makes it useful to practitioners interested in promoting child-nature-connecting environments and children's HNC. In conclusion, ACHUNAS provides a starting point to classify a social-ecological system as more or less child-nature-connecting.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations "ESPA Ethics Principles and Procedure" produced by the Directorate of the Ecosystem Services for Poverty Alleviation, with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the ethical committee at the Stockholm Resilience Centre.

AUTHOR CONTRIBUTIONS

MG: Work conception, research design, data collection, data analysis, data interpretation, paper arrangement and revision, writing, and submission; US: Data collection, data analysis, data interpretation, paper arrangement and revision, and writing; CR: Data interpretation, research design, paper arrangement and revision, and writing; TB: Data interpretation, paper arrangement and revision, and writing.

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Residents' Dissatisfaction and All-Cause Mortality. Evidence from 74 European Cities

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Background: About 2/3 of the Europeans reside in cities. Thus, we must expand our knowledge on how city characteristics affect health and well-being. Perceptions about cities' resources and functioning might be related with health, as they capture subjective experiences of the residents. We characterized the health status of 74 European cities, using all-cause mortality as indicator, and investigated the association of mortality with residents' dissatisfaction with key domains of urban living.

Methods: We considered 74 European cities from 29 countries. Aggregated data on residents' dissatisfaction was obtained from the Flash Eurobarometer, Quality of life in European cities (2004–2015). For each city a global dissatisfaction score and a dissatisfaction score by domain (environment, social, economic, healthcare, and infrastructures/services) were calculated. Data on mortality and population was obtained from the Eurostat. Standardized Mortality Ratios, SMR, and 95% Confidence Intervals (95% CI) were calculated. The association between dissatisfaction scores and SMR was estimated using Generalized Linear Models.

Results: SMR varied markedly (range: 73.2–146.5), being highest in Eastern Europe and lowest in the South and Western European cities. Residents' dissatisfaction levels also varied greatly. We found a significant association between city SMR and residents' dissatisfaction with healthcare ($\beta = 0.334$; IC 95% 0.030–0.639) and social environment ($\beta = 0.239$; IC 95% 0.015–0.464). No significant association was found with the dissatisfaction scores related with the physical and economic environment and the infrastructures/services.

Conclusions: We found a significant association between city levels of mortality and residents' dissatisfaction with certain urban features, suggesting subjective assessments can be also used to comprehend urban health.

Keywords: urban health, city planning, European Union, physical environment, health services, socioeconomic environment, community participation

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INTRODUCTION

Urbanization is probably one of the most important demographic phenomena of our times (Galea and Vlahov, 2005). Currently, about two thirds of the Europeans and more than half of the world population reside in cities (WB, 2014). Thus, more than ever, we must expand our knowledge about how city characteristics affect the health and well-being of the urbanites (Galea et al., 2005). An

healthy city is "*one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential*" (WHO-EUROPE, 1995), which, ultimately, promotes human health and urban sustainability (Portney and Sansom, 2017). This multifaceted definition implies that cities must offer health-supportive physical and socioeconomic environments and adequate access to infrastructures and services, which, according to several conceptual models, represent the main determinants of population health within urban contexts (Galea and Vlahov, 2005). Altering affordances of the physical and social environment can contribute to reduce the stress and unhealthy behaviors associated with urban living, to the restoration of depleted cognitive resources and, by this means, promote a healthy Biosphere (Hartig and Kahn, 2016).

City government plays an enormous role in changing several of these affordances and urban planning can be seen as a form of "preventive medicine" (Corburn, 2015). Indeed, for centuries the most important public health actions started in large urban areas and this trend might accentuate with the increasing decentralization that has brought more power to the local governments (Lawrence, 2013), which deal with a network of city actors/organizations (civil society, corporates, trade unions, informal organizations) and, at same time, cope with the decisions of the central state's agencies (Devas, 2001). To design healthy cities and to motivate planners toward this goal it is crucial to include the civil society, to monitor the current state of population's health, and to take into consideration the residents' opinions about the cities' resources and functioning (Frankish et al., 2002; Hogan et al., 2015). As stated by Burrows and Rhodes in 1998 "we need to move from assuming what is best for people to letting them say what they think would be better" (Burrows and Rhodes, 1998).

Cities, per definition, share some characteristics. Yet, due to distinct geographic situation, size, and cultural and historical background, European cities are very unequal in terms of physical and socioeconomic environments. These specificities might shape the indicators of health and well-being of these cities and, by this means, might create an unequal distribution of health. Health inequalities across European regions have been largely documented (Richardson et al., 2014; Ribeiro et al., 2016), but few studies systematically evaluated the differences in health status across European cities (Gray et al., 2012; Richardson et al., 2017) or explored the determinants of such differences (Richardson et al., 2017). Those determinants are likely to be heterogeneous and difficult to grasp. Despite much attention given to objective measures about the cities environment [pollution (Beelen et al., 2014), greenness (Gascon et al., 2016), socioeconomic deprivation (Marí-Dell'Olmo et al., 2015)], perceptions about the places might also influence and inform on other dimensions of people's health, as they capture subjective experiences of the residents, something that traditional, objectively measured indicators cannot. Subjective assessments capture the "human perception of space" (i.e., place) improving our the understanding of the urban environment and of the population preferences and dislikes (McCrea et al., 2006; Kothencz et al., 2015). Individual perceptions are derived from filtering objective characteristics through standards of evaluation, which depend on past experiences, aspirations, and personal characteristics (John, 1987). By this means, objective attributes become subjective and lead to a certain degree of satisfaction (John, 1987; Amérigo and Aragonés, 1997; McCrea et al., 2006).

A handful of studies, conducted at individual-level, have reported that residents' satisfaction with cities' resources and functioning is related with health outcomes. In 2012, after inquiring over 5550 Taiwanese youth, Shiue found that satisfaction with neighborhood environment was associated with self-rated health (Shiue, 2012). More recently, Hogan and colleagues evaluated the relationship between happiness levels and city environment. After analyzing data from 5,000 adults aged 25–85 years old living in Berlin, Paris, London, New York, and Toronto, they found that younger adult's happiness levels were associated with having easy access to cultural, shopping, transport, parks and sport amenities and the attractiveness of their cities, whereas, among the older participants, it was more strongly associated with the provision of quality governmental services (Hogan et al., 2016). Perceived neighborhood safety and social environment, specifically, have been often associated with self-rated health (Wen et al., 2006; Kim et al., 2013; Assari et al., 2015), health-related quality of life (Parra et al., 2010), mental illness (Polling et al., 2014), and stroke risk (Kim et al., 2013). And, it is important to highlight that some of these studies confirmed that this association remained significant after accounting for objective measures (Wen et al., 2006; Kim et al., 2014) and one have found that perceived measures, rather than objective ones, have a bigger impact over the studied outcomes (Polling et al., 2014).

Residents' ratings about city resources and functioning have been regularly collected at request of European Union through large Europe-wide surveys (EU, 2016) and might constitute a convenient and informative data source to characterize European cities from that point of view. Although some evidence exists that perceived urban characteristics are associated with individuals' health, so far those datasets remain underexplored and underutilized. Thus, the present study aimed (i) to characterize the health status of 74 European cities, using as indicator all-cause mortality, and (ii) to investigate whether mortality levels are associated with the residents' dissatisfaction with five key domains of urban living: physical, social and economic environment, healthcare, and infrastructures/services.

MATERIALS AND METHODS

Data

All data was obtained at city-level. A city is a local administrative unit where the majority of the population lives in an urban center of at least 50,000 inhabitants (EUROSTAT, 2016).

Data on residents' dissatisfaction was obtained from the Flash Eurobarometer, "Quality of life in European cities" (EU, 2016). This survey has been conducted since 2004 every 3 years at the request of the Directorate-General for Regional and Urban Policy to get a snapshot of people's opinions on a range of urban issues.

Surveys were conducted in 2004, 2006, 2009, 2012, and 2015. The latest survey covered 79 European cities plus four greater cities (greater city is an approximation of the urban centers when this stretches far beyond the administrative city boundaries, EUROSTAT, 2017) and inquired a total of 41,000 citizens.

Although the type and number of items vary by year and country, this survey includes roughly 55 items, covering issues as diverse as employment, environment, housing, transport, culture, city services, and immigration (**Table 1**).

To obtain an overall picture of the residents' dissatisfaction in each city, a global dissatisfaction score and dissatisfaction scores by domain were constructed, according to the following steps:

1. Group items according to domains (social environment, economic environment, physical environment, healthcare, and infrastructures/services; **Table 1**). Items that did not clearly fit these domains (e.g., are you satisfied with the life you lead) were not included ($n = 5$). Groupings were made after discussion between the coauthors. Besides, we examined the robustness of the results to alternate specifications of the scores by serially excluding items and recalculating the score (results remained unchanged, data not shown).
2. Calculate the mean proportion of the dissatisfied and very dissatisfied for each of the 50 included items. We used the mean proportions of the five surveys instead of using a single survey to capture the average ratings of each city. For items with a scale ranging from totally agree to totally disagree we summed the proportion of residents that totally agree/agree or those that totally disagree/disagree depending on whether the issue was detrimental or beneficial.
3. Classify the obtained proportion into quintiles according to obtain a punctuation ranging from 1 to 5 (1 = least dissatisfied … 5 = most dissatisfied).
4. Average the punctuations of the items to obtain a global dissatisfaction score and then average according to domain to obtain dissatisfaction scores by domain for each city. This method of generating punctuations and scores has been employed elsewhere (Ribeiro et al., 2015; Hoffimann et al., 2017) and allow to generate a measure of dissatisfaction based on rank position of each city in the sample distribution.

Because not all cities had complete information on both residents' dissatisfaction and mortality, we included only those with complete information, a total of 74 European cities from 29 countries pertaining to four European regions—Western ($n =$ 32 cities), Southern ($n = 15$), Northern ($n = 10$), and Eastern Europe ($n = 17$) (EUROVOC, 2016). These four regions are characterized by different political, socioeconomic and cultural environments (Vågerö, 2010).

Data on mortality and population were obtained from the Eurostat database for the latest year available (mostly 2013). Total counts of deaths for each city were obtained, as well as deaths by sex and age group for the EU-28, which was used as reference to calculate Standardized Mortality Ratios (SMR) and corresponding 95% Confidence Intervals (95% CI).

TABLE 1 | Items from the Quality of life in European cities survey included in the creation of the summary scores of resident's dissatisfaction ($n = 50$).

SERVICES AND INFRASTRUCTURE ($n = 18$)	
Public transport in the city, for example bus, tram or metro	Outdoor recreation outside/around this city, such as walking, cycling or picnicking
Schools in the city	Minutes per day spent traveling to work/training place
Sports facilities such as sport fields and indoor sport halls in the city	Why don't you use public transport?
Cinemas in the city	Most important in my city: public transport
Cultural facilities such as concert halls, theaters, museums, and libraries in the city	Most important in my city: education and training
Public Internet access such as internet cafes or libraries in the city	Most important in my city: road infrastructure
Internet access at home in the city	State of streets and buildings in my neighborhood
When you contact administrative services of this city, they help you efficiently	Availability of retail shops
This city spends its resources in a responsible way	Public spaces in this city such as markets, squares, pedestrian areas
SOCIAL ENVIRONMENT ($n = 9$)	
Foreigners who live in this city are well integrated	Most important in my city: social services
The presence of foreigners is good for this city	You feel safe in this city
Generally speaking, most people in this city can be trusted	You feel safe in the neighborhood you live in
Most important in my city: Urban safety	The public administration of the city can be trusted
Most people in my neighborhood can be trusted	
ECONOMIC ENVIRONMENT ($n = 9$)	
In this city it is easy to find a good job	The financial situation of your household
In this city, it is easy to find good housing at a reasonable price	Most important in my city: jobs creation / reduce unemployment
You have difficulty paying your bills at the end of the month	Most important in my city: housing conditions
In this city, poverty is a problem	Your personal job situation
Most important in my city: Unemployment	
PHYSICAL ENVIRONMENT ($n = 10$)	
Green spaces such as public parks or gardens	The beauty of streets and buildings in your neighborhood
In this city, air pollution is a big problem	Most important in my city: air pollution
In this city, noise is a big problem	Most important in my city: noise
This city is a clean city	The quality of the air in the city
The cleanliness in the city	The noise level in the city
HEALTHCARE ($n = 4$)	
Health care services offered by hospitals in the city	Most important in my city: health services
Health care services offered by doctors in the city	Health care services offered by doctors and hospitals in this city

Statistical Analysis

Generalized Linear Models (Gaussian) were used to estimate the association between the SMR in each city and residents' dissatisfaction scores. We fitted four different models. First, we measured the bivariate associations between each dissatisfaction score, European region and the SMR (Model 0). Model 1 includes only the SMR and the variable "European Region." In Model 2, dissatisfaction scores were added simultaneously, and successively removed, so that only predictors that made a significant unique contribution were retained. Finally, Model 3 is the same as Model 2, but adjusted for European regions.

It is important to refer that the role of the variable "European Region" was explored because it was clearly associated with both mortality and dissatisfaction and it was not in the pathway between the two, so that it acted as a confounder of the association we aimed to estimate. Besides, to exclude the hypothesis "region" could be a moderator, an interaction term was added to the final model, but it was not statistically significant ($p = 0.269$).

A significance level of 0.05 was used. A Gaussian model was used instead of Poisson's because the SMR were normally distributed and the counts of the deaths were too over-dispersed to run a Poisson or even a negative Binomial model (Kwan, 2014).

RESULTS

Figure 1 and **Table 2** show the distribution of the SMR for the 74 cities included in this study. Twenty-one cities registered SMR significantly lower than 100 (the EU-28 average) and 37 SMR significantly higher than 100. As observable in **Figure 1**, there was a clear Northeast-Southwest division of the SMR, with the highest SMR predominantly found in Eastern and Northern European cities—Miskolc (146.5; 95% CI 140.6–152.6), Riga (136.3; 133.5–139.1), Sofia (133.8; 131.6–136.1), Copenhagen (132.4; 128.4–136.4), Burgas (131.1; 125.6–136.7) and Ostrava (130.2; 125.8–134.7)—and the lowest in Western and Southern European cities—Paris (73.1; 72.0–74.4), Madrid (74.0; 73.1–74.9), Rennes (75.7; 72.8–78.8), Barcelona (79.6; 78.3–80.8), and Heraklion (80.7; 75.5–86.0).

Figure 2 and **Table 3** show the distribution of the residents' dissatisfaction scores. Large geographical differences were also found in the residents' dissatisfaction scores. Eastern and some Southern European cities (mean global dissatisfaction score 3.48 and 3.82, respectively) tended to have higher dissatisfaction scores, contrasting with Western and Northern European cities (mean global dissatisfaction score 2.25 and 2.35, respectively). The five cities with highest global dissatisfaction score were Naples (score of 4.84), Athens (4.84), Rome (4.80), Palermo (4.65), and Sofia (4.45), whereas the lowest were observed in Luxembourg (1.66), Newcastle (1.50), Munich (1.46), Aalborg (1.38), and Zurich (1.31).

Very similar patterns were observed for the domains of dissatisfaction. Dissatisfaction with the economic environment (i.e., unemployment, poverty, ability to make ends meet) was highest in Lisbon (5.00), Naples (4.84), Rome (4.80), Athens (4.84) and Palermo (4.65) and lowest in Aalborg (1.00), Cardiff (1.50), Essen (1.50), Munich (1.67), and Oulu (1.67). Concerning the physical environment (i.e., green spaces, noise, pollution), higher dissatisfaction scores were observed in Rome (4.90), Bucharest (5.00), Sofia (5.00), Athens (5.00) and Naples (5.00), and the lowest in Zurich (1.00), Luxembourg (1.10), Rostock (1.20), Rennes (1.20), and Newcastle (1.29). Healthcare services were rated more poorly (5.00) in Naples, Athens, Sofia, Bucharest, Rome, Palermo, Warsaw, Burgas, Riga, Vilnius, Cluj-Napoca, Gdansk, and Pietra Neamt, whereas Zurich, Rennes, Newcastle, Munich, Bordeaux, Geneva, Oslo, Strasbourg, Graz, Lille, Antwerp, Liege, and Brussels exhibited lower dissatisfaction levels (1.00). Higher residents' dissatisfaction with infrastructures/services (i.e., transport, schools, cultural facilities) were observed in Madrid (4.36), Palermo (4.43), Rome (4.43), Naples (4.50) and Athens (4.71) and lower in Aalborg (1.50), Helsinki (1.50), Zurich (1.00), Geneva (1.00), and Newcastle (1.00). And, finally, the dissatisfaction with the social environment (i.e., trust safety, integration) was higher in Palermo (4.57), Turin (4.86), Naples (4.86), Rome (5.00), and Athens (5.00), and lesser in Zurich (1.14), Aalborg (1.43), Munich (1.43), Luxembourg (1.43), Copenhagen (1.43) and Rostock (1.43).

It is important to note that all domains of dissatisfaction were moderately-highly correlated, and particularly strong was the correlation between dissatisfaction with physical environment and social environment ($r = 0.85$; **Figure 3**), meaning that generally urbanites tend to be simultaneously dissatisfied with numerous aspects of the city environment.

Table 4 shows the associations between residents' dissatisfaction scores and mortality. In Model 0, we looked for the bivariate associations between each dissatisfaction score, region and SMR and we found that only the dissatisfaction score with healthcare ($\beta = 0.286$; 95% CI 0.065, 0.507) was significantly associated with the SMR, although all other regression coefficients were positive, indicating that increased dissatisfaction with cities' attributes was associated with increased mortality. European region was also significantly associated with mortality: compared with Eastern Europe, Southern (-1.476; -2.080, -0.871) and Western European cities (-0.896; -1.408, -0.384) presented significantly lower levels of mortality.

Model 1 only included mortality and the European regions. The proportion of variance explained by this simple model was nevertheless 24.2%.

In Model 2, to take into account the inter-correlation between the five dissatisfaction scores, we entered all dissatisfaction scores in the model and kept only those significantly associated with the SMR. We observed that only the healthcare dissatisfaction score (0.286; 0.065, 0.507) was independently and significantly associated with the SMR, i.e., the higher the dissatisfaction levels of the residents with health aspects the higher the mortality. All the other dissatisfaction scores lost statistical significance, probably due to the high degree of inter-correlation between them, as depicted in **Figure 3**. The proportion of variance explained by Model 2 was very low: 6.9%, much lower than when only European regions were considered.

Adjusting for the European regions (Model 3), dissatisfaction with healthcare (0.286; 0.065, 0.507) and with social environment (0.286; 0.065, 0.507) were both found to be significantly and

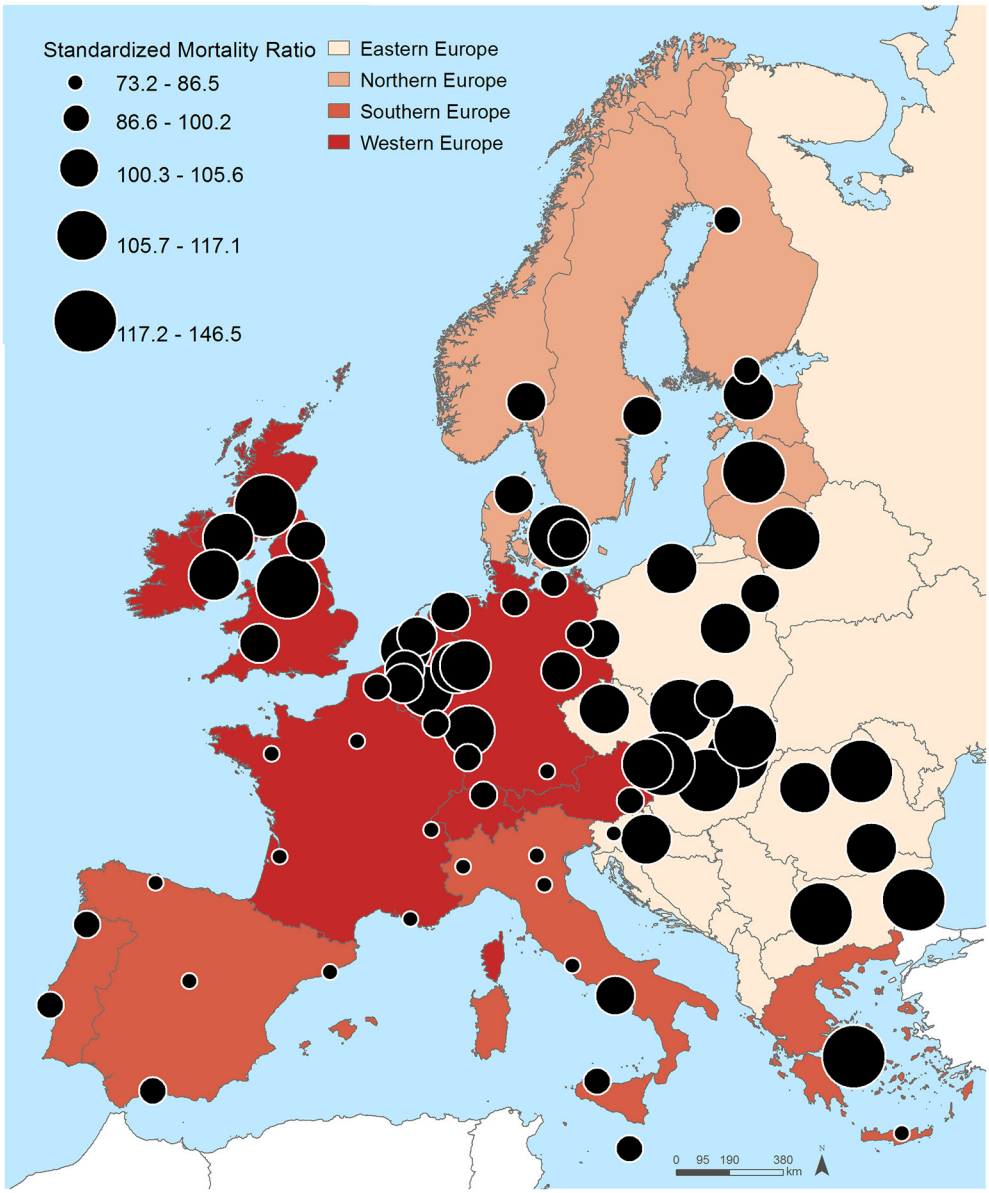

FIGURE 1 | Spatial distribution of the standardized mortality ratios across the 74 included cities.

positively associated with mortality. At the same time, the proportion of variance explained by the model increased to 33.7%.

DISCUSSION

This study was one of the first addressing the health status of European cities. Grounded on a set of Europe-wide Quality of Life Surveys, we were able to explore the link between residents' dissatisfaction with the city and health. We found profound differences in mortality across 74 cities in Europe, with the highest risk of death generally found in Eastern and Northern Europe and the lowest in the South and Western European cities. Residents' dissatisfaction levels varied greatly as well, and were generally higher in Eastern Europe and in some Southern European cities. We found a significant association between city levels of mortality and residents' dissatisfaction with healthcare services and social environment.

The Southwest-Northeast division of health in Europe was a constant in this study. The East-West divide of Europe has been extensively reported elsewhere (Vågerö, 2010). Similarly, the comparatively unexpectedly poor performance in life expectancy gains in some Northern European countries has also been matter of discussion (Juel et al., 2000). This panorama supports the idea that, although cities share some characteristics, both detrimental (pollution, segregation, crowding) and beneficial (concentration

TABLE 2 | Standardized Mortality Ratios (SMR) and 95% Confidence Intervals (IC 95%) in the 74 European cities (ascending order).

City (country, region)	SMR	IC 95%
Paris (FR, W)	73.2	72.0–74.4
Madrid (ES, S)	74.0	73.1–74.9
Rennes (FR, W)	75.7	72.8–78.8
Barcelona (ES, S)	79.6	78.3–80.8
Heraklion (EL, S)	80.7	75.5–86.0
Verona (IT, S)	81.4	78.3–84.5
Bordeaux (FR, W)	81.6	79.5–83.1
Geneva (CH, W)	83.8	79.6–88.2
Rome (IT, S)	83.8	82.8–84.8
Bologna (IT, S)	83.8	81.4–86.3
Munich (DE, W)	84.4	82.9–86.0
Marseille (FR, W)	84.4	82.7–86.1
Turin (IT, S)	84.5	82.9–86.2
Ljubljana (SI, E)	84.6	81.1–88.1
Oviedo (ES, S)	86.5	82.9–90.1
Braga (PT, S)	86.8	81.9–92.0
Graz (AT, W)	88.9	85.1–92.8
Oulu (FI, N)	90.4	84.8–96.3
Málaga (ES, S)	90.8	88.2–93.5
Lisbon (PT, S)	90.9	88.8–93.1
Strasbourg (FR, W)	91.6	88.6–94.6
Luxembourg (LU, W)	93.5	86.4–101.0
Rostock (DE, W)	94.4	90.6–98.4
Palermo (IT, S)	95.7	93.4–98.1
Lille (FR, W)	96.7	94.6–98.7
Zurich (CH, W)	97	93.8–100.3
Valletta (MT, S)	99.3	94.7–104.1
Helsinki (FI, N)	99.5	96.7–102.3
Berlin (DE, W)	99.7	98.6–100.7
Hamburg (DE, W)	100.2	98.7–101.7
Leipzig (DE, W)	100.3	97.7–102.8
Kraków (PL, E)	101.1	98.8–103.5
Bialystok (PL, E)	101.1	97.2–105.2
Newcastle (UK, W)	101.5	97.4–105.8
Stockholm (SE, N)	102.1	99.8–104.6
Groningen (NL, W)	102.5	97.1–108.2
Aalborg (DK, N)	102.7	98.0–107.5
Naples (IT, S)	103.3	101.3–105.4
Malmö (SE, N)	104.1	100.3–108.1
Oslo (NO, N)	104.6	101.5–107.7
Brussels (BE, W)	104.8	102.7–106.9
Frankfurt (DE, W)	104.8	97.6–112.5
Cardiff (UK, W)	105.2	101.3–109.1
Antwerp (BE, W)	105.3	102.4–108.1
Amsterdam (NL, W)	105.6	102.8–108.4
Warsaw (PL, E)	105.6	104.1–107.1
Tallinn (EE, N)	107.2	104.0–110.6
Gdansk (PL, E)	108.3	105.3–111.5
Kaiserslautern (DE, W)	109	102.7–115.4
Vienna (AT, W)	109.6	108.0–111.3
Dortmund (DE, W)	110.3	107.7–112.9
Prague (CZ, E)	110.5	108.5–112.4
Bucharest (RO, E)	111.9	110.4–113.4
Essen (DE, W)	112.6	110.1–115.2
Rotterdam (NL, W)	112.9	110.0–115.9
Cluj-Napoca (RO, E)	113.4	109.3–117.6
Dublin (IE, W)	114.6	111.2–118.2
Belfast (UK, W)	115.1	110.8–119.6
Zagreb (HR, E)	115.6	113.2–118.1
Liège (BE, W)	117.1	113.7–120.6
Bratislava (SK, E)	117.8	114.2–121.5
Piatra Neamt (RO, E)	120.8	113.5–128.3
Manchester (UK, W)	122	118.0–126.1
Kosice (SK, E)	122.3	117.1–127.7
Budapest (HU, E)	125.1	123.4–126.7
Vilnius (LT, N)	129.2	125.9–132.6
Ostrava (CZ, E)	130.2	125.8–134.7
Burgas (BG, E)	131.1	125.6–136.7
Copenhagen (DK, N)	132.4	128.4–136.4
Sofia (BG, E)	133.8	131.6–136.1
Glasgow (UK, W)	135.9	132.6–139.3
Riga (LI, N)	136.3	133.5–139.1
Athens (EL, S)	145.7	142.9–148.5
Miskolc (HU, E)	146.5	140.6–152.6

AT, Austria; BE, Belgium; BG, Bulgaria; CH, Switzerland; CZ, Czech Republic; DE, Germany; DK, Denmark; EE, Estonia; EL, Greece; ES, Spain; FI, Finland; FR, France; HR, Croatia; HU, Hungary; IT, Italy; LI, Lithuania; LT, Latvia; LU, Luxembourg; MT, Malta; NL, Netherlands; NO, Norway; PL, Poland; PT, Portugal; RO, Romania; SI, Slovenia; SK, Slovakia; SE, Sweden; UK, United Kingdom; W, Western Europe; N, Northern Europe; S, Southern Europe; E, Eastern Europe.

of employment, equipment, goods), truth is they seem to reproduce the health status of the whole country making them a kind of a barometer of national health. The Southwest-Northeast division of Europe was also observed for the dissatisfaction levels of the residents, although in Southern European cities a rather large proportion of the residents did also rate poorly several aspects of the city functioning and resources. Real-life problems in city functioning and resources, but also cross-national cultural differences might explain these differences. For instance, when it comes to self-reported health, studies observed cross-national and cultural differences in self-assessed health; generally southern European respondents tended to perceived more poorly their health status than their Scandinavian counterparts (Jürges, 2007).

We found that after removing the effect of the European region (a latent variable that summarize the tremendous structural and cultural differences between European countries/regions), citizen's dissatisfaction levels with key aspects of the urban resources and functioning—healthcare and social environment—were associated to mortality levels of the cities. Evidence of an association between residents' satisfaction and health outcomes and well-being can be found in the literature. Hogan and colleagues, in a four-city study,

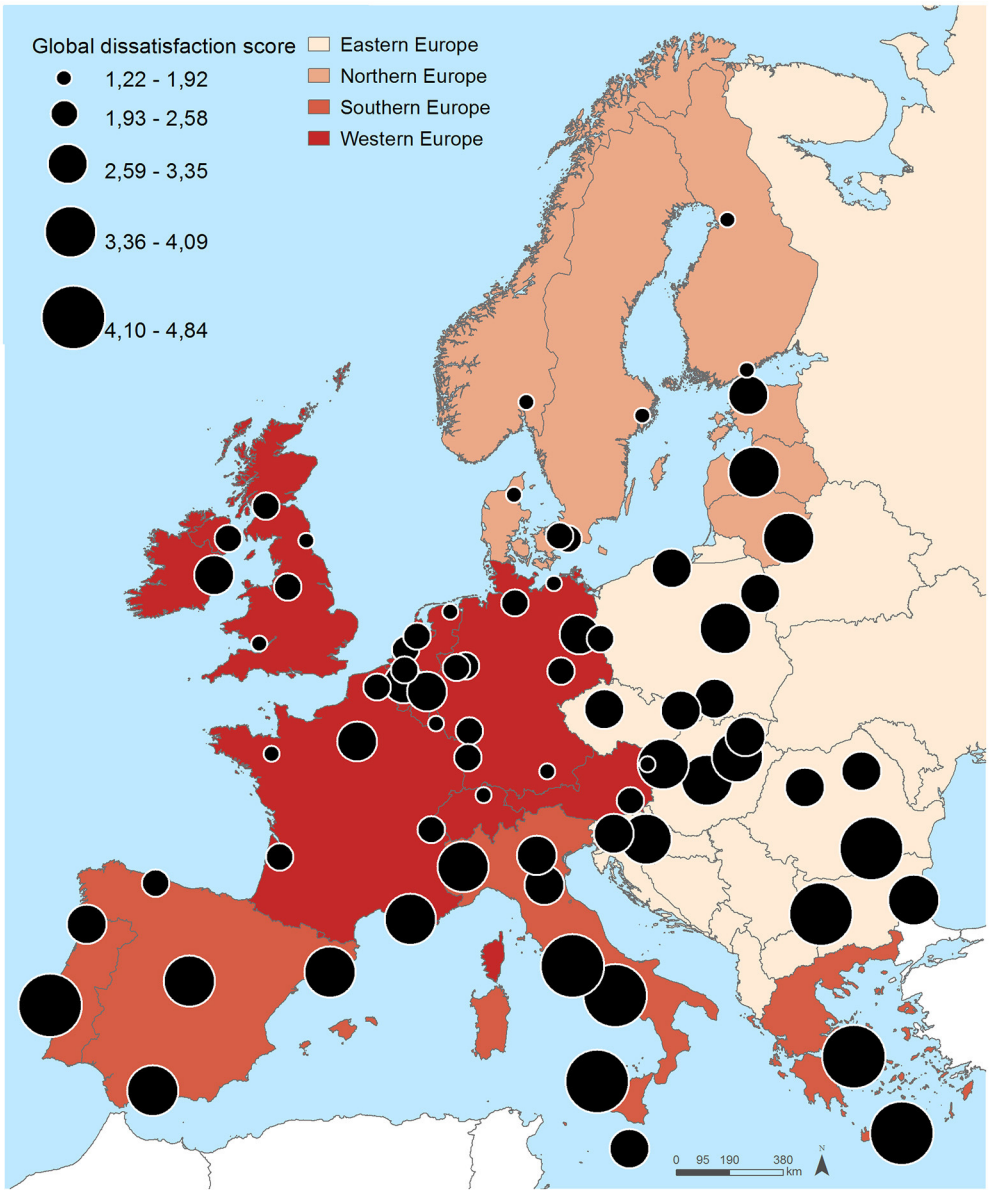

FIGURE 2 | Spatial distribution of the global dissatisfaction scores across the 74 included cities.

have precisely observed an association between residents' ratings about city performance/amenities and their happiness levels (Hogan et al., 2016). Shiue, in Taiwan, found that satisfaction with neighborhood environment was related with self-rated health (Shiue, 2012). And, finally, perceived neighborhood safety and social environment have been consistently associated with numerous health outcomes (Wen et al., 2006; Kim et al., 2013; Polling et al., 2014; Assari et al., 2015).

Apart from the previously mentioned studies, which addressed subjective feelings about the city's performance, the health-impact of the urban environment has been essentially evaluated through objective assessments. Interestingly, our findings corroborate those drawn from studies that used objective measures. This highlights the importance of keep conducting large surveys, as the ones employed in the present study, and of using these data as a complement of objective information. In addition, using perceived/subjective measures offers a number of advantages. Certain issues, such as aesthetics, safety, and disorder, satisfaction with the way services work and/or feelings and attitudes, are difficult to capture using objective assessments (McCrea et al., 2006). Moreover, subjective measures capture the "human perception of space" (i.e., place) improving our the understanding of the urban environment (McCrea et al., 2006; Kothencz et al., 2015). Putting in other words, the objective attributes of the city's environment, once they have been evaluated by the individual (and the personal

TABLE 3 | Residents' dissatisfaction scores according to domain in the 74 European cities (ascending order according global dissatisfaction score).

City (country, region)	Global	Economy	Physical	Healthcare	Infrastructures/services	Social
Zurich (CH, W)	1.31	1.80	1.00	1.00	1.63	1.14
Aalborg (DK, N)	1.38	1.00	1.30	1.67	1.50	1.43
Munich (DE, W)	1.46	1.67	1.30	1.00	1.93	1.43
Newcastle (UK, W)	1.50	1.75	1.29	1.00	1.67	1.80
Luxembourg (LU, W)	1.66	1.83	1.10	1.67	2.29	1.43
Cardiff (UK, W)	1.73	1.50	1.30	2.00	1.71	2.14
Oulu (FI, N)	1.77	1.67	1.40	2.33	1.86	1.57
Rennes (FR, W)	1.83	2.67	1.20	1.00	2.00	2.29
Stockholm (SE, N)	1.85	1.67	1.80	2.00	2.21	1.57
Oslo (NO, N)	1.85	2.40	2.00	1.00	2.13	1.71
Rostock (DE, W)	1.87	2.17	1.20	2.00	2.55	1.43
Wien (AT, W)	1.90	1.83	1.60	1.33	2.00	2.71
Helsinki (FI, N)	1.92	2.00	1.70	2.67	1.50	1.71
Leipzig (DE, W)	1.95	2.33	1.40	1.67	2.36	2.00
Graz (AT, W)	1.97	1.83	2.50	1.00	2.36	2.14
Geneva (CH, W)	1.99	2.80	1.80	1.00	1.63	2.71
Copenhagen (DK, N)	2.02	1.67	3.00	1.67	2.36	1.43
Bordeaux (FR, W)	2.05	3.50	1.70	1.00	2.07	2.00
Belfast (UK, W)	2.08	2.17	1.80	2.00	2.14	2.29
Hamburg (DE, W)	2.12	2.33	1.60	2.00	2.64	2.00
Oviedo (ES, S)	2.12	2.67	1.50	2.00	2.57	1.86
Malmö (SE, N)	2.12	1.67	1.80	3.00	1.86	2.29
Amsterdam (NL, W)	2.17	2.50	2.60	1.33	2.00	2.43
Antwerp (BE, W)	2.20	2.00	3.00	1.00	1.71	3.29
Strasbourg (FR, W)	2.25	3.33	2.40	1.00	1.79	2.71
Rotterdam (NL, W)	2.25	2.00	3.00	1.33	1.79	3.14
Essen (DE, W)	2.27	1.50	2.60	1.67	3.00	2.57
Kaiserslautern (DE, W)	2.30	4.00	1.40	2.00	2.38	1.71
Manchester (UK, W)	2.34	2.17	2.30	2.00	2.64	2.57
Dortmund (DE, W)	2.35	2.17	2.20	1.67	3.00	2.71
Glasgow (UK, W)	2.35	2.67	2.60	2.00	2.36	2.14
Frankfurt (DE, W)	2.56	3.00	2.00	2.00	3.78	2.00
Lille (FR, W)	2.58	3.67	2.60	1.00	2.21	3.43
Ljubljana (SI, E)	2.66	2.83	2.40	3.00	2.93	2.14
Bialystok (PL, E)	2.74	3.33	1.30	4.33	2.57	2.14

AT, Austria; BE, Belgium; BG, Bulgaria; CH, Switzerland; CZ, Czech Republic; DE, Germany; DK, Denmark; EE, Estonia; EL, Greece; ES, Spain; FI, Finland; FR, France; HR, Croatia; HU, Hungary; IT, Italy; LI, Lithuania; LT, Latvia; LU, Luxembourg; MT, Malta; NL, Netherlands; NO, Norway; PL, Poland; PT, Portugal; RO, Romania; SI, Slovenia; SK, Slovakia; SE, Sweden; UK, United Kingdom; W, Western Europe; N, Northern Europe; S, Southern Europe; E, Eastern Europe.

characteristics and experience they carry), become subjective, and lead to a certain degree of satisfaction (John, 1987; Amérigo and Aragonés, 1997).

Regarding the impact of social environment, our results corroborate the literature reporting that social support and social connectedness networks are very important, not only as a complement to the formal healthcare system, but also as a protection against the adversities inherent of being ill, being poor and being alone (Seeman, 1996). Indeed most of the studies that addressed whether residential satisfaction affected health outcomes, point toward the same direction. Perceived neighborhood safety and social environment have been associated with self-rated health (Wen et al., 2006; Kim et al., 2013; Assari et al., 2015), health-related quality of life (Parra et al., 2010), mental illness (Polling et al., 2014), and stroke risk (Kim et al., 2013). And, importantly, some of these studies confirmed this association remained significant after accounting for objective measures (Wen et al., 2006; Kim et al., 2014) and others found that indeed perceived measures of the social environment, rather than objective ones, show a larger association over the studied outcomes (Polling et al., 2014). It is also interesting to note that our results do also show a particularly strong correlation between social and physical environment that has also been reported elsewhere; apparently, health-supportive physical environments influence the social capital of the places, by reducing social inequalities (Mitchell and Popham, 2008), and

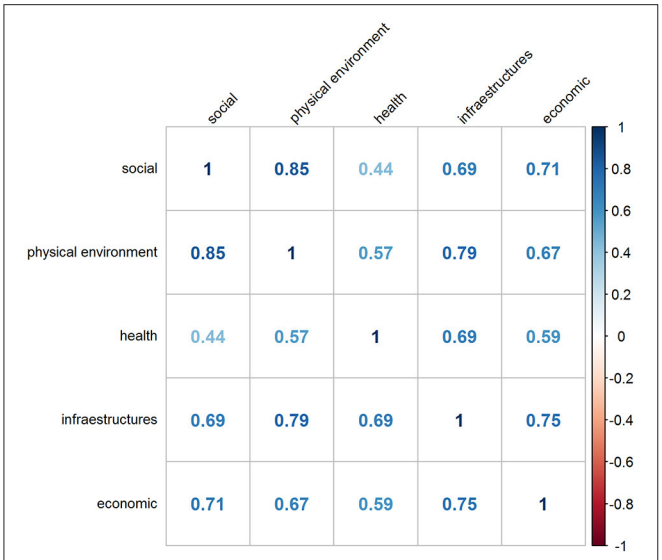

FIGURE 3 | Correlations between the domains of residents' dissatisfaction.

TABLE 4 | Association between residents' dissatisfaction scores and standardized mortality ratio in the 74 cities.

Variables	Model 0 (β and 95% CI)	Model 1 (β and 95% CI)	Model 2 (β and 95% CI)	Model 3 (β and 95% CI)
DISSATISFACTION SCORES				
Economic	0.007 (−0.224; 0.238)		–	–
Physical environment	0.171 (−0.057; 0.399)		–	–
Healthcare	**0.286 (0.065; 0.507)**		**0.286 (0.065; 0.507)**	**0.334 (0.030; 0.639)**
Infrastructures/ services	0.093 (−0.137; 0.323)		–	–
Social	0.142 (−0.087; 0.370)		–	**0.239 (0.015; 0.464)**
EUROPEAN REGION				
Eastern	Ref	Ref	–	Ref
Northern	−0.326 (−1.006; 0.354)	−0.326 (−1.006; 0.354)	–	0.196 (−0.506; 0.899)
Southern	**−1.476 (−2.080; −0.871)**	**−1.476 (−2.080; −0.871)**	–	**−1.510 (−2.096; −0.923)**
Western	**−0.896 (−1.408; −0.384)**	**−0.896 (−1.408; −0.384)**	–	−0.153 (−0.859; 0.553)
Variance explained (%)	–	**24.2**	**6.9**	**33.7**

Model 0, univariable; Model 1, multivariable, not adjusted for European region; Model 2, multivariable, adjusted for European region.
In bold, statistical significant coefficients.
β, standardized regression coefficient and 95% Confidence Intervals (CI).

by enhancing social interaction and social inclusion (Maas et al., 2009).

When it comes to healthcare, although the questions from Urban Audit were comparatively fewer and somehow vague, the answers might provide an idea on how satisfied patients were with healthcare services. In our study, we found a significant association with mortality—higher mortality rates were observed in cities with higher dissatisfaction scores with healthcare—indicating that, as other suggested, the systematic evaluation of patient satisfaction might provide useful information on patients' experiences that can contribute for improving the performance of healthcare services and the quality of care provided to the patients (Browne et al., 2010).

Several studies and reports support the health benefits of high patient satisfaction; satisfied patients may have increased treatment adherence and better health outcomes (Chue, 2006; Glickman et al., 2010; Zgierska et al., 2014). Also suggesting that satisfaction with healthcare is critical for the population well-being, Hogen and colleagues observed that the effect of healthcare performance on well-being and happiness was significant for all groups and not only for those over 65 years, contrasting with most of the studied satisfaction domains that did only associate with happiness in specific age groups (Hogan et al., 2016).

In our study, we did not find a significant association between dissatisfaction levels with the physical environment and mortality, a topic that numerous studies have explored by looking at the impact of air pollution exposure. Multiple polled and meta-analysis studies showed air pollution is directly associated with mortality, cardiorespiratory diseases and allergies (Beelen et al., 2014). Access to greenspace and noise exposure did also seem to be associated with numerous health outcomes: overall mortality (Barceló et al., 2016; Gascon et al., 2016), mental health (Lee and Maheswaran, 2011), and behaviors, such as physical activity (Cohen et al., 2007). More recently, increasing attention has been given to the contact with nature and water within urban contexts (Hartig and Kahn, 2016). According to numerous studies conducted in different countries, the human interaction with natural environment provides opportunities for relaxation, enhances connections between urban inhabitants and the biosphere, and promotes subjective well-being and happiness (MacKerron and Mourato, 2013; Marketta et al., 2015; Hartig and Kahn, 2016; Samuelsson et al., 2018).

Yet, several other studies have found that, compared to other aspects, namely socioeconomic conditions and access to healthcare, the physical environment play a less important role (Hood et al., 2016). Moreover, some investigations have shown that the exposure to harmful physical environments may be more strongly associated with specific causes of death, namely cancer, and not so strongly with overall mortality (Ribeiro et al., 2015). Regrettably, in our study we were not able to differentiate the causes of death. Note that, as previously mentioned, physical, and social environment dissatisfaction scores were very correlated, which means that these two kinds of deprivation tend to happen simultaneously, making it difficult to separate their effects.

Although several studies suggest that availability of destinations, services and good-quality infrastructures bring numerous health benefits (Frumkin, 2002), from obesity prevention (Sarkar et al., 2017) to feelings of well-being (Marketta et al., 2015), in our study, no significant association between dissatisfaction with infrastructures/services and mortality levels was observed. Similarly, we found that perceived economic environment was not significantly related with

mortality in European cities. This finding deserves further validation, as the absence of an association does not imply they are uncorrelated. The fact we did not find a significant link between urban mortality and resident's ratings about the economic circumstances might be related with the specificity of our data and of our study area. The link between health and socioeconomic individual or group characteristics is probably one of the oldest and solidest findings in public health. But, these findings have been mostly drawn on objective indicators of socioeconomic circumstances (personal income or area level income, unemployment rates, occupation, etc.), which might not necessarily reflect the people's feelings about their and cities' economic problems. Some authors argue that income inequality, the discrepancy in income between population groups, rather than income, the population average, might be particularly important for health, being associated with higher disparities and lower longevity and life expectancy (Wilkinson, 1992; Truesdale and Jencks, 2016). The commonly used indicators of economic environment evaluate the amount of disposable income and material resources per capita, which despite being undoubtedly essential, turn a blind eye to people's beliefs about the fairness of income distribution, perceptions of their own income and their ability to make ends meet. These aspects are particularly important in the definition of deprivation. Deprivation refers to unmet need, which is caused by a lack of all kinds of resources, rather than financial needs alone and it can also be categorized as objective or subjective (Townsend, 1979, 1987; Guillaume et al., 2016). Objective deprivation is perceived collectively or socially and is registered in the census; subjective deprivation is individually perceived and is assessed by questionnaire in specific surveys (Townsend, 1979, 1987; Guillaume et al., 2016). Finally, it is also important to highlight that, in general, cities are characterized for being economically dynamic places even in more disadvantaged regions/countries, which might mean that what would distinguish a city from another might be aspects unrelated with economic circumstances (Hogan et al., 2015, 2016), as the ones we identified.

Our study presents some limitations that deserve further discussion. Firstly, we have focused on a pre-selected set of large cities leaving behind medium and small urban settings, which hold a significant amount of the European population. Then, our results might not be valid for these medium and small urban settings. Secondly, we have also focused on a single indicator of population health, mortality. A study of such nature would be improved by including other measures of health status such as preventable mortality or healthy life expectancy, unfortunately not available at city-level. Additionally, we assumed a single value of mortality of each city, despite knowing that European cities tend to exhibit a rather large within city heterogeneity in health outcome (Marí-Dell'Olmo et al., 2015) that an overall measure might not capture. The ecological design constitutes another important limitation, as we cannot guarantee the observed associations occur at individual-level too. Yet, notice that a dozen cross-sectional studies, conducted at individual-level, reported a significant relationship between satisfaction and individual health status (Wen et al., 2006; Shiue, 2012; Kim et al., 2013; Polling et al., 2014; Assari et al., 2015). Finally, the present study relied on a relatively small dataset and we could not confront our results with the ones that would be obtained by using objective measures about the urban environment, which would be ideal, since they are non-overlapping measures complementing each other (Nyunt et al., 2015).

Study strengths should be highlighted too. Our study provides a global view of the health status of European urbanities and it is the first establishing a link between residents' ratings about several aspects of city functioning and resources and objective measures of health. Because we grounded our study on Urban Audit Database, our geographical units and indicators are directly comparable, which strengthens our study. Our findings may also be important for city planners as they showed a relationship between citizen's perceptions about certain urban attributes and mortality, suggesting that measuring citizen's satisfaction with the urban environment might aid in the construction of healthier cities.

In conclusion, we revealed large inequalities in health between European cities and we found a significant association between city levels of mortality and residents' dissatisfaction with certain urban features, suggesting subjective information can be also used to comprehend the health of the urbanities. At a city-level, dissatisfaction with the healthcare services (care provided by doctors and hospitals) and social environments (trust, networks) seemed to be detrimental factors to health across European cities. So, although much more attention has been given to traditional economic and material determinants of health, these complementary aspects should not be disregarded by the local governments.

AUTHOR CONTRIBUTIONS

AR designed the study, performed the statistical analysis and drafted the manuscript. SF and HB supervised the research, contributed to the interpretation of results and helped to draft the manuscript. All authors read and approved the final manuscript.

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Cultivating Positive Youth Development, Critical Consciousness, and Authentic Care in Urban Environmental Education

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This paper addresses the issue of how to provide affordances for youth development in the context of environmental stewardship in cities. Urban environmental education encompasses place-based and action-oriented stewardship practices, including community gardening and vegetable production, often with the dual goals of developing youth and community assets. Yet in-depth understanding of how these goals are achieved is lacking. Using narrative inquiry, we explored participant experiences in a multi-year agriculture internship program conducted by the food justice organization East New York Farms! (ENYF) in Brooklyn, NY. Emerging from our conversations with youth were five themes defining their intern experience: ENYF as somewhere to belong, to be pushed, to grapple with complexity, to practice leadership, and to become yourself. We propose a theory of change that emphasizes politicized notions of caring as a foundation for cultivating developmental assets, including competence, contribution, and critical consciousness, among youth who participate in ENYF programs multiple years. This paper extends the literature on socio-environmental affordances to encompass urban environmental education programs, which incorporate physical and social features that act as affordances. Further, this paper describes a feedback loop in which youth afforded opportunities to develop assets through contributing to their community in turn create affordances for additional youth and adults.

Keywords: environmental education, positive youth development, authentic care, urban environmental education, youth of color, critical consciousness

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INTRODUCTION

Urban environmental education is one means by which children realize the affordances offered by nature and social interactions in cities (Chawla, 2001, 2006). For example, urban environmental education programs serve as settings for developing youth assets (Schusler and Krasny, 2010), elements of sense of place (Kudryavtsev et al., 2012) and social capital (Krasny et al., 2013), and resilience at the individual, community, and social-ecological systems levels (Dubois and Krasny, 2016). In U.S. cities, community organizations and non-profits conduct environmental education programs after-school and during summers, often with youth of color who live in low-income neighborhoods and are hired as paid interns (Smith et al., 2015). Activities include urban agriculture, collaborating with scientists in data collection (e.g., on treatments to mitigate combined sewer overflow), park maintenance, oyster and coastal dune restoration, street tree planting and

pruning, and other forms of direct stewardship action. Urban environmental education programs also engage youth in indirect actions such as policy advocacy and teaching younger children (Russ and Krasny, 2017).

In a study of nine rural, suburban, and urban programs that engaged youth in direct and indirect environmental actions, Schusler and Krasny (2010) found that such programs can provide affordances for developing cultural and interpersonal competence, self-esteem, sense of purpose, and other youth developmental assets or qualities that help youth succeed in school and civic life (Benson et al., 2011). However, we lack in-depth knowledge of how features of environmental education programs, such as physical setting and social interactions, afford opportunities for positive youth development in ways that are responsive and relevant to urban young people of color, such as through developing critical consciousness, or a moral stance linked to socio-political awareness and actions in the larger world (Mustakova-Possardt, 1998). In this paper, we explore in-depth how an urban agriculture youth intern program in Brooklyn NY, provides developmental affordances for youth of color in a low-income neighborhood. Specifically, we asked: How do interns' narratives describe the ways in which participation in an urban agriculture, environmental education program fosters development of youth assets and critical consciousness?

Through in-depth interviews with youth, elements of authentic care, or caring relationships that honor students' experiences of class, race, and culture (Valenzuela, 1999), emerged as part of the process of developing youth assets. Thus, we propose that urban environmental education, rooted in a context of authentic care demonstrated by adult leaders and peers, provides affordances for positive youth development and the development of critical consciousness. The results of this research contribute to our understanding of a widespread practice in urban environmental education, i.e., engaging youth in urban agriculture and other direct and indirect environmental action, while expanding on earlier notions of urban affordances for child development, which have focused largely on physical infrastructure (e.g., Kyttä, 2002).

THEORY AND BACKGROUND

Research on positive youth development, authentic care, critical pedagogy of place, affordances, and environmental education informed this study and are briefly reviewed below.

Positive Youth Development

Starting in the 1990s, interventions and research to support families and children shifted from a focus on problem behaviors of troubled teenagers to factors that are present when youth experience healthy physical, intellectual, emotional, and social development (Eccles and Gootman, 2002; Roth and Brooks-Gunn, 2003; Catalano et al., 2004; Lerner and Lerner, 2011). An outcome of this work is an asset-based approach, referred to as positive youth development, which assumes that all youth have the capacity to become successful adults given appropriate support (Eccles and Gootman, 2002; Lerner et al., 2005).

Positive youth development scholars and practitioners consider both youth assets and the types of settings that enable youth to develop those assets (Eccles and Gootman, 2002). Assets include self-efficacy, prosocial norms, and meaningful relationships with peers and adults, as well as more broadly social, emotional, cognitive, behavioral, and moral competence (Catalano et al., 2004). Another approach to positive youth development focuses on the "Five Cs," defined as "Competence, Confidence, Connection, Character, and Caring" (Lerner et al., 2005), with competence, confidence, and connections more common outcomes of youth programs than character and caring (Roth and Brooks-Gunn, 2003). Studies of youth programs as contexts for positive youth development have revealed that a sixth C, "Contributions" to community and civil society, is possible when the other five are present (Lerner et al., 2005).

Youth programs conducted by community-based organizations and national non-profits (e.g., YMCA, Boys and Girls Clubs) offer features known to promote positive youth development (Larson, 2000; Larson and Angus, 2011; Lerner and Lerner, 2011; Salusky et al., 2014), including supportive relationships, opportunities to belong, positive social norms, support for efficacy and mattering, opportunities for skill building, structure and safety, and integration across family, school, and community efforts. To support positive youth development, programs should be long-term; foster positive relationships among youth and between youth and adults; include activities that build life skills through setting expectations, posing challenges, and providing recognition; and empower youth by providing opportunities to use life skills as participants in and leaders of community activities (Eccles and Gootman, 2002; Roth and Brooks-Gunn, 2003; Lerner and Lerner, 2011).

Although influential in policy and research, the positive youth development framework has been critiqued for paying scant attention to structural inequities and barriers to development such as poverty, racism, sexism, homophobia, and other forms of injustice (Sukarieh and Tannock, 2011). Social justice youth development, which seeks to cultivate critical consciousness and social action (Ginwright and Cammarota, 2002), addresses these critiques and mirrors calls for environmental education that engages issues of power and justice (Bowers, 2002; Gruenewald, 2003).

Authentic Care

Valenzuela (1999) study of Mexican-American and immigrant youths' schooling points to the importance of authentically caring relationships that honor students' experiences of class, race, and culture. Similarly, Bartolomé (2008) offers the notion of *cariño,* reflecting an "understanding that caring for and loving one's subordinated students is insufficient unless the love and care are informed by authentic respect and a desire to equalize unequal learning conditions in school" (p. 2). For teachers, authentic care goes beyond solely caring for individual students to encompass preparing students to confront inequitable and undemocratic social structures (Ladson-Billings, 1995). Drawing from a study of exemplary black women educators, Beauboeuf-Lafontant (2002) articulates a notion of womanist caring that

links self-change to long-term work toward social change, and embraces "the maternal," political clarity, and an ethic of risk that acknowledges caring does not guarantee one can have a positive influence on youth. Discussions of care and caring in environmental education traditionally focus on teaching students to care for and about nature (Russell and Bell, 1996; Martin, 2007), although McKenzie and Blenkinsop (2006) outline a broader ethic of care in outdoor adventure education programs. Authentic care for youth by adult leaders can be considered a social affordance provided through environmental education programs.

Critical Pedagogy of Place

Environmental education taking place in the context of racial and ethnic diversity in cities demands a critical perspective (Ceaser, 2012; Cermak, 2012; McKenzie et al., 2017) that seeks to promote ecological and social justice by addressing issues related to structural oppression and social identity (Cole, 2007). In one such program, Cermak (2012) used "green hip hop" to connect environmental concepts to students' lived experiences as a means of instilling critical ecological literacy.

Drawing on place-based education (Sobel, 2004), ecosystem science, and critical pedagogy (Freire, 1970), Gruenewald (2003) proposes a "critical pedagogy of place" that integrates ecological understanding with an analysis of issues related to power and justice. The goal is to cultivate critical consciousness (*conscientização*, Freire, 1973) and encourage action that addresses poverty, environmental racism, food security, and equitable access to green space. Critical pedagogy of place integrates *decolonization,* or the undoing of the damage caused by oppression through recognizing, developing the tools, and acting to disrupt inequitable systems; and *reinhabitation*, or learning to live well together in a place through restoration, preservation, and transformation of both human and non-human relationships (Gruenewald, 2003; Gruenewald and Smith, 2008). Smith (2007) demonstrated how community-based projects were successful in connecting students to local people and places—supporting a process of reinhabitation—but took only small steps in instigating a process of decolonization, which he attributes to educators' fear of administrator or community backlash when addressing controversial topics.

Affordances and Environmental Education

Previous work on affordances has focused on how children in environmental education programs can use and shape features of the physical environment, such as making a sculpture from branches or building a dam with small rocks in a stream (Chawla, 2006; Said, 2012). Being able to use and shape these physical affordances contributes to learning and action. According to Chawla (2006), when children are able to see changes in their environment as a result of their actions, they learn not only about physical properties of the world but also about their own capabilities, and thus develop competence.

In addition to physical settings, behavior settings that enable interactions among youth and adult leaders provide opportunities for learning (Chawla, 2006). Researchers have emphasized affordances for developing social skills, which may be particularly important for children and adolescents as they go through stages of development (Kyttä, 2004), and have described how children might shape affordances through participation in environmental planning (Kyttä et al., 2004; Rudd et al., 2017). Clark and Uzzell (2002) proposed the notion of integrated socio-environmental affordances, such as a young person's home, school, playground, neighborhood, or city center, which integrate physical (e.g., plants, buildings) with social features, such as people with knowledge, observable behaviors, attitudes, and cultural values. We suggest that urban environmental education programs also offer socio-environmental affordances stemming from the rich settings (e.g., community gardens, farmers' markets) and social interactions that occur within these programs. In this paper, we are particularly interested in affordances that lead to the development of youth assets, such as caring, contribution, and competence, and that incorporate critical thinking or awareness.

Environmental Education Programs as Providers of Affordances for Positive Youth Development

Environmental education encompasses a wide range of programs that provide access to nature and adult mentors (Sauvé, 2005; Fraser et al., 2014), including those in which youth are active agents changing their environment and community. Thus, similar to youth programs more broadly, environmental education programs may provide adolescents with opportunities to develop responsibility and agency (Larson and Angus, 2011; Salusky et al., 2014) and may serve as a gateway to broader participation in civil society (Lerner et al., 2003, 2005; Lewis-Charp et al., 2003). In particular, place-based (Sobel, 2004), critical pedagogy of place (Gruenewald, 2003), participatory (Reid et al., 2008; Læssøe and Krasny, 2013), and environmental action (Jensen and Schnack, 1997; Schusler and Krasny, 2014) approaches to environmental education seem well-suited to providing affordances for positive youth development because they engage young people in reflection and in community environmental action.

Insights into positive youth development and environmental education have emerged from studies of environmental action programs in community settings (Schusler et al., 2009; Schusler and Krasny, 2010). Such programs engage youth in volunteerism, service learning, and related forms of civic participation, which provides opportunities for developing youth assets (Lerner et al., 2003; Lewis-Charp et al., 2003; Chung and Probert, 2011; Lerner and Lerner, 2011). In one study, educators leading environmental action programs spoke about "preparing youth for future roles as voters who think critically about issues and as citizens committed to serving their community whether in environmental or other arenas" and as "agents of social change within their communities" (Schusler et al., 2009, p. 117). Other studies have linked youth environmental civic engagement to school success, communication skills, feelings of self-worth, sense of social commitment and responsibility, and development of social skills and positive relationships (Riemer et al., 2014; Stephens, 2015). Leaders of environmental action

programs describe multiple program elements that contribute to positive youth development including creating safe spaces, providing structure, building relationships, bridging differences, setting expectations, providing opportunities for meaningful contribution, supporting youth, connecting youth with their community, and expanding horizons through novel experiences and reflection (Schusler and Krasny, 2010). Similarly, studies of environmental clubs have documented multiple positive youth development outcomes in Africa (Johnson-Pynn and Johnson, 2010), China (Johnson et al., 2007), Guyana (Comber, 2016), and Canada (de Vreede et al., 2014).

In addition to being outcomes of environmental action programs, youth assets such as locus of control and social connectivity may predict future environmental behaviors (Hungerford and Volk, 1990) and collective environmental actions (Chawla and Cushing, 2007), suggesting feedbacks between engaging in action and developing assets. The notion of feedbacks between environmental action and positive youth development is consistent with Silbereisen and Eyferth's (1986) "development as action in context," which proposes that development is an outcome of intentional, goal-oriented action that produces changes not only in the individual but also in the program context or community. For example, youth in environmental action and club programs shape their environment to meet larger social goals—such as planting a community garden to enhance community cohesion and food access—which in turn provides a setting for youth to develop competence and self-efficacy. In short, adolescents in an environmental education program may *shape* an environment or an affordance so that it supports the pursuit of their goals and in so doing develop assets (Clark and Uzzell, 2002).

METHODOLOGY AND METHODS

The results reported here are drawn from a master's degree study integrating positive youth development and critical pedagogy of place in urban environmental education (Delia, 2013).

Program Context

We examined positive youth development within the context of the non-profit organization East New York Farms! (ENYF), whose mission is "to organize youth and adults to address food justice in our community by promoting local sustainable agriculture and community-led economic development[1]." Because ENYF is part of a community organization started in the 1960s as a grassroots, community response to racist policies and poverty (Thabit, 2003) and a need for educational and social programming (UCC, 2017) in East New York, we felt it would be an ideal site to examine positive youth development within the context of an organization that explicitly integrates resistance and critical perspectives into youth and community development.

We worked with ENYF's urban agriculture youth internship program, which employs up to 35 youth during the growing season from March until November. The interns learn hands-on agricultural skills at the ENYF farm and in nearby community gardens, run ENYF farmers' market stands, and learn about environment, health, community development, leadership, and social justice through their hands-on experiences and workshops. First-year interns participate in all aspects of growing and selling the food at markets as well as in all in-house workshops and off-site conferences. Returning interns (second-, third-, and fourth-year) take on greater responsibility including leading crews of first-year interns at the ENYF site and nearby community gardens, learning specialized knowledge (e.g., about producing and selling food), and leading workshops for first-year interns and at conferences (Delia, 2013). In this study, we focused on nine returning interns some of whom were also crew leaders for younger interns, and how they depicted the ways in which participation in an urban, farm-based environmental education program contributed to their development and critical consciousness.

Methodology

The first author used narrative inquiry (Clandinin and Connelly, 2000) over two summers to establish a trusting relationship with ENYF staff and youth, to understand how youth and staff perceived the youths' experience at ENYF, and to offer insights that can be reshaped and applied in other settings. Narrative inquiry is suited to the study because it allows for deep understanding of participants' experiences in the context of their lives within and beyond ENYF, and addresses ethical considerations and views of the authors about what counts as knowledge and the purposes of research (e.g., that research "subjects" are authoritative experts on their own lives and lived experiences, and that this knowledge goes beyond the "anecdotal"). Reflecting "the stories of life contained in the inquiry" (Clandinin and Connelly, 2000, p. 41), the interns' personal narratives allowed us to explore in-depth observations and practical theories regarding positive youth development in the context of an urban agriculture intern program.

Ethics

We followed an appreciative inquiry process, defined as "a research method focusing on positive organizational attributes that may fuel change" (Grant and Humphries, 2006, p. 402), to address ethical concerns about conducting research on a small, community-based organization and its participants. This entailed focusing our interview questions on youth assets and programmatic strengths to elicit intern stories that demonstrated what worked well at ENYF, while applying a critical lens through reflection and deliberation during (Reed, 2007) and after (Grant and Humphries, 2006) the inquiry process. Further, recognizing her positionality as a white outsider, ten years older than interviewees, the first author and researcher spent significant time participating in the program to be able to develop trusting relationships with participants. She sought to bring intern voices to the forefront and allowed interns to largely determine the tempo and direction of the interview. Finally, the first author is an experienced youth worker who brought training and expertise to engaging young people in conversations around potentially challenging topics.

[1]ENYF (2017). *East New York Farms!* Available online at: https://ucceny.org/enyf/.

This study was approved by the Cornell University Institutional Review Board and ENYF. Informed written consent was obtained from all interviewees and where appropriate, their legal guardian. In the consent form and in practice, participants could decline to participate in the study, refuse to answer a question, or request to turn off the audio recorder at any time.

Participants

After working alongside interns during the first year to establish trust and rapport and develop preliminary insights, the first author pursued open-ended interviews with nine returning interns (two males and seven females). The interviewees were purposely chosen as being the only returning interns in the program and thus being able to reflect on their long-term internship experience. All interviewees were secondary-school-aged (15–18 years, mean age = 16.3, $SD = 1.1$) youth of color living in Brooklyn, NY. Their ethnicities and race varied, including African-American and youth of Dominican, Puerto Rican, Nigerian, Guyanese, and Jamaican heritage. Family income for interns was not available although ENYF considers financial need in the intern application process. All names used in the study are pseudonyms chosen by the participants to protect their anonymity.

Data Collection

In her first field season, the first author conducted informal discussions and focus groups with interns and ENYF staff to develop the interview questions. During the second season, she conducted and recorded two-part interviews (each about an hour in length) with returning interns to elicit thick description (Geertz, 1973) of participants' ENYF experiences in the context of their personal histories. The first interview, designed to understand youths' stories in context, focused on life-story and personal background, prioritizing questions related to school, family, friends, and role models, activities outside the program, and future personal and professional aspirations. The second interview focused on participants' ENYF experiences including how they found out about the program; how they became involved; stories about their interactions with other youth, staff, and community members; and reflections on what they had learned and its usefulness outside the program. All interviews were conducted one-on-one with the exception of one second interview conducted with two interns. The first author also recorded reflections and observations of the intern program in field notes.

Data Interpretation

The first author and two research assistants transcribed all the interviews as close to verbatim from the recordings as possible, including various speech utterances (e.g., um). The first author then read all transcripts, which informed her initial understanding of the relationship between the two a priori theoretical frameworks (positive youth development and critical pedagogy of place) and the emergent focus of care and caring. During subsequent coding, the first author focused on themes that emerged from analysis of individual narratives, which she then "checked" and explored further by looking across narratives.

Although the a priori frameworks influenced the initial reading, subsequent interpretation was based on open coding of the narratives. By utilizing both deductive and inductive strategies, both authors were able to identify codes that were informed by questions related to positive youth development and critical pedagogy of place but also be open to emergent codes that connected statements in context of a coherent understanding of the whole program (Glaser and Strauss, 1999; Maxwell, 2005). After the first open coding generated an extensive list of codes, the first author revisited the data to identify major themes and subthemes related to these codes using Atlas.ti. Through an iterative process of reading, coding, and reflecting on the transcripts, a relationship between the major themes emerged, which the authors sought to represent as a theory of change to explain how ENYF fosters positive youth development.

The first author returned to ENYF to conduct a focus group with a subset of interviewees to solicit feedback on early data interpretation. She shared transcript excerpts with participants to member check their stories and seek permission before sharing quotes. Through discussions with ENYF staff, she also developed a deeper understanding of the emergent theme of authentic care.

Throughout the data interpretation, the first author recorded memos noting general themes, patterns, novel or confusing information, and contradictions within and across narratives (Saldaña, 2013). She also used a process described as "rigorous improvisation" in the context of social justice youth development research (Ginwright and Cammarota, 2007), which involved observing young people at ENYF, immersing herself in dialogue with academic colleagues about what was happening in the program, returning to ENYF to delve deeper into understanding youths' experiences, and revising her interpretation based on overlapping and divergent information within interviews, literature, conversation, observations, and ethnographic notes.

RESULTS

> … you not dragging me down now 'cause I got somewhere to *go*, I got somewhere to *be*, so when you gonna stay in this house, while I go work at the garden, at the farm, you know, making my money while you just sit here. (Nova, fourth-year intern).

Starting with Nova's statement in which she passionately explains how ENYF gives her "somewhere to go…somewhere to be," we explore how ENYF is not just a job or educational program for the interns, but *somewhere to belong*, *to be pushed*, *to grapple with complexity, to practice leadership,* and *to become yourself*. Within each of these themes that emerged from our analysis, we identified subthemes, which we mapped to constructs related to developmental assets and settings from the positive youth development literature and to critical consciousness from critical pedagogy of place scholarship (Delia, 2013). Below we cover all five themes but focus on *belonging* and *being pushed* as relates to authentic care, and *grappling with complexity* as relates to critical consciousness. We have edited the intern quotes illustrating these themes slightly to remove words such as "like" and repeated phrases, while trying to maintain youth voice accurately. A full

narrative account of the interns' stories can be found in Delia (2013).

Somewhere to Belong

> …so we see that person—all right, they havin' a bad day. And we go cheer 'em up or go talk to them… It's just like a family. East New York Family Farm—like a family. … I'm wanted here 'cause I don't wanna be no place that I'm not wanted. (Cedrick, second-year intern, crew leader).

Youth shared stories of their initial days as first-year interns and how they remembered *feeling welcomed* and appreciated by staff and returning interns. Over time, interns began to *feeling safe* and able to open up to adults and their ENYF peers, and *felt cared for and connected*.

Feeling Welcomed

Tamara recounts her early days at ENYF and the ways in which other youth persisted in their attempts to welcome and get to know her when she was reluctant to open up.

> My first year, the first time I started working here I was quiet, like I didn't want to talk to nobody. I didn't really know anybody and I was working in the garden and then I had to work with Kimberlé, Jayden, and Aisha… Jayden kept trying to get conversations out of me. And I was answering him with one [word] answers. … and then Kimberlé tried talking to me and then she was like, you know, forget it. And then, everybody, but they still trying to talk to me and then finally I loosened up and I started talking. (Tamara, third-year intern, crew leader).

Kiah explains how staff members made her and the other interns feel respected and appreciated when they first started the youth program.

> … when I first came to the program, [staff member] made me feel welcome… even when I wasn't really open—I wasn't really open to like a lot of youth here, she always made me feel comfortable, you know, like I was appreciated or something. (Kiah, second-year intern).

Feeling Safe

Kimberlé recounts a story in which she shared personal information with a staff member, explaining how the staff person would never "throw her under the bus" or break her confidence. She also makes a connection to a feeling of safety and familiarity by describing ENYF as a kind of second home.

> …one person I always go to…just to talk and get a lot of stuff outta my mind is [staff member]. Like, she's a good listener, and she just, I really talk to her about anything and everything, … you can come in, and if you have something on your mind…you can talk to them about anything. …they wouldn't you know, throw you under the bus, … look at you a different way because, you know, ohh, you talked to them about something… they wouldn't spread your business also, so yeah, that's another good thing about this job. It's very comforting, you know, you feel like it's a second home. (Kimberlé, fourth-year intern).

Feeling Cared for and Connected

Returning interns described the ways in which their bonds with other interns and staff knit them into a family complete with inside jokes and stories, nicknames, favorite "siblings," and an experience of intimately knowing and being known. Tamara described the ways in which "people in this job notice stuff about you," giving the example how she earned her nickname "Miss Buttercrunch T" for her love of buttercrunch cookies. She also articulates how other interns and staff observe and adopt each other's unique forms of expression, similar to how family members share mannerisms, speech patterns, and gestures. By pointing out, riffing on, and even adopting one another's idiosyncrasies, the interns and staff are drawn closer together.

> … oh gosh–who could not talk about Kimberlé's laugh? …you can't meet somebody with a laugh like Kimberlé's. … and now it's contagious…Saturday I was working, I was painting and Priscilla was doing market, she was doing the stand and she laugh and they said, "oh gosh, you can hear Kimberlé all the way in the garden." And I was like, that wasn't Kimberlé! That was Priscilla. (Tamara, third-year intern, crew leader).

Cedrick explains how paying attention and getting to know the other interns actually allows them to "bring each other up," make each other feel better, and look out for each other at work, pointing to the ways in which supporting peers is a learned skill. Here he talks about Sadie, his fellow returning intern and co-crew leader.

> Sadie [is the] person [that brings me up] 'cause there's supervisors but me and Sadie knew each other from last year. …me and Sadie got a connection that nobody expect 'cause the returning interns all got connections that people might not understand. You might look at each other, start laughing. They be like, "what is wrong with y'all two?" You be like, nothin'. It's just something that we remembered. So…we all got the connection that always bring each other up. Like everybody knows when I'm mad 'cause I'm quiet. Everybody knows when Tamara's mad 'cause she gets that face. Everybody knows when Schuyler's mad 'cause Schuyler goes in the hallway. So it's like we all know each other already… (Cedrick, second-year intern, crew leader).

Returning interns' stories made clear the importance of close, caring relationships with staff and other youth. In this sense the staff's work with the youth and in turn the returning interns' work with first-year interns became an affordance that enabled the youth to develop caring relationships.

Somewhere to be Pushed

> …[staff] really push you a lot … it's just so you can have fun and break outta your shell, you know? So that's really good about this job. (Kimberlé, fourth-year intern).

Returning interns share stories about how staff demonstrate *high expectations* by challenging them to perform new roles, revealing how they negotiate the tension between the discomfort of being asked to do too much and the benefit from performing outside

their comfort zones. They also explain how the *clear structure* of the program pushes them to honor the guidelines and agreements they make at the beginning, pointing to both the frustration and appreciation created by rules and the consequences of not following them. Interns struggle early on but later thrive within this program structure, which initially holds them accountable for their behavior and over time facilitates them taking ownership for their actions.

High Expectations

Kimberlé tells a story about how the staff pretended not to know the routine in order to press interns to take leadership at the farmers' market: "during the markets, [the staff] would catch amnesia and they wouldn't remember, we would have to clean up the market without going to them." She goes on to explain how the staff's high standards pushed her and others to grow or to "crack you out your shell."

> … other jobs, they don't really do what, you know, this job does. Like this job… you get a learning experience, you go to workshops…they teach you a whole bunch of stuff about leadership, dedication, how to save your money, everything…they don't only send us out to the garden, we have a farmers' market, we have tours, we have, just have a whole bunch of stuff. (Kimberlé, fourth-year intern).

Sometimes the high expectations of staff can be overwhelming, as Tamara articulates.

> Maybe sometimes it can be a little bit too hard on us …I think sometimes they expect us to … know everything. … Sometimes we feel like we're stuck in between a rock and a hard place and we don't know what to do because, you go to them, and ask for help… and they're like, well, you should know that and it's like you go and you do it. (Tamara, third-year intern, crew leader).

Tamara explains how staff pushed her and others to stretch out of their comfort zone and into new roles leading younger interns:

> (w)hen I had to first lead the harvest by myself… some of the kids would ask me, "How do you do this?" and I was like, I don't know. … when I first did my first harvest I think I had Sadie with me and I was asking Sadie and she was like, "I don't know." We both … was like, okay, go over there and ask [staff member]. … sometimes she would give them an answer and sometimes she would send us back to them and we were like, dang. She sent them back.

Kiah appreciated the challenging expectations: "I appreciate every task that I get because I see them helping me…for the real world."

Clear Structure

ENYF staff make the program structure transparent to interns from the start of the season. Interns sign contracts agreeing to specific guidelines with consequences for "violations" including reduced wages. They also agree to participate in a system of straight talk with staff and peers that includes receiving positive affirmations and constructive criticism on their work performance. The clarity and enforcement of the expectations and ongoing feedback provide opportunities for youth to improve their work and leadership skills. Youth interns struggle initially but many thrive within a system that holds them accountable for their behavior. Several even offered feedback to the first author that she should more strongly enforce the guidelines to help meetings go more smoothly.

Kimberlé explains the intent and consequences of violations and how the system supports the youth. Even during a challenging time where she sometimes just felt "down," she kept a mature perspective about the purpose of violations as helping interns identify areas for improvement.

> (v)iolations are not really, to like, throw you under the bus or throw you down. But it's really to … be like, "Hey, you know. You did this, can you improve on it." … unless it's to the certain extent where you're cursing and fighting, you know then… you need to change your act, that's when the strictness comes. …there'll be some days last year I used to get unmotivated, … where I just was like "You know, I'm just down," you know? And…it's just really to better yourself, and not really to, you know, throw you down. (Kimberlé, fourth-year intern).

Cedrick describes how the system for violations becomes more rigorous for returning interns who can no longer "earn back" or reverse the impact of a violation in the way allowed for first-year interns.

> I miss those days, like first-year, you can't do no wrong. It was like, you got earn-backs so you get a violation, take five dollars out of your paycheck … Next paycheck, you got five dollars back on your paycheck. It's like, whoa, ok, earn-backs. This year, no earn-backs. You like, "Oh. What happened?" So it's different. I still love it. (Cedrick, second-year intern, crew leader).

The program structure is daunting at first but like most returning interns, Cedrick rises to the occasion and plans his daily routines such that he is motivated, on time, and prepared each day for work.

Somewhere to Grapple with Complexity

> I like seeing direct change and immediate change but that's not always the way things happen, sometimes it's a long change. Yeah, like we was trying to talk to people and stuff like that but some people didn't wanna learn about something that was new… they were so much brainwashed throughout their life, that they just don't accept no more information. They're like, "Aw, someone already told me information. My mother told me that this was the correct way and how are you a stranger telling me that that's the wrong way?" So, yeah telling people, you don't have to always stay with something. You could always learn new things and if you think it's correct, you could go with it. (Sadie, second-year intern, crew leader).

Returning interns spend much of the growing season grappling with *complex tasks* including leading crews of first-year interns, giving and receiving straight talk, managing farm and farmers' market responsibilities, serving food at a soup kitchen, and speaking publicly at workshops, conferences, and occasionally

public hearings. They also grapple with *complex concepts* related to the environment, ecological systems, and questions of food justice and the food system at workshops and conferences. While returning interns may not report every detail accurately, they do attempt to articulate what is important about the concepts they are learning and the work they do. Most notably, returning interns express pride at learning through challenges and demonstrate an emerging critical consciousness through their questioning of what they are learning.

Complex Tasks

Returning interns take on new roles (e.g., crew leader, Urban Agriculture Intern) that involve managing and completing complex tasks. As a crew leader, Tamara explained the myriad day-to-day responsibilities of picking a game and opening ice breaker question for her crew, keeping track of time, getting outside, and remembering to put away all the tools. Crew leaders also manage weekly harvests with the first-year crews.

Kiah is responsible for managing the share table, which involves collecting and tracking multiple gardeners' produce for sale. At the farmers' market, all sales and amounts must be recorded based on whose produce is sold, a complicated job that can be compounded by latecomers dropping off their produce on market day. Kiah masters this task and is able to take on new projects, which she sees as helping her prepare for the future.

> …as far as my job go…it's mad stressful 'cause you come in, you go to the garden to whoever garden you goin' to, you get they stuff, you record it on the list, then after you record it on the list, you come back here, you gotta wash it and weigh it, then after you wash it and weigh it, put it in the fridge. Make sure you put labels for their names, so that way they don't get confused. Then it's like, all right, boom! (claps) You done. Whoo! Now Saturday come, now people wanna come with they stuff, mad late. I ain't gonna put no names out, but a few … people be coming mad late and stuff and then it gets really confusing when they come at you… (Kiah, second-year intern).

In addition to their daily responsibilities, returning interns give "straight talk" to other interns and staff at the end of the season. Although returning interns are accustomed to receiving feedback through straight talk, giving comments presents the challenge of communicating constructive criticism to peers and supervisors, which feels complicated because youth worry about making others feel badly. As Kimberlé commented, "it's very difficult to give comments when you're really close to someone."

Complex Concepts

In addition to job responsibilities, participating in and teaching workshops challenges interns to grapple with complex environmental, food systems, and social and food justice concepts. Returning interns work to articulate the multifaceted nature of these issues; while at times their explanations are incomplete, they demonstrate critical questioning as well as an emergent critical social-ecological consciousness.

Sadie describes a workshop in which she has to practice talking to others about the importance of behaviors such as composting. In addition to beginning to understand ecological processes, she is thinking about why teaching others about environmental behaviors is important.

> Like how to talk to someone like, when you cross the street, get your point across and they would know what you was talkin' about. So that helped me, you could start off the conversation like, "Oh, do you know that mostly all of our leaves go to the landfill in New York, New Jersey and all of that could be composted and put into nutritious dirt, for the soil and it's going right back into the earth. It's like a cycle process." And they're like, "Oh, that's true, I…" and then they're like, " I just threw a bag of leaves in the garbage." I was like, "See, that could have been right here, you could even put it like in a jar or something and bring it to us," and they be like, "Okay, so next time I'll rake my leaves and bring it." I was like, "Yes, that's a good idea.… That grass could go in compost too. You don't have to mow it on the streets and then it goes into ocean and then it just sits, stays there just like seaweed." (Sadie, second-year intern, crew leader).

Sadie's discussion of vegetable production demonstrates how she is grappling with understanding and articulating food system issues and opportunities.

> … a cucumber from California and a cucumber from East New York … the one from California was waxed and the one here wasn't, it was just shiny naturally and theirs was extremely big which you know they were inputted with steroids and stuff like that. Ours was a good size but it wasn't like there was some fertilizer that wasn't organic. And we learned the farmer gets one cent per tomato and we pay 50 cents a pound for a tomato and how does the farmer get one cent? … so it taught me you should really think about who to buy from, a lot 'cause the gardeners, you're paying exactly what they're selling. They're givin' it to you and you're givin' the money back to them so it's like healthily grown instead of all the way from half around the world and all the pollution that has to come over here, and all the workers that it's payin' minimum wage or even lower or the immigrants that was forced, "if you don't do this, I'm gonna take you to the immigration center." (Sadie, second-year intern, crew leader).

Similarly, Schuyler works to articulate her understanding of the way food system issues including eating healthy will take "years and years and years to fix because it took years and years to build." She reflects on the ways in which her job at ENYF has helped her learn about "the things that we deal with every day that you can actually be blindsided by" and the impact of an unjust food system on people in her community. When asked to give an example of what she meant by being "blindsided," Schuyler told a story about a workshop in which she learned how much sugar is in an Arizona iced tea.

> The workshop with … the Arizona. I used to always buy Arizona's, and I'm like, I'm looking at the Arizona when they show me how much sugar is in Arizona. I was like, that is ridiculous. There is no reason why there should be that, the whole bottle should contain so much sugar. And the fact that they're actually tricking people in the bottle, saying, oh it's such and such grams for 8 fluid ounce bottle but the bottle itself is 20-something ounces, 20-something fluid ounces. And I was like, that is ridiculous. (Schuyler, third-year intern).

She then shares her struggles with how to personally address health and food issues.

> Ever since I was younger, I used to always be a person to love food but I'm trying too hard to start eating more healthier, I guess you could say. But then again, if I get hungry, and I don't feel like cooking or something, I'll be the first one to run to the corner store and get a bag of chips or something like that. And it's something I'm accustomed to, and, to be accustomed to something, it's really hard to get away from it. So, … the knowledge that I have now is helping me a lot to be able to understand what's going around… what is actually happening in the community. But, like, habits and being accustomed to different things is making it harder for me to actually adapt to the knowledge that I just learned about the community. So, even though–all the knowledge I have about this stuff, I don't even know if I'll be able to use it. (Schuyler, third-year intern).

Schuyler's descriptions are rich, complicated, and personal. She sees that change will take a long time and that adapting to new knowledge can be difficult. Whereas she might not offer an answer to solving food system problems, she is asking critical, systems-level questions as she works to make changes in her personal life.

Somewhere to Practice Leadership

> I feel like this program really shook the shy outta me. (Kimberlé, fourth-year intern).

Returning interns reported the ways in which they learned about *responsibility and accountability* by growing into new positions and leadership roles within the program, and how they *became the experts* at ENYF and beyond by leading workshops and volunteers and by teaching others outside of the program. Finally, they shared their reflections on leadership and their *developing praxis*, while stressing the importance of *youth as leaders* in the food justice movement.

Responsibility and Accountability

Returning interns talk about having responsibility for teaching new interns because older interns previously taught them, and about learning how to be responsible for their own actions and those of their crew. For example, Schuyler talks about learning to take responsibility for miscommunication between staff and interns.

> … if I work on a project, before, I'd probably be "Oh, she made that mistake"… But now I'd probably be like, Oh, it was a team effort that we both take responsibility for the mistakes that we made. And I will be able to be more accountable for others because, I guess I can say I struggled with that before. Like if I messed, if I was working with a team and I messed up, I'd be the first one to point, "I did not do that! That was her!" So I guess now I'll able to account, to have accountability for others. (Schuyler, third-year intern).

Becoming Experts and Teaching Others

Returning interns teach and become a role model for younger interns, and share their new knowledge with ENYF adult volunteers, thus becoming a "parent of the garden." They also share their knowledge with parents and peers at workshops outside of the program. Gloria explains how she is struggling to overcome nervousness about offering her ideas.

> I think one of my weaknesses is keeping things to myself, like keeping things bottled up inside. …maybe when I have an idea, I'm not like the first one to say "Oh, I have an idea!, like, here's a faster way to do this"–and I think trying to be a good leader, I haven't yet mastered that yet. This program is definitely helping me but, like it's so hard! (laughs) 'cause, you know sometimes you're skeptical about what people will say like, "Would this really work out?" or "What is she thinking?" … Maybe that's one of my weaknesses but, I should just not care about what people think, and just say it, or, voice my opinions sometimes. (Gloria, third-year intern).

Developing Praxis

Through their experiences, returning interns recognize leadership as a process rather than a discrete accomplishment. Cedrick reflects on how he works with younger interns.

> I don't want [a new intern] to feel like, "Oh, that person's bothering me. I'm not coming to work." Messing up an opportunity, because somebody's bothering 'em. That's what I always tell the first-years. "If you feel somebody's playing too much, come to me. If I'm not in your group, go to your crew leader." (Cedrick, second-year intern, crew leader).

Additional elements of Cedrick's developing practice include "crackin' jokes" with his crew to break down "walls" or communication barriers within the ENYF "family." Other returning interns talk about the importance of "straight talk" or feedback in helping them to hone their leadership skills.

Youth as Leaders

Returning interns reflect on how by doing community food work and by being leaders in their community, they are defying stereotypes of what teenagers are "supposed" to be. They also express awe and inspiration at attending conferences in which youth take active leadership roles. Amazed by youth coming from all over to a conference in Philadelphia, Cedrick sees that he is part of a food justice movement larger than himself or ENYF, and how he might benefit from the connections he's making.

> It was like…now I know I'm not the only person doing it. I know different people, around New York City, in the United States is doing it, so I'm like, okay. People from Cali, Chicago, Louisiana, North Carolina, Kentucky, Texas, Boston, it was a lot of different people… you made a lot of friends, you might see in the future, that might help you, in different ways. Be like, Oh, remember me? Can you do me a favor? So it's a lot of people, it's good, knowing a lot of people.
>
> … at the conference. Youth bill of rights…food justice, we want all food to be organic, we want at least five pounds in each store of fresh fruits and vegetables from the community, so it was

all about food justice. It was just saying what we demand, as youth and everything, to make sure that our generation, and the next generation doesn't suffer from the generation that's in front of us. So it's like we just want a healthy and better lifestyle than other people. (Cedrick, second-year intern, crew leader).

Somewhere to Become Yourself

Well, I feel like you learn to gain… confidence in yourself. Not to always be shy because that's how I was when I first got in here. Like I was just so shy and quiet… But yeah, this program really helps you to shaping yourself up. Learn a lot of stuff, gain a lot of knowledge about the garden and the fruits and vegetables and, during the protest [in support of community gardens], even though I was nervous, I just shook it off, and you know, I'm doing it for a right cause. So yeah, it was really exciting. And you just really learn how to just, you know, be yourself. (Kimberlé, fourth-year intern).

Returning interns tell stories that reflect the development of a *new sense of self*, or "re-storying" who they are. Although this can be expected as youth become young adults, returning interns also point to a *triumph over the past* and their possible future. Out of this triumph comes the choice to pursue a particular decision or even major life course; most striking in these decisions is that returning interns now have the knowledge and ability to define and pursue *success on their own terms*. These three subthemes are integrated in the quotes below, starting with Kimberlé explaining overcoming odds to succeed in the intern program and in school.

…another success is being here for my third year, looking back to like my first year, it's really successful … getting accepted to a college … my one main big thing was getting my [high school] diploma, …, I was so happy when I went back to school on Tuesday, and she handed my diploma and I put it in my case…I'm so amazed that I really made it. 'Cause you know, my sister, she didn't make it, my other brother didn't make it, … so I'm the first one who has a diploma in the family. (Kimberlé, fourth-year intern).

Tamara explains how working with diverse youth and the ENYF guidelines around confidentiality help her to learn to trust and confide in others, which is important given her previous experiences.

I never used to trust people and I always like to be by myself, wanted to do everything on my own, I didn't want no help, nothing. And then coming here and having to work with another person and they havin' to help me like, shovel something or doing somethin' that had to be worked in a pair and then having to trust that the person's gonna do it and I think—giving trust is easier for me … now and… it helped me out because if I needed somebody to talk to I know I can always run to one of my other co-workers or one of the supervisors and talk to them and let them know something and know that I won't have to hear it back another minute. (Tamara, third-year intern, crew leader).

Finally, Sadie reflects on how adults in the community are taking note of the changes interns have made in "re-storying" themselves.

… we're all changing like the way people see teenagers. Instead of being rude, we're trying to help the community and being respectful. It's like adults and all. So I was like, this is good so that people don't always stereotype us… (Sadie, second-year intern, crew leader).

DISCUSSION

Our results suggest that in addition to nature and neighborhoods, an environmental education program that engages youth in environmental action can provide socio-environmental affordances for positive youth development. Whereas ENYF's urban farm, community gardens, and farmers' market constitute physical settings that provide affordances (e.g., through youth growing produce, managing produce sales), the interns' stories place greater emphasis on the social affordances contributed by adult leaders and other interns. In particular, the interns spoke about how adults create a sense of belonging, yet constantly challenge them to perform complex tasks at the farmers' market and to grapple with complex concepts during workshops. This fosters interns' developmental assets including caring for and connection to other youth, adult leaders, and the broader community; and competence in performing tasks and in beginning to develop critical consciousness. Whereas connection and competence are commonly seen as outcomes of youth programs, previous work has shown that caring (Roth and Brooks-Gunn, 2003) and critical consciousness (Smith, 2007) are more difficult to cultivate.

Developing these assets occurs through youth contributing to the intern program (training younger interns) and to the broader community (community gardening, farmers' market, workshops); in this way, intern interaction with the ENYF program affordances creates new affordances for interns and the community. Further, in addressing and developing a critical awareness of food system justice, youth become agents of change. Through their contributions, ENYF youth develop critical consciousness and the program reflects a social justice youth development approach (Ginwright and Cammarota, 2002, 2007; Ginwright and James, 2002).

Below we first articulate a theory of change that emerged through our work at ENYF, and then discuss connection and caring as relates to authentic care, competence as relates to critical consciousness, and contribution as relates to creating new socio-environmental affordances for youth and community development in cities. Because other urban youth intern programs may be seen more as summer jobs and provide fewer opportunities for youth development (DuBois et al., 2017), the program model and discussion are specific to ENYF yet provide insights into what is possible through thoughtfully designed programs.

Program Model

ENYF interns' testimony illustrates how a participatory, praxis, place-based, and critical form of environmental education, known as environmental action (Schusler et al., 2009), provides socio-environmental affordances for youth development in an urban community. The process (**Figure 1**) begins when educators create *somewhere to belong* as characterized by interns' stories of feeling welcomed, cared for, and safe. But it is clear from the expectations educators set at the onset that ENYF is also *somewhere to be pushed* and youth soon come to realize that the program entails taking on difficult challenges. Creating such a sense of belonging while presenting challenges are features of positive youth development settings (Eccles and Gootman, 2002) and of authentic care (Valenzuela, 1999).

Returning interns also find that the program becomes *somewhere to grapple with complexity*, building on their first-year experience and being asked to perform ever more challenging tasks. They are also challenged to think through contested social and environmental justice issues, and thus begin to form a critical ecological literacy (Cermak, 2012). In addition, returning interns delegate responsibility during harvest time and model and reinforce community norms while facilitating workshops; in this way the program becomes *somewhere to practice leadership*. The challenges staff present to the interns (e.g., "amnesia" about tasks they feel the interns can tackle on their own) are consistent with findings demonstrating how leaders of youth environmental action programs continually struggle with how to balance offering youth guidance while letting youth take the lead (Schusler et al., 2017). Further, similar to youth in other environmental and social justice programs (Fusco, 2001; Calabrese Barton, 2003), returning interns demonstrate leadership situated in and for community at ENYF and in the broader community, as they teach peers and community members what they learned. Finally, as youth come to see ENYF as *somewhere to become yourself*, they draw on their skills, experiences, critical reflections, and relationships to create a story of their future, defining success on their own terms. In short, the affordances provided by ENYF come in the form of interns practicing community environmental stewardship, while building relationships with and learning and teaching alongside their peers, ENYF staff, and community members about how to live well in this shared place.

Authentic Care

The literature on authentic care (Valenzuela, 1999), womanist caring (Beauboeuf-Lafontant, 2002), and other "politicized" understandings of care (Bartolomé, 2008) provides a context for understanding a major finding that emerged from this study, i.e., the presence of a kind of familial intimacy involving the affectionate scrutiny of habits, characteristics, and mannerism, or as one youth expressed, "people notic[ing] things about you at this job." Although McKenzie and Blenkinsop (2006) have addressed issues of care in an outdoor adventure program, we are not aware of other empirical studies addressing this program element in urban environmental education. Authentic care offers a critical sociocultural perspective for understanding the intimacy developed among ENYF interns and staff, and how returning interns are initiated into and then help create this

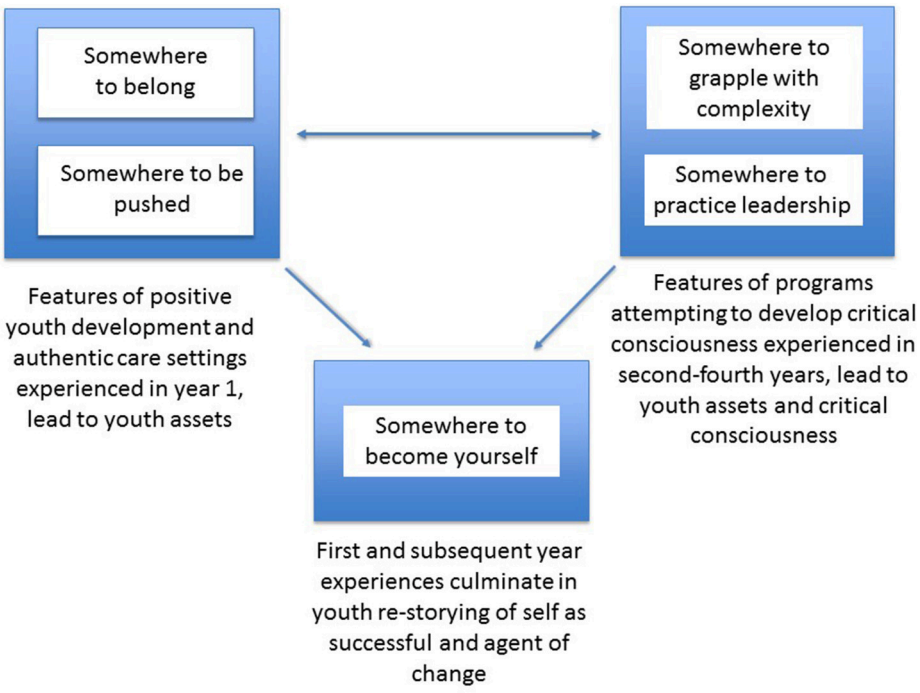

FIGURE 1 | Program elements can be considered affordances for positive youth development for interns, provided initially by staff and later by returning interns themselves.

culture of care and caring at ENYF and in the community by leading first-year interns at the farm and market, and by their desire to effect change in the neighborhood related to food choices and access.

The ENYF culture of authentic care reflects Gruenewald's (2003) notions of how, when educators and learners recognize what needs to be transformed and what needs to be conserved, youth can re-story themselves and in so doing reinvent local social-ecological places. ENYF staff's caring also reflects political awareness as young people are cared for inside of individual relationships with attentiveness to the political landscape in which the child is living and to opportunities to enact social change (Beauboeuf-Lafontant, 2002). Intern stories reflect trends in Brooklyn and other urban centers with high rates of disconnected youth (MOA, 2012), where ENYF provides one counterpoint to non-caring spaces that youth often encounter. For participants, this opens the possibility of moving beyond "inactive caring" (McKenzie, 2006), in which students care about the environment (or their community) but feel unable to make positive change. The care modeled by staff is later assumed by returning interns who practice leadership at ENYF by caring for first-year interns, creating a feedback between the theme of practicing leadership and the belonging and being pushed themes that comprise authentic care.

Critical Consciousness

Drawing from Gruenewald's (2003) critical pedagogy of place, Smith (2007) describes how reinhabitation, or collective restoration and related stewardship activities, is more readily achieved in place-based education than decolonization, which involves developing a critical consciousness and addressing systemic injustice. At ENYF, reinhabitation entailed complex tasks, such as organizing and tracking multiple growers' produce at a farmers' market. Decolonization entailed struggling with larger issues related to organic wastes, food systems, and nutrition and food access in their community. The interns' narratives demonstrate they were able to accomplish the complex tasks, and that they were beginning to develop a critical consciousness as they struggled with more nuanced scientific and policy concepts. That the interns were beginning to think critically about larger issues may be due to the program's focus on food justice, which provides opportunities for interns to participate in and later lead workshops related to food deserts and similar issues. ENYF interns also participate in community organizing efforts and attend youth-centered conferences. In short, ENYF intern narratives describe how an urban environmental education program that challenges youth within a safe setting can provide affordances for youth to develop competence while demonstrating critical thinking and consciousness. This critical consciousness allows learners to perceive, understand, and potentially counter oppressive systems and structures (Freire, 1973).

Affordances

In addition to using socio-environmental affordances such as adult mentors and urban gardening to develop their own assets, returning interns shape their larger program and community through mentoring new interns, educating adults, and providing access to fresh food for neighbors. In so doing, they extend notions of "shaping affordances" beyond manipulating nature (e.g., turning a stick into a play object, Said, 2012), and designing or planning infrastructure (Kyttä, 2002; Kyttä et al., 2004; Rudd et al., 2017), to encompass creating a public good by changing the physical and social landscape of their neighborhood. Playing an active role in civil society is in itself an affordance that leads to positive youth development outcomes, including a new sense of self and contribution to one's community (Lewis-Charp et al., 2003; Lerner et al., 2005), while engaging youth in addressing structural issues integral to social justice youth development (Ginwright and James, 2002; Sukarieh and Tannock, 2011).

CONCLUSION

Although interns reported positive relationships with adults and peers outside of their ENYF activities, the program stood out as providing socio-environmental affordances that integrate access to natural areas like gardens and opportunities for revitalizing communities and reinventing one's story. Thus, ENYF provides affordances for positive youth development through a transactional approach, where an affordance is understood as a non-deterministic *in-situ* precondition for human activity, enabled by interactions of individual abilities with material and social features of the surrounding environment (Barthel and Kyttä, 2016). Youth at ENYF successfully address the challenges of growing produce and managing a farmers' market and demonstrate critical thinking and an emerging critical consciousness through posing questions about food security in an under-resourced, urban community of color. ENYF returning interns in turn become part of the social affordances for the development of assets among new interns, and through their composting, food production, and farmers' market activities, create affordances for the larger community. We attribute these results to the ENYF program design and leaders who create long-term repeat experiences, safe spaces, and appropriate challenges for youth. Although these outcomes are not universal across all urban environmental action intern programs, they do suggest that through attention to positive youth development, affordances, authentic care, and critical pedagogy of place, program leaders can foster youth assets that also contribute to socio-environmental affordances for additional youth and the broader community.

ETHICS STATEMENT

This study was approved by the Institutional Review Board of Cornell University and by East New York Farms. Informed consent using a Cornell IRB written form was obtained from all individual participants included in the study and from their parents for participants younger than 18 years.

AUTHOR CONTRIBUTIONS

JD conducted the field work, analyzed data, and wrote a Master's thesis based on this work. MK was JD's Master's committee chair and took the lead in revising the thesis for publication.

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Using Behavioural Insights to Promote Food Waste Recycling in Urban Households—Evidence From a Longitudinal Field Experiment

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Promoting pro-environmental behaviour amongst urban dwellers is one of today's greatest sustainability challenges. The aim of this study is to test whether an information intervention, designed based on theories from environmental psychology and behavioural economics, can be effective in promoting recycling of food waste in an urban area. To this end we developed and evaluated an information leaflet, mainly guided by insights from nudging and community-based social marketing. The effect of the intervention was estimated through a natural field experiment in Hökarängen, a suburb of Stockholm city, Sweden, and was evaluated using a difference-in-difference analysis. The results indicate a statistically significant increase in food waste recycled compared to a control group in the research area. The data analysed was on the weight of food waste collected from sorting stations in the research area, and the collection period stretched for almost 2 years, allowing us to study the short- and long term effects of the intervention. Although the immediate positive effect of the leaflet seems to have attenuated over time, results show that there was a significant difference between the control and the treatment group, even 8 months after the leaflet was distributed. Insights from this study can be used to guide development of similar pro-environmental behaviour interventions for other urban areas in Sweden and abroad, improving chances of reaching environmental policy goals.

Keywords: pro-environmental behaviour, nudging, community-based social marketing, food waste recycling, natural field experiment, longitudinal, difference-in-difference analysis

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INTRODUCTION

Most sustainability problems we face today (e.g., global warming, biodiversity loss, deforestation, water and air pollutions, and overfishing) are rooted in human behaviour (Vlek and Steg, 2007). Behaviour among urban dwellers stand for a disproportionally large share of global resource use (Grimm et al., 2008), which is predicted to increase even further, as the number of urban citizens is predicted to grow from 3.2 billion (2005), to ∼6.4 billion by 2050 (UN, 2014, 2015; UN-Habitat, 2016). Thus, to avoid potentially catastrophic global environmental change, promoting pro-environmental behaviour amongst urban inhabitants needs to be a top priority, both for policy and for research (Brewer and Stern, 2005; Vlek and Steg, 2007; Clayton et al., 2016).

Even seemingly small behaviour changes can have a big aggregate impact. One estimate suggests that an emission reduction of 123 million tons of carbon dioxide per year over 10 years (7.4% of US national emissions) can be achieved by relatively small alterations in behaviour (e.g., switching to low-flow showerheads, efficient water heaters or more fuel-efficient vehicles) in United States households and amongst non-business travellers (Dietz et al., 2009). One household level behaviour with potentially large positive impacts is recycling of food waste. Out of all the food produced in the world approximately one third is lost or wasted (Gustavsson et al., 2011). Food loss and waste stand for 8% of global greenhouse gas emissions, consume a quarter of all water used by agriculture, and generate about $940 billion in economic losses globally (FAO, 2015). There is no doubt a big potential in changing the way we manage our food, where a reduction in food wasted is a key element in creating a sustainable food system. Simply reducing food waste would naturally be the most effective tool (Lipinski et al., 2013) but around 20% of all household food waste is unavoidable, e.g., peels, shells, and bones, (Quested et al., 2011) and recycling unavoidable food waste has clear societal benefits, such as reducing associated greenhouse gases and pollution from landfills, creating bio-gas to replace fossil fuels, and bio-fertilizer (digestate) that can recycle nutrients and organic matter back to the soils (Al Seadi et al., 2013). Sweden (alongside other countries) has recently set strong policy goals to develop organic collection programs intended to increase the amount of food waste recycled from 38% of the total food waste in 2014 to 50% in 2018, which equals an annual increase of 112 200 tons of food waste (Naturvårdsverket, 2017). To achieve such goals large scale behaviour changes are needed, but organic collection programs developed today tend to focus on structural changes and technological development, often overlooking the essential role that households' behaviours play in reaching these goals (Geislar, 2017).

Changing human behaviour is seldom a straightforward process. Information based campaigns are commonly used to promote behaviour changes, their goal is often to alter attitudes or enhance knowledge about an environmental problem and in that way promote behaviour changes. Unfortunately this attitude-behaviour approach is often an ineffective way of sparking behaviour change, and when evaluated, they repeatedly fall short of achieving their goal (McKenzie-Mohr, 2013). Large scale information and advertising campaigns also tend to be very expensive In one rather extreme example, utility companies in American state of California spent yearly about 200-million-dollar on advertising campaigns promoting the installation of energy-efficient devices in households, along with suggestions on behaviour changes that could save energy (like closing windows on sunny days; Archer et al., 1983). However, when evaluated only mixed results could be shown, at best, and audits suggested that there is a weak linkage between consumers receiving conservation information and actually acting on that information (Coltrane et al., 1986).

Scholars in environmental psychology and behavioural economics have long highlighted the fact that insights from behavioural sciences is usually not utilized in the design of campaigns and information strategies trying to promote environmentally friendly behaviour (e.g., McKenzie-Mohr, 2000a,b; Thaler and Sunstein, 2008; Kazdin, 2009). Even though we are constantly surrounded with these messages it is clear that many of them still do not take full advantage of current scientific knowledge. Furthermore, information campaigns are seldom evaluated, at least not with a solid experimental design with one or more "treatment" groups and a comparable control group, analysing "objective" outcome measures e.g., waste weight or kWh (Clayton et al., 2016). Even rarer are long-term evaluations; only a few studies have investigated how treatment effects have lasted or changed over time, stretching more than a couple of weeks past intervention (Osbaldiston and Schott, 2012; Allcott and Rogers, 2014; Anderson et al., 2017). As a result, there is currently little knowledge about how such interventions influence behaviour over time (Clayton et al., 2016).

This study aims to shed some light on the research gaps presented above. In particular we want to explore if insights from environmental psychology and behavioural economics applied in the design process of an information leaflet can increase food waste recycling. We chose an information intervention as it is the standard tool used by housing companies, waste companies, and by municipalities in their efforts to promote recycling behaviour. It is also cheap to implement and easy to scale up or adapt. We designed a natural field experiment (NFE) to test our main hypothesis: The information leaflet increases the amount of food waste collected from sorting stations in our research area (compared to a control group without the intervention). Since food waste is being sorted out from the regular unsorted household waste we also test the following secondary hypothesis: The information leaflet decreases the amount of household waste collected from the sorting stations. Moreover, we are interested in evaluating the potential long-term effects of the leaflet and not only the immediate effects. We observe how behaviour changes over the 8 months following the intervention. This study is to the best of our knowledge the first study analysing an "objective" outcome measure—the actual weight of food waste collected (not self-reported or self-assessed), in a longitudinal study. Even though interventions aimed at reducing food waste have gotten some attention in the behavioural science literature (e.g., Kallbekken and Sælen, 2013; Graham-Rowe et al., 2014; Visschers et al., 2016) there are only a handful of studies focusing on developing and evaluating interventions promoting the sorting and *recycling* of food waste (see e.g., Karim Ghani et al., 2013; Bernstad, 2014; Geislar, 2017).

STUDY AREA

Our study area was Hökarängen, a city district in southern Stockholm (Sweden). At the time of the study around 9,400 people lived in Hökarängen and population data showed a strong political support for the more socialistic leaning political parties, a slightly below average income and enrolment in education above high school (see **Table 1**).

The study was conducted in collaboration with the housing company Stockholmshem, which is owned by the municipality and accommodating more than 50,000 residents (about 5% of the

TABLE 1 | Demographic data for Hökarängen compared to the Stockholm (municipality) average, the data was received from Statistik om Stockholm (n.d), and collected in year 2016.

Demographic data	Hökarängen	Stockholm average
Unemployment rate	3.6%	2.8%
Mean income (16 years and over)	255,100 SEK	352,000 SEK
Higher education	42.1%	57.5%
Foreign background (not born in Sweden)	34.6%	32.1%
Politic votes in 2014 election. (Socialistic block)	68.7%	49.8%
Politic votes in 2014 election. (Liberal/conservative block)	19.7%	43.5%

total population of Stockholm municipality). Stockholmhem is Stockholm's largest housing company, and owns around 2,900 of the total 4,700 apartments in Hökarängen.

The majority of the households in Hökarängen have not had the possibility to recycle their food waste. However, in 2014 Stockholmshem started a project to provide their residents with stationary sorting stations outside their apartment complexes for recycling food waste (a picture of a sorting station can be seen in **Figure 1**) in line with Swedish policy goals. The plan is to eventually install sorting stations for all their apartments in Hökarängen. The research took place in an area where 474 households (about 10 % of all households in Hökarängen) live in area-typical apartment complex consisting of mainly 2 or 3 room apartments, all in six storey buildings (12 apartments in each). All households in the research area had access to food waste sorting stations, and they were installed more than one year before the information leaflet was sent out (except for two stations that were installed 7 months before the intervention, these were divided up into the control- and the treatment group). At the time of the installation Stockholmshem provided their residents with information about the new sorting stations and the possibility to now sort and recycle food waste (all household in the area got the same information when a sorting station was installed). Still, only a few of the households started sorting and recycling food waste, and the desire from Stockholmshem to increase food waste recycling in the area is in part what lead to this collaboration.

THEORETICAL BACKGROUND

When designing the information leaflet, we focused primarily on theories from environmental psychology and behavioural economics with the explicit goal to promote pro-environmental behaviour changes. We are using the broad definition of pro-environmental behaviour as: "any human behaviour that either benefits the environment, or harms it as little as possible" (Steg and Vlek, 2009).

A grand challenge for environmental psychologists today is to study, explain, and predict how to promote pro-environmental behaviour (Sörqvist, 2016). Environmental psychology is a branch of psychology science that deals with the complex relations between people and the natural or built environment. In an integrated review of the pro-environmental behaviour research within environmental psychology four key phases are identified as recurring suggestions for how to promote pro-environmental behaviour effectively: (1) identification of the behaviour to be changed, (2) examination of the main factors underlying this behaviour, (3) design and application of implementation to change behaviour (4) evaluation of the effects of implementation (Steg and Vlek, 2009)

There have been numerous studies within psychology research on how and why information interventions succeed or fail to spark pro-environmental behaviour. Even though they often are criticized for being ineffective tools, there are several studies showing positive results from using information interventions (Farrow et al., 2017). Many of these interventions are using messages crafted around social norms, both descriptive norms (the perceptions of which behaviours are typically performed) and injunctive norms (the perceptions of which behaviours are typically approved or disapproved of) are commonly used (Cialdini, 2003). Descriptive norms have shown to be especially effective in some cases, one study aiming to reduce energy consumption showed that using the descriptive norm, of "Join your neighbours in conserving energy" was more effective than the more commonly used injunctive normative message of environmental protection "Protect the environment by conserving energy" or even messages of self-interest "Save money by conserving energy" (Nolan et al., 2008). Similar results have been found when trying to promote hotel guests to reuse towels, and the more specific and "local" the descriptive norm, the more effective it was, e.g., a message along the line with "The guests in this room tend to reuse the towel," worked better than the more general "The guests in this hotel tend to reuse their towel" (Goldstein et al., 2008). Other pro-environmental behaviours that have been successfully promoted by the use of norms include: recycling (Andersson and von Borgstede, 2010) reducing plastic bag use (De Groot et al., 2013) and water conservation (Bernedo et al., 2014) to name a few. On the other hand, some studies have shown that misusing norms and descriptive norms in particular can generate unwanted backlash effects, even increasing the behaviour the intervention was designed to prevent (Cialdini, 2003).

One of the most prominent theories in promoting pro-environmental behaviour within environmental psychology is community-based social marketing (CBSM) (Schultz, 2014). CBSM has its roots in social marketing which was first coined by Kotler and Zaltman (1971) and presents a framework for incorporating traditional commercial marketing techniques and insights (e.g., planning, pricing, communication, distribution, and marketing) to design more effective social campaigns. Social marketing seeks to influence behaviours that benefit individuals and communities for the greater social good (Lefebvre, 2016). CBSM was initially presented as guidelines on how to make psychological knowledge visible to better develop and deliver programs that promote pro-environmental behaviours by McKenzie-Mohr (2000a,b). It has been tested and used with promising results to promote pro-environmental behaviours such as: inspiring residents to start back-yard composting, reducing travel by car, and increasing curb side recycling rates

(McKenzie-Mohr, 2000a,b; Haldeman and Turner, 2009). It has also been successful in delivering programmes addressing several human health issues (Athey et al., 2012). CBSM is aligning with the steps mentioned above by Steg and Vlek (2009) and presents five steps to promote behavioural changes: (1) selecting behaviour (2) identifying barriers and benefits (3) developing strategies (4) piloting, and (5) broad-scale implementation, highlighting the importance of evaluating interventions and adapting them to the specific context (McKenzie-Mohr, 2013). This study will in part follow these steps when designing the information leaflet (see Methodology).

The field of behavioural economics incorporates insights from other social sciences, most notably psychology, in order to enrich the standard economic model by identifying how human behaviour deviates from the assumptions of Homo Economicus. In essence these assumptions suggest that people have well-defined preferences, unbiased beliefs, and that they make optimal choices based on these beliefs and preferences. This in turn implies that people have perfect cognitive abilities and infinite willpower. It is also often assumed that their primary motivation is self-interest (Thaler, 2016). Behavioural economists argue that human behaviour needs to be understood in the light of people having limited cognitive capacities, imperfect willpower and bounded self-interest, all deviations from the Homo Economicus model that have been replicated in numerous studies (see e.g., Kahneman, 2003). Being aware of such deviations, e.g., how heuristics (cognitive rules of thumb), framing information, loss aversion, social pressure etc., influence choices, and knowing when they are more or less present could potentially improve policy design and interventions, which is what Thaler and Sunstein (2008) argue in their book "Nudge"—Improving Decisions about Health Wealth and Happiness.

According to Thaler and Sunstein's (2008) definition, a nudge-intervention is changing some aspect of the decision-context in a way that steer people's behaviour in a predictable direction. To be called a nudge the intervention is not allowed to prohibit or remove any choice alternatives and it must respect people's free will. Furthermore, a nudge is not allowed to drastically change or add any financial incentives. Nudging is mostly used to promote or change a certain behaviour (often without increasing knowledge or changing attitudes). Nudging as a concept has increased immensely in popularity over the last decade, not only among academics, but also among policy makers and in civil society (as exemplified by numerous governmental and non-governmental initiatives with the purpose of applying behavioural insights in policy[1]. Nudging approaches have been successfully applied in many different areas and to different types of behaviour e.g., to increase private savings and tax compliance (see e.g., Hallsworth et al., 2014), reduce energy consumption (Allcott and Mullainathan, 2010; Allcott, 2011; Costa and Kahn, 2013; Allcott and Rogers, 2014), limit water and paper consumption (Egebark and Ekström, 2016), and reduce food waste from restaurants (Kallbekken and Sælen, 2013).

Outside academia nudging is often portrayed as a success story, yet it is a fairly new branch of research and has been heavily critiqued by some scholars. For one, it is seemingly hard to define and distinguish "nudges" from other types of psychology-based interventions and tools and therefore some argue that the term nudge is just a rebranding of already established psychological terms (Kosters and Van der Heijden, 2015). It has also been critiqued for being manipulative (see e.g., Marteau, 2011; Goodwin, 2012) or serving as an easy way out for policy makers that favour them over "harder" policy instruments, such as regulations and economic incentives, when such policy tools in fact are needed (Bonell et al., 2011). Furthermore, the effectiveness of nudging as a public policy tool has been questioned based on the lack of evaluations (Kosters and Van der Heijden, 2015). This latter critique was addressed recently by Benartzi et al. (2017) showing how public nudge interventions can be both cost effective and in some circumstances a favourable option over traditional policy tools.

The nudging literature sometimes suggests similar phases (see e.g., Ly et al., 2013) and often rests on the same psychological insights as CBSM. It does not generally take an equally holistic approach though, focusing mostly on evaluating and quantitatively measuring the effect of a specific tool and on adapting the chosen tool to different decision contexts (Mont et al., 2014; Lindahl and Stikvoort, 2015). Despite the seemingly interlinked research using similar behavioural insight tools surprisingly little cross-referencing exists between CBSM and nudging. In this study we use and combine insights from both these research fields.

METHODOLOGY

Designing the Intervention

The design of the information leaflet was highly influenced by the phases presented above, we combined the frameworks found within environmental psychology (Steg and Vlek, 2009; McKenzie-Mohr, 2013), and included insights from behavioural economics and nudging (e.g., from Sunstein, 2014).[2] The methodical framework used is presented below:

(1) ***Selecting Behaviour to Change***
For this study the choice was made together with Stockholmshem to focus on promoting the pro-environmental behaviour of recycling food waste.

(2) ***Examination of the Main Factors Underlying the Behaviour***
To examine the main factors underlying the behaviour, two steps are typically recommended as was also implemented for this study; a pilot study, and a review of literature. The main goal of a pilot study is to learn about the area and to uncover context specific barriers (and benefits) for the desired behaviour, this is often argued to be a crucial

[1]For example the "Behavioural Insight Team" in the UK, similar governmental initiatives are seen in the US, Canada, Australia and New Zealand. In Norway and Denmark non-profit organizations for nudging have been initiated (Mont et al., 2014), as well as the European Nudge Network (http://www.behaviouralinsights.co.uk; http://tenudge.eu/).

[2]For a more in-depth guide to each of the steps see Steg and Vlek (2009), McKenzie-Mohr (2013) and Linder (2016).

step if any form of sustainable behaviour is to be widely adopted (McKenzie-Mohr, 2013). Barriers can be both internal: individual motivation like moral concerns or normative influences, and external: barriers that varies with community, e.g., accessibility, convenience, or cost of changing the behaviour (Steg and Vlek, 2009), and barrier removal is often at the core of successful interventions (Lorenzoni et al., 2007). The main goal of the pilot study in Hökarängen was to identify barriers for the residents to recycle food waste, to get an overview of their attitudes toward sorting food waste, and to get a rough estimate of the residents already recycling food waste. To this end, the pilot study was carried out in two phases, where the first phase was visiting and learning about the research area, distributing and analysing surveys, and interviewing key individuals. In the second phase we analysed food- and household waste data in order to decide how to divide the area into a control- and a treatment group (for more information on the pilot study and a list of the barriers uncovered see Appendix A in Supplementary Material). Once barriers had been identified we conducted a non-systematic literature review with the aim to identify suitable tools for addressing those particular barriers.

(3) ***Designing the Implementation***

The barriers and behavioural insight tools identified in step 2 lay the foundation for the design of the intervention. For our purposes a three-page long information leaflet was constructed. The front page of the leaflet was designed to address two barriers uncovered in the pilot study: (1) lack of information (the information about the new station might not have reached out to all residents) and (2) the tenants struggled to tell the difference between the two sorting stations. To address these two barriers the front page featured a picture of a food waste sorting station from the area. Also, the leaflet itself addressed the lack-of-information barrier.

The subtitle of the information leaflet was using a local descriptive social norm, to encourage recycling, using the phrasing (translated) *"Join your neighbours on Hovmästargatan, recycle your food waste"*[3], See **Figure 1**. As mentioned above such messages have shown to have great potential of promoting pro-environmental behaviour in numerous studies, and the same approach have been successfully been used in behavioural economics e.g., in order to nudge people toward tax compliance (Hallsworth et al., 2014).

Another example of a behavioural insight tool used in the leaflet was phrases designed to be vivid, tangible, and relatable, for example by using formulations such as (translated);

"*If all households in Hökarängen would sort their food waste it would be enough biofuel to support 15 garbage trucks for a year" "A bus can drive 2.5 km on only one bag of food waste", "Every Swede produces on average 100 kilos of food waste per year*".

FIGURE 1 | The front page of the information leaflet (translated from Swedish, see the full leaflet Appendix B in Supplementary Material) the picture used was taken by one of the authors.

Presenting information in a vivid and tangible way increases the likelihood that a message will be attended to initially and more likely to be remembered (Gonzales et al., 1988; McKenzie-Mohr, 2013).

The attitudes uncovered in the pilot study were pro-recycling, and this was highlighted in the leaflet as follows (translated): "*In a survey recently sent out to households in Hökarängen around 8 out of 10 residents stated that they considered recycling food waste to be "very important*" Aligning the community injunctive norms such as "People in Hökarängen believe recycling food waste is the right thing to do" with the descriptive norms "Join your neighbours [. . .] sort your food waste" could be a persuasive way to frame information (Schultz et al., 2007).

Moreover to address the barriers "Sorting food waste is an inconvenience", "Laziness" and "The need for the brown compostable bags" two recyclable garbage bags needed to start recycling was included in the envelope. See Appendix B in Supplementary Material for the full information leaflet and Linder (2016) for the design process in more detail.

(4) ***Executing the Implementation (On a Smaller Scale)***

In order to avoid expensive failures or unexpected results,

[3]"Hovmästargatan" is the name of the street the participants live on.

like promoting unwanted behaviour or backlash effects, a smaller scale implementation should be evaluated before broadly implementing the strategy. This also provides an opportunity to modify and adapt the implementation if necessary before the large scale implementation (McKenzie-Mohr, 2013). We designed our field experiment for exactly this purpose. The leaflet was sent out to 264 households in the research area in Hökarängen (see experimental design).

(5) ***Evaluating the Effectiveness of the Implementation***
To evaluate the effectiveness of the intervention, a solid experimental evaluation design with one or more "treatment" groups and a comparable control group is strongly advised (Steg and Vlek, 2009). Furthermore, measuring actual behaviour changes over self-reported behaviour changes or intentions is preferable (McKenzie-Mohr, 2013; Clayton et al., 2016). Self-reports have been shown to not always correlate well enough with observed behaviour (See e.g., Corral-Verdugo, 1997). We analysed our field experiment using a difference-in-difference method (see below), with the outcome variable being the amount of food waste and household waste collected from sorting stations in the research area.

Experimental Design

To evaluate the effect of the leaflet a NFE was designed. A NFE is an experiment in a field environment where the subjects are unaware of being part of the experiment (Harrison and List, 2004). To address the ethical concerns of NFE, and potentially creating real world effects with the implementation (Cohen, 2013), every contact with residents was approved by Stockholmshem, furthermore in an effort to avoid any manipulative aspects the purpose of the leaflet was clearly stated on the front page, in line with Hansen and Jespersen (2013)

In total 474 households were targeted in the study, with 264 households in the treatment group and 210 households in the control group. The two groups were divided geographically by their blocks to avoid potential spill-over effects. Nine sorting stations were located in the research area, five in the control group and four in the treatment group (see **Figure 2**). We assumed that the households would use the closest sorting station. Note in **Figure 2** that a few households from the control group (red) are in close proximity to both a red and a blue sorting station. In these cases we assumed that they would tend to choose the sorting station located on the way to the centrum, subway and grocery store more often. These households were therefore placed in the control group.

Evaluating the Implementation

To analyse the results a Difference in difference (DiD) analysis was used. DiD is one of the most popular tools in applied economics research for evaluating the effects of public interventions and other treatments (Abadie, 2005). DiD has, for example, been used to evaluate the effectiveness of policy implementation (see e.g., Finkelstein, 2002), the effect of nudges in field experiments (Kallbekken and Sælen, 2013), and the impact of natural disasters (Tian and Guan, 2015). DiD is especially useful when the aim is to estimate causal effect of an implementation and there is no way to randomly select the population in the control and treatment group which was the case here; the control and treatment groups were defined by geographical conditions. DiD is designed to control both for pre-treatment differences between the treatment and the control group and for trends over time that are unrelated to the intervention (Gertler et al., 2016).The most basic DiD design analyses data for two groups (treatment and control group) over two time periods (pre- and post-implementation). In this study we have one treatment and one control group but several time periods. The treatment group was exposed to the treatment, and the control group was not. The average gain in the control group can then be subtracted from the average gain in the treatment group to calculate the Average treatment effect (ATE).

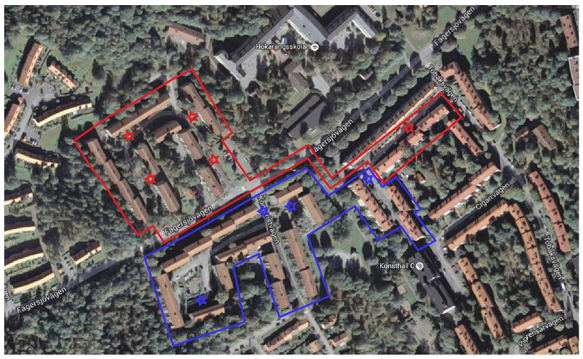

FIGURE 2 | Satellite picture of the research area. The blue area represents the treatment group, all the houses within that area got the information leaflet delivered to them. The red area represents the control group which got no information. The red and blue stars show where the sorting stations are located. Source: Google, Kartdata.

DiD is thus a suitable method to analyse the effectiveness of the information leaflet, but only if some key assumptions hold true. For one, the parallel trend assumption; that is in the absence of the treatment, the average outcomes for the treated and control groups would have followed parallel paths over time (Gertler et al., 2016). Moreover, we assume that no spill-over effects occurred; that the implementation in the treatment group did not affect the households in the control group. The analysis also assumes a constant group composition over time, i.e., that the type and size of households in the two groups remained constant over the time period. These assumptions will be revisited in the discussion.

RESULTS

Data

Our data set include data on food and household waste gathered from nine sorting stations in the research area from January 1st 2015 until December 31st 2016, the waste was weighed and reported by the waste collection vehicles during each collection. Food waste was collected and reported (in kilos) every second week on average, and in total we have data from 373 collections stretching over the entire period. Household

waste was collected more frequently (756 collections), but for comparison we aggregate these collections to match the food waste data into 48 different time periods (see **Figure 3**). In total 13,211 kilos of food waste and 194,736 kilos household waste was collected from the research area. There were several occasions when no record of collection was reported for a certain time period, or waste collection was reported but no weight was recorded (spread over the nine sorting stations) these are registered as missing values. In total there were 95 missing values on food waste, and 43 missing values on household waste. Furthermore, we decided to remove the first reported collection of newly installed food waste stations as we cannot know for sure how long it took before this first collection after installation. Those weights could therefore be misleading and not comparable to the other time periods, we removed in total 19 observations, in total the dataset consisted of 665 aggregated data points of which 302 was food waste data.

An Overview of the Results

Figure 3 shows an overview of the total amount of household- and food waste collected before and after the information leaflet was sent out (indicated with the vertical dashed line).

The leaflet was sent out to all apartments in the treatment group on April 14, 2016. Visually it looks like a treatment effect might have occurred (both for the food waste and the household waste). To explore the results further, **Table 2** lists the average amount of food waste each station collected in the time period before the treatment, and after the treatment, and the difference between the two groups.

Table 2 shows that the difference in the average amount of food waste collected between the two groups was higher after the intervention; before the intervention the average amount of collected food waste in the treatment group was 19.64 kg more than the control group (57.31 kg compared to 37.67 kg), and after the intervention the difference between the control and the treatment group was 31.96 kg. The average amount of household waste collected was 53.42 kg more in the treatment group compared to the control group before the leaflet. After the leaflet was sent out an average of 185.01 kg less household waste was collected in the treatment group compared to the control group. These numbers then suggest that the estimated ATE for food waste was positive and amounted to 12.32 kg collected per station, every 2 weeks (corresponds to an increase of about 26% compared to a pre-intervention average). The estimated ATE for household waste was negative and equal to −212.9 kg collected per station every 2 weeks (corresponds to a decrease of about 48% compared to a pre-intervention average).

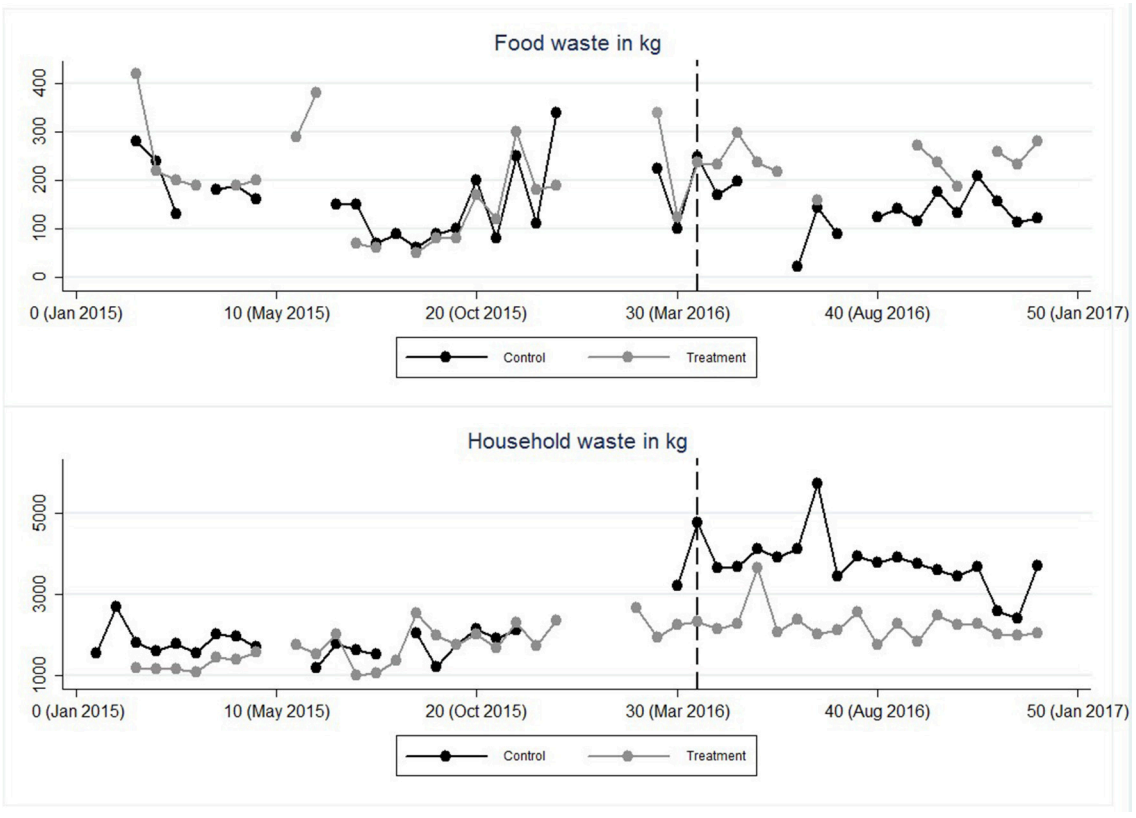

FIGURE 3 | Data points indicate aggregated data on food and household waste registered for all stations in the treatment and control group respectively. Each point represents waste collected over the 2-week period described above starting from February 2015 to December 2016. Note that some of the variation is due to different number of collections in each period. Data points with more than one missing value is removed from the plotted data (but included in the regression analysis).

TABLE 2 | Average amount of food waste and household waste collected per sorting station in the control group (five stations) and in the treatment group (four stations) before and after implementation and the difference between the groups before and after implementation.

	Food waste Pre-intervention (T1) (kg, average per station)	Food waste Post-intervention (T2) (kg, average per station)	Difference (T2–T1)
Control (CG)	37.67 (29.76)	27.81 (13.67)	−9.86
Treatment (TG)	57.31 (55.67)	59.77 (25.04)	2.46
Difference (TG-CG)	19.64	31.96	
			DiD (ATE)12.32
	Household waste Pre- intervention (T1) (kg, average per station)	**Household waste Post-intervention (T2) (kg, average per station)**	**Difference (T2–T1)**
Control group (CG)	419.03 (196.95)	744.32 (190.49)	312.6
Treatment group (TG)	472.45 (167.15)	559.31 (152.92)	99.7
Difference (TG-CG)	53.42	−185.01	
			DiD (ATE) −212.9

Standard deviations in brackets. The Difference-in-difference (DiD), or the average treatment effect (ATE) is presented in italics.

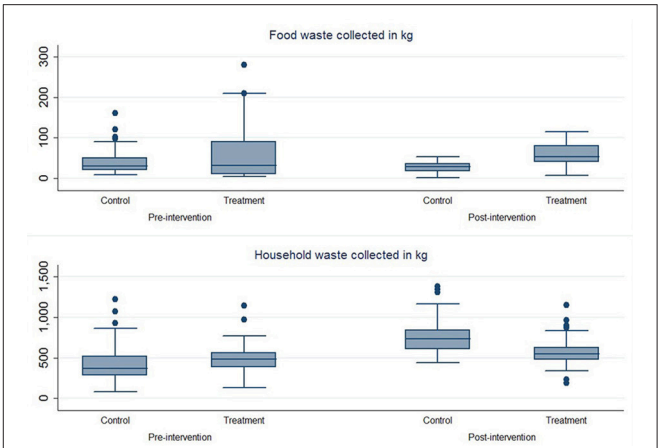

FIGURE 4 | Box plots of the amount of food waste collected (upper) and household waste collected (lower) in the control group and the treatment group pre- and post-intervention.

The positive ATE for food waste, and the negative ATE for household waste can also be illustrated in Box plots (see **Figure 4**). Looking at the median of food waste collected before and after the treatment we can clearly see an increase in the treatment group and a relative unchanged control group. The box plot also highlights the fact that there was an increase of household waste collected in both groups, but that the increase was considerably higher in the control group. **Figure 4** might be more representative (compared to **Table 2**) for the treatment effect on food waste, because of some outlier values in the beginning of year 2015 (a year before the intervention) driving up the pre-intervention average in the treatment group (we chose not to remove any outliers in our data set), this means that the ATE, looking at averages, might be underrepresenting the actual effect of the intervention. The overview of data still indicates that the intervention had the desired effect. To see if these results are statistically significant we performed a regression analysis.

Regression Analysis

A multivariate linear panel regression was executed using STATA 12, which allowed us to control for other variables that may have influenced the results (such as the number of collections in each time period). Results from the regression analysis can be found in **Table 3** below. A fixed effect model was used (as opposed to a random effects panel data model) to account for the fact that the population was not randomly selected (Baltagi, 2008). To account for potential serial correlation we used robust standard errors clustered at the group (station ID) level (Bertrand et al., 2004).

The regression analysis confirmed that the ATE of the intervention was significant for both food ($p < 0.05$) and household ($p < 0.05$) waste. The regression analysis revealed that the leaflet had an ATE of 13.02 kg of food waste per station per time period (which equals about 52 kilos more food waste collected every other week). We can also see in **Table 3** that the intervention had a negative significant ATE on household waste of 221.54 kg per station. Note that these numbers are similar to the ones estimated above, but here accounts for the number of collections and potential serial correlation within stations.

Because we used kg/collection as dependent variable in the regression analysis we also controlled for the number of collections in each time period. The number of collections in each period (how many times the garbage truck collected waste in the given time period) had a significant impact on the waste collected per station in each time period. In the DiD regression we also needed to control for potential external effects that may have affected behaviour in both the treatment and the control group at the same time as the actual intervention was implemented; what if it suddenly was warmer outside, or there was a policy of some sort that affected waste behaviour? Such potential effects were controlled for by the variable "post-intervention," which is a dummy variable for post intervention observations. Without such a dummy we would run the risk of overestimating the effect of the intervention. The model test (an F-test) which compares a model with no predictors to the specified model shows significance.

In summary, we cannot reject our main hypothesis: the information leaflet increased the amount of food waste collected

TABLE 3 | Average treatment effects for food waste and household waste through a panel data regression model, robust standard error in brackets.

	Food waste		Household waste	
	Coefficient (Robust St. error)	***p-value***	**Coefficient (Robust St. error)**	***p-value***
Constant	15.76 (9.62)	0.140	−37.72 (30.55)	0.252
ATE	13.06* (3.98)	0.011	−221.54* (66.32)	0.010
# Collections	22.70* (7.58)	0.017	237.49** (10.461)	0.000
Post Intervention	−4.89† (2.48)	0.084	287.52** (35.14)	0.000
Model test	6.59*	0.0149	197.51**	0.000
N	296		364	

*We let † denote significance below 0.1, * a significance below 0.05 and ** a significance below 0.01.*

TABLE 4 | Behavioural pattern over time for food and household waste.

	Lag period 2	**Lag period 4**	**Lag period 6**	**Lag period 8**	**Lag period 10**
FOOD WASTE					
ATE	β_0	β_0	β_0	β_0	β_0
	9.07	12.95*	–	16.69**	16.25**
Lag effect	β_2	β_4	β_6	β_8	β_{10}
	7.40*	5.69	–	7,42†	6.92
Model test, $F_{(4, 8)}$	4.15*	16.51**	–	6.95*	7.60**
HOUSEHOLD WASTE					
ATE	β_0	β_0	β_0	β_0	β_0
	−109.96*	*−133.27**	–	−220.98*	−288.37**
Lag effect	β_2	β_4	β_6	β_8	β_{10}
	57.85	48.89	–	52.93	38.74
Model test, $F_{(4, 8)}$	63.90**	58.03**	–	87.60**	98.40**

*The coefficients have been estimated through a fixed effects panel data regression model, using robust standard errors clustered at the station level. We let † denote significance below 0.1, * a significance below 0.05 and ** a significance below 0.01. The coefficients for lag period 6 could not be estimated because of multicollinearity.*

from the sorting stations in the treatment group compared to the control group. Moreover, these results are also aligning with our secondary hypotheses: The information leaflet decreased the amount of household waste collected from the sorting stations in the treatment group compared to the control group.

Next we looked into behavioural patterns over time. Visually it looks like the effect persists over time (see **Figure 3**). Ideally, to test for patterns over time one would run a regression with additional interaction variables testing for lag-effects of the intervention. One would then compare the effect of the intervention at the time of the actual intervention (the ATE) with the coefficients of the additional lag-periods. Lag coefficients of the same sign and of similar magnitude would indicate that the effect of the intervention remained stable. Larger lag coefficients for food waste (and vice versa lower for household waste), would mean that the effect of the intervention increased over time and smaller lag coefficients that the effect of the intervention attenuated over time. Unfortunately, we did not have enough observations (per period) to include several potential lag-periods. Instead, we ran several regressions where we in each regression tested for one potential lag effect. The estimated coefficient (the ATE) of the actual intervention period is labelled β_0 in **Table 4** below[4]. We tested if the effect of the intervention lasted after 2, 4, 6, 8, and 10 time periods post intervention (with estimated coefficients β_2, β_4, β_6, β_8, *and* β_{10}).

Looking at the food waste estimations in **Table 4** there seems to have been a slight lag effect in the first estimation; when we tested the effect of the intervention after 2 periods (about 4 weeks) we saw that indeed there seemed to be a slight delay in the effect of the intervention. **Table 4** shows that all other ATE coefficients are positive and significant for food waste. Similarly are all coefficients for household waste negative and significant. Please note that the coefficients for lag period 6 could not be estimated because of multicollinearity. **Table 4** thus confirms that a significant behaviour shift occurred at the time of (or shortly after) the actual intervention. Unfortunately, it is hard to make additional inferences about behavioural patterns over time based on these estimations. All estimated lag coefficients are insignificant (except for one showing a positive lag effect for food waste even 8 periods - about 4 months - after the intervention). The only conclusions we can draw with certainty is that the effect of the intervention lasted even 8 months after the intervention regardless of any potential attenuation over time.

[4]The actual regressions can be obtained upon request from the authors.

A Robustness Check

Most of the missing values occurred in the beginning of 2016 when a new waste collection company was contracted. The transition did not go smoothly and as a consequence no waste collection data could be recorded for the first two and a half months of 2016 (time periods 25–28). It is important to note that this affected both the control and the treatment group and occurred before we implemented the experiment. Nevertheless, we wanted to control for a potential pre-treatment (lead) effect in a regression where we included a "fake" treatment period; the weeks after the problems were sorted out but before our implementation. For food waste data we found no such effect (the p-value of the coefficient equals 0.829). For the household data however the results indicate that something did happen before the intervention, but in the opposite direction (to the ATE). Household waste *increased* just before the intervention, (p-value < 0.001) but then decreased post intervention (this trend can be observed in **Figure 3**). The regressions can be found in the Appendix C (Supplementary Material).

DISCUSSION

The results show statistically significant support that the information leaflet increased the recycling of food waste in the area. The difference between the control and the treatment group persists and is significant even 8 months after the information was handed out. Before discussing the relevance of

these findings there is a need for a critical reflection about their reliability.

As mentioned above, the study design and execution was interrupted by the change of waste managing companies, this change affected both the treatment and the control group and resulted in some missing data. Missing data makes it harder to justify the assumption of equal trends in the DiD. Even though the trends look similar before the implementation, the DiD analysis attributes any trend change that might have happen to the intervention. If there are any other confounding variables present that may have changed the trends, the estimation will be biased (Gertler et al., 2016). There is no way to guarantee that these trends remained parallel during the time of the missing data, but the robustness test presented above does support the parallel trend assumption, at least for the food waste data (our main variable of interest), increasing the likelihood that the change observed was caused by the leaflet. The robustness check also supports the assumption that the change in waste collection company affected the treatment group and the control group equally for food waste. Furthermore, to strengthen the assumption in our DiD analysis of a constant group composition, we looked into official statistics (from Stockholm municipality) on Hökarängen for the year 2016. Household sizes stayed essentially the same over the year, with a net population increase of 23 people (to 9,434), and only about 14% of the households changed residents. Since our research area constitute about 10% of the Hökarängen suburb, we think it is unlikely that these changes are big enough to significantly influence our results.

NFEs have inherent weaknesses and there is always a risk for unknown factors affecting the outcome (Harrison and List, 2004). Our analysis shows evidence of confounding factors influencing the household waste data that manifests itself in the lead effect presented above. This makes it impossible to fully attribute the ATE to the intervention for the decrease of household waste collected. The trend responsible for the lead effect shows a rapid increase in household waste just before the intervention, this trend is visible in both groups but appears to be stronger in the control group (See **Figure 3**). Fortunately, there is no such lead effect visible in the food waste data. Potential confounding variables are more likely to affect household waste data simply because of the variety of different types of waste being dispatched there. Furthermore, these sorting stations are not locked (the food waste station are locked, and only residents have the key), and in the pilot study we found some reports of "external" households throwing waste into these sorting stations. Due to the limited data available to us we can only speculate about potential causes for this spike, it could be due to the new collection vehicles, or waste coming from external households (or something entirely different). It is therefore important to highlight here that the reliability of the statistical significant results in the household data is low. That being said, the hypothesized trend seems to continue after the lead effect occur and combined with the significant results in the food waste data (which show no sign of such confounding variables) it is still likely that some of the change observed in the household data is caused from sorting out and recycling food waste.

As stated above there is a lag effect in the interventions effect on food waste, however, this is to be expected since it will take some time from the point residents decided to starting sorting food waste, filling up the bag and recycling, before the weight gets registered by a collection vehicle.

The concerns and potential biases mentioned above should be taken into account when evaluating the results from this study. Nevertheless, the results do indicate that by using a theoretically informed design process—an information leaflet using psychological insights can have a significant effect. While at the same time being easy and cheap to adapt, scale up and repeat. There is often an economic incentive for housing companies to promote the recycling of food waste amongst their residents. Stockholmshem for example, paid 610 SEK (64 Euros) per ton for the collection of household waste and 350 SEK (37 Euros) per ton for food waste at the time of the study. Considering the low costs involved in the execution of this study, and the promising results, it seems the leaflet is both an environmentally and economically sound strategy for housing companies, presenting a possible win-win situation. And even more promising since the difference between the control and the treatment group seems to persist even 8 months after the intervention. Our study provides some further support for the use of methodological frameworks such as the ones presented by CBSM and Steg and Vlek (2009). The next natural step for Stockholmshem would be a larger scale implementation of the intervention in Hökarängen, adding to the methodological framework used in this study this would be step *(6) Large scale implementation,* only after testing and evaluating at a smaller scale, a large scale implementation of interventions is advised, which should if possible also be evaluated (Steg and Vlek, 2009).

The encouraging results motivate further research. Relevant next steps would be to test different follow-up implementations (e.g., reminders, prompts or other complementary measures) in order to secure stronger long-term effects, and test the methodological framework on other behaviours and in other contexts. Since we only measure the behavioural impacts of the information leaflet, future research could follow up with qualitative approaches exploring how interventions like this one affect attitudes and values and how these may change over time, as well as exploring potential spill-over or reactance effects. For example it is possible that the households that started recycling food waste will be more willing to throw out food since they perceive it to be put to good use anyway hence increasing their waste production instead of only recycling waste that would otherwise been unsorted household waste. On the other hand it is also possible that food waste recycling can have a positive spill over on other pro-environmental behaviour, a recent study provided some proof of just that (Sintov et al., 2017). Since this study is focusing on evaluating and testing the intervention as a whole and not a specific behavioural insight tool, we cannot assert with certainty which tool worked or contributed more than another. Qualitative approaches, coupled with experiments with the particular purpose to distinguish between tools could shed further light on these questions. Due to the complexity of human behaviour we want to re-emphasize the importance of testing and adapting interventions to the specific context and

target group. Some of the barriers found in the pilot study are highly contextual, and demographical traits such as political support for the socialistic block and pro-environmental norms in Hökarängen might have been strong contributing factors to the seeming success, such demographics have previously shown to influence how susceptible people are to pro-environmental interventions (Costa and Kahn, 2013).

The design of the information leaflet and the research approach of this study rest on combining insights, terms and theoretical frameworks from both environmental psychology and behavioural economics, in particular linking CBSM and nudging. It is apparent that a lot of promising research on how to promote pro-environmental behaviour is occurring both within behavioural economics and environmental psychology today, but surprisingly little cross references occur. There has been some expressed concerns about how to integrate these frameworks (Badshah, 2010). However, based on the experiences gained during this study no obvious obstacles in combining the frameworks were encountered, we had rather the opposite experience. CBSM generally has a more holistic view on behaviour change and present guidelines in line with the ones used in this study. The rapidly expanding field of nudging, based on insights from lab and field experiments could be an important contribution when designing interventions, and adding insights from the growing field of nudging, as a way to expand the toolbox for changing behaviour is therefore something that we recommend for CBSM-researchers. On the other hand, practitioners from behavioural economics and nudging could equally learn from social marketing approaches and environmental psychology, especially when it comes to the strategic planning process e.g., how to find and address barriers, or how to select which behaviour to change. We would recommend researchers taking a nudge approach to follow a methodological framework similar to the one used in this study. As mentioned before nudging approaches have been criticized for being insufficient responses to current environmental challenges, and similarly Corner and Randall (2011) state that "Social Marketing alone is insufficient to build support for the more ambitious policy changes and interventions that constitute a proportional response to climate change" (p.1). We also want to emphasize that interventions using psychological insights to spark behaviour changes amongst individuals should not be viewed as a silver bullet solution to our current sustainability problems. Only focusing on promoting pro-environmental behaviour amongst individuals would not suffice to create the large scale transformation needed. For example, it is estimated that about 44% of food waste in the US is stemming from households, but the rest is from manufacturing, retail and food service sectors (Vogliano and Brown, 2016). Thus behaviour change needs to be integrated and operationalized across sectors, organizations, policy, as well as among individuals.

Nevertheless, designing more effective interventions looking at quick achievable behaviour changes with the potential of big aggregate impacts without reducing human well-being is arguably a good way to complement other measures. Insights gained from this study and behavioural science are useful not the least when designing interventions in cities. Urban areas are complex systems, often rich in terms of cultural diversity, world-views and life-styles co-existing on dense geographical scales (Colding and Barthel, 2013). Designing and building new urban landscapes for 3.2 billion new inhabitants before year 2050 without generating devastating environmental and social impacts is a grand challenge indeed. However, we see opportunity in the fact that the world moves toward a more densely settled urban population (UN, 2015) as it allows for interventions in contexts and action arenas where small scale changes can reach many people and therefore have large aggregated effects. These are environments in which interventions using psychological insights could prove to be especially effective tools to promote pro-environmental behaviour.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of APAs Ethical Principles of Psychologists and Code of Conduct. To fulfil the requirements stipulated in (Swedish) Act concerning the Ethical Review of research involving humans (2003:460) we did not collect any sensitive data. The data collected was purely aggregated waste data from sorting station in the research area, with no way of connecting it to individual households or individual behaviour. Every contact or message sent to residents in the research area was approved and consent given by Stockholmshem, and the purpose of the information hand-out was clearly stated on the front page (see **Figure 1**) in line with, Hansen and Jespersen (2013). The pilot study presented in this study was conducted as a part of Linder's (2016) master thesis and was aligning with ethical guidelines for master thesis works at Stockholm Resilience Centre, an ethical statement was written and approved by the centre before the study started. To fulfill the requirements of the Swedish Personal Data Act (1998:204), each subject was informed about the purpose of the pilot, how the information would be used and their anonymity was maintained. They could remain anonymous at all times if they preferred.

AUTHOR CONTRIBUTIONS

NL, TL, and SB all contributed to the initial idea, the design and planning of the study. NL collected the data, conducted the pilot study and designed the intervention with inputs from TL and SB. Designed the field experiment with inputs from TL. Wrote the majority of the text and handled the collaboration and communication with Stockholmshem. TL led the data analysis with input from NL, wrote most of the results section. Made the graphs and tables. Contributed to the writing and provided continuous feedback on the whole manuscript. SB initiated the collaboration and contacts which made the study possible, contributed to the writing process, and provided continuous feedback on the whole manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.00352/full#supplementary-material

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Overcoming the Subject-Object Dichotomy in Urban Modeling: Axial Maps as Geometric Representations of Affordances in the Built Environment

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The world is witnessing unprecedented urbanization, bringing extreme challenges to contemporary practices in urban planning and design. This calls for improved urban models that can generate new knowledge and enhance practical skill. Importantly, any urban model embodies a conception of the relation between humans and the physical environment. In urban modeling this is typically conceived of as a relation between human subjects and an environmental object, thereby reproducing a humans-environment dichotomy. Alternative modeling traditions, such as space syntax that originates in architecture rather than geography, have tried to overcome this dichotomy. Central in this effort is the development of new representations of urban space, such as in the case of space syntax, the axial map. This form of representation aims to integrate both human behavior and the physical environment into one and the same description. Interestingly, models based on these representations have proved to better capture pedestrian movement than regular models. Pedestrian movement, as well as other kinds of human flows in urban space, is essential for urban modeling, since increasingly flows of this kind are understood as the driver in urban processes. Critical for a full understanding of space syntax modeling is the ontology of its' representations, such as the axial map. Space syntax theory here often refers to James Gibson's "Theory of affordances," where the concept of affordances, in a manner similar to axial maps, aims to bridge the subject-object dichotomy by neither constituting physical properties of the environment or human behavior, but rather what emerges in the meeting between the two. In extension of this, the axial map can be interpreted as a representation of how the physical form of the environment affords human accessibility and visibility in urban space. This paper presents a close examination of the form of representations developed in space syntax methodology, in particular in the light of Gibson's "theory of affordances." The overarching aim is to contribute to a theoretical framework for urban models based on affordances, which may support the overcoming of the subject-object dichotomy in such models, here deemed essential for a greater social-ecological sustainability of cities.

Keywords: space syntax, affordances, urban modeling, sustainable urban design, spatial cognition

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INTRODUCTION: THE HUMANS-ENVIRONMENT RELATION IN URBAN MODELING

The world is witnessing unprecedented urbanization (United Nations, 2014), bringing extreme challenges to contemporary practices in urban planning and design. This calls for improved urban models that can generate new knowledge and enhance practical skill. Importantly, any urban model embodies a conception of the relation between humans and the physical environment. In urban modeling this is typically conceived of as a relation between human subjects and an environmental object (Wilson, 2000), thereby reproducing a humans-environment dichotomy.

Alternative modeling traditions, such as *space syntax* (Hillier and Hanson, 1984) that originates in architecture rather than geography, have tried to overcome this dichotomy. Central in this effort is the development of new representations of urban space, such as in the case of space syntax, the *axial map*[1] (Hillier and Hanson, 1984). This form of representation aims to integrate both human behavior and the physical environment into one and the same description. Interestingly, models based on these representations have proved to better capture vehicular and pedestrian movement than regular models (Hillier and Iida, 2005). Such movement, as well as other kinds of human flows in urban space, is essential for urban modeling, since increasingly flows of this kind are understood as drivers in urban processes (e.g., Batty, 2013).

Critical for a full understanding of space syntax modeling is the ontology of its' representations, such as the axial map discussed below. The issue has given rise to several approaches in the space syntax literature, that not are immediately congruent. Through the years, there has been aims to view these representations from the point of view of phenomenological geography (e.g., Seamon, 2007), systems biology (Griffiths and Quick, 2005), neuroscience (e.g., Sakellaridi et al., 2015), or spatial cognition (Conroy Dalton et al., 2012). While this discussion remains inconclusive, there has also been a more technical debate, propelled by the rapid increase in accessible geodata on the internet (Stavroulaki et al., 2017). Essential here is the shift from Axial maps drawn by hand in GIS to maps based on Road Center Lines downloaded from, for instance, Open Street Map or different national road authorities. While this primarily has been driven by convenience, in that it is less time consuming to download a road system than to draw one yourself, and by incentives to adapt to other directions in urban modeling, where this is standard procedure, it again highlights the issue of the ontology of these representations. Moreover, there has been several proposals from within the space syntax field about how the axial map could be improved. One may identify four major directions here, (1) Angular Segment Analysis (e.g., Turner, 2007); (2) Natural Streets maps (Jiang and Claramunt, 2002); (3) Continuity maps (Figueiredo and Amorim, 2005); and (4) Directional Distance models (Peponis et al., 2008). These directions are thoroughly analyzed and compared in Stavroulaki et al. (2017).

Altogether, however, this leaves the status of the ontology of the representations in space syntax unsettled, where we by this simply mean; we do not quite know what they represent. To simply state that they are representations of space, or space as structured by built form, in the end leaves the issue far too open. Put differently, although we repeatedly see powerful correlations between analyses of the built environment based on space syntax representations and human behavior, especially movement, we do not have a theory that help us understand why this is so. This in turn hinders conscious improvements of the representations and ultimately also precision in the translations of these findings into policy and practice.

In this paper, we aim to remedy this by returning to the axial map, which we deem a highly original form of representation with a potentially strong foundation in psychological theory, in particular James Gibson's theory of affordances (1977), which we believe can shed light also on the ontological status of more recent development of the axial map, such as segment maps, as well as ready-mades, such as road center lines. Gibson's theory of affordances has often been referred to in the space syntax literature (e.g., Hanson, 2000), yet his broader theory about An Ecological Approach to Human Perception (1986), of which his affordance theory is part, has never been thoroughly discussed in relation to space syntax theory, despite the great affinity between the two theories on the matter of the humans-environment relation. Ultimately, we propose that Gibson offers a theory that help us understand why space syntax modeling works and that space syntax offers modeling techniques that make Gibson's theories operative on the scale of the city.

Hence, if this affinity can be substantiated into a distinct link, it may prove vital, both from the point of view of urban modeling, aiming to inform practices in urban planning and design, and environmental psychology, aiming to understand the relation between human behavior and the physical environment, and that in several respects. First, it opens for models that capture how human behavior is conditioned by the environment, which offers the opportunity to also model and understand how interventions of the built environment may influence human behavior. Second, it opens for models that capture how the same physical environment gives rise to different affordances depending on variations in the physical ability among humans, relating for instance to physical disabilities or age, but also, how the same physical environment gives rise to different affordances relating to other species than humans, such as birds or bees. Finally, it opens for combining affordances relating to both humans and other species in urban environments, which would substantially broaden the capacity of urban planning and design when it comes to transforming cities into greater social-ecological sustainability.

Hence, this paper aims to contribute to a stronger theoretical foundation of the form of representations developed in space syntax methodology, such as the axial map, by way of a close reading of Gibson's theories about affordances and ecological

[1]We will only refer to the axial map here, while keeping in mind the general implications of our argument for other geometric representation typical for space syntax, such as the segment map or the isovist. For full review of these representations, see Stavroulaki et al. (2017).

space, which also is intended as an argument for space syntax modeling as an approach that in contrast to much urban modeling bridges the humans-environment dichotomy. In extension, the aim is to also introduce to psychological theory a strand of urban modeling directly linked to important directions in psychology. We deem both important in the light of the shared aim of the two fields to create greater social-ecological sustainability in cities.

SPACE SYNTAX: AN ARCHITECTURAL APPROACH TO THE HUMANS-ENVIRONMENT RELATION

The central components of any urban model are a set of modes to measure the key variables *distance* and *attraction* within a *representation of urban space* (Wilson, 2000). Distance can here be measured in many different ways, for instance as metric and temporal distance or as economic cost; attractions may be measured as anything from density of residents or accessibility to retail or parks. Similarly, urban space may be represented in many different manners, but the most common are either as coordinates in continuous space or as patterns of discrete spaces, for instance census tracts (Wilson, 2000). The issue of spatial representation becomes particularly interesting if we shift from a geographical to an architectural conception of space, since we in the latter find interesting alternatives, not least in what is known as space syntax research (Hillier and Hanson, 1984).

Space syntax origins in the 1970's debate about the need for sounder knowledge foundations for the design of new housing areas (Hillier et al., 1976). The background was the severe criticism of the ambitious British social housing program of the 1960's, where these, if anything, seemed to create social problems rather than remedy them. Similar criticism could be found throughout the western welfare states in the early 1970's. In most cases it embodied the same paradox: when the social ambitions had been the highest, architecture had failed the greatest.

An early contribution to this aim from the main originator of space syntax theory, Bill Hillier, concerned a critique of the established conception of the humans-environment relation (Hillier and Leaman, 1973). This line of argument was again taken up by Hillier in Space is the Machine (1996), which we here will follow closely in the aim to both identify the foundations of space syntax theory in this respect, but also in the aim to closer tie space syntax theory to Gibson's conception of embedded cognition.

Hillier follows Canguilhem (1971) in identifying the origin of the environment concept in emerging disciplines like biology and zoology in the seventeenth century (Hillier, 1996). The central issue here was to explain the great variety of species on Earth, where one, following the ideal of physics, looked for material explanations. The idea evolved that this was a result of the environment, typically conceptualized in a rather awkward mechanistic way that later often has been ridiculed. Hillier argues that this idea, even so, lived on into the twentieth century in architecture, translated into a paradigm of the machine; the idea that architecture through its' materiality somehow is able to influence, change and direct individual behavior. He in particular points out how a central problem here is how this idea reinforces the subject-object duality: "This blinds the inquirer to the most significant single fact about the built environment: that it is not simply a background to social behavior—it is itself a social behavior" (Hillier, 1996, p. 300). The reason it can be seen as such, according to Hillier, is that the built environment not is a natural environment, it is an artifact, and as such shaped according to basic human abilities with the very aim to condition and direct human behavior.

It is important to recognize the two-front character of the argument pursued here. At heart, space syntax springs from a critique of social engineering, architectural determinism and the paradigm of the machine, but it does not abandon either a belief in positive knowledge or a systematic relation between space and society, as much of the 1970's critique did. Hillier means that the latter critique led to a decisive change in architectural research from analytical studies of function, to hermeneutical studies of meaning, that is, an altogether different topic, somewhat mirroring the debate between behavioral and cognitive approaches in psychology (e.g., Sörqvist, 2016). In short, Hillier and Hanson want to save the idea that architecture has social effects, cognitively through the reading of architectural signs as well as behaviorally through the use of spatial form, by the means of a new and better scientific paradigm, where the critical difference from the earlier one is a shift from theory based on a direct relation between the physical environment and humans, to one where this relation is mediated by *spatial configurations*.

The central argument here is that human use of space must be understood dynamically, that is, through human movement in space rather than as static uses in particular spaces. This put emphasis on the relation between spaces, their configuration, rather than the physical form of individual spaces *per se*—we see the reason for the name space syntax. This, next, leads to the observation that in real life different human uses typically overlap in space rather than stick to particular spaces. Hillier and Hanson call this a *non-correspondence relation* between space and use, in contrast to the conventional *correspondence relation* between the two (Hanson and Hillier, 1987). This means that human use of space for movement has a vital and intermediate role in relation to other human uses or social phenomena in urban space. The configuration of space, as captured in the axial map, has then in a long line of empirical tests proven to an important degree structure movement patterns in urban space so that we find different numbers of co-present people in different urban spaces. This, in turn, create particular situations of varying social and economic potential in these spaces, relating to such things as social integration (e.g., Legeby, 2013) and local markets (e.g., Scoppa, 2015).

Importantly, such movement patterns are also essential when it comes to the encounter between people and urban green, central for changing people's behavior and attachment to environmental issues and improved sustainability (Marcus et al., 2016). This happens in three ways. First, in that the configuration of space structures movement so that it to greater or lesser extent pass urban green areas. Second, in that these movement patterns

generate particular situations of co-presence in urban green areas that become part of their experience—whether there are 2, 20, or 200 people co-present around a water pond in a park dramatically changes its meaning. Third, in that depending on the size of these co-presences the landscape design may change to create more useful encounters between people and urban green. The two latter emphasize how space syntax methodology also can address symbolic and affective affordances and not only functional.

We may illustrate this with an example. Imagine a city where everyone walks to work each morning, whether these people encounter any form of urban green on their journeys, naturally depends on the distribution of green areas in the city but also on the configuration of the street network. Walking to work normally implies simple and direct journeys, which according to the arguments above, generally means streets of high centrality in the street system, hence we need to distribute green areas along these particular streets for such encounter to happen. In the next step, however, this also means that green areas in these locations will be frequently visited, that is, I normally will encounter the green together with others and often with many others. This creates a particular situation for the encounter with the green; it is somehow "colored" by the large group of others. This naturally does not mean that this is bad, but it is different from a situation where you encounter the same green alone or together with few other people.

The first case may also imply that one should design the urban green in a particular way to accommodate for this particular situation of quite few simultaneous visitors. For instance, large groups of people mean a lot of wear and tear, why areas covered with grass need certain treatment or perhaps even to be avoided, not to present nature as something worn and dirty to visitors, which then may come to prefer shopping malls with flower pots. In contrast, more segregated space may be designed in a very different manner and also have a different function for human interaction with nature. There naturally are many dimensions to this example, but in principle it demonstrates how movement patterns and the situations of co-presence it generates is essential for building a relation between humans and nature in cities, where the point in our current discussion is that we can learn to better model and understand these patterns through space syntax models based on representations of certain human affordances.

Naturally, every step in this argument, while empirically supported in many studies (e.g., Hillier and Iida, 2005), has also been debated: from the representation of the axial map itself (Batty, 2013), over to its distance measure (e.g., Jiang and Claramunt, 2002), its statistical correlation with number of co-present people (e.g., Ståhle et al., 2005), and the social interpretation of these situations of co-presence (Liebst, 2014). In relation to current urban development challenges, it also demonstrates limitations, where major directions in need of development concern, joining the axial map with other models of urban mobility (Gil, 2016), incorporating also urban green structures (Berghauser Pont et al., 2017), and extending the models over time, allowing for dynamic analysis.

Hence, space syntax is a field still in development but has introduced a novel and substantiated approach to the humans-environment relation by way of spatial configuration: "Spatial configuration proposes a theory in which we find pattern effects from space to people and from people to space that in no way invokes mechanistic determinism. At the same time, the configuration paradigm saves the idea that architecture has social effects. By changing the design of a building or complex we do change outcomes. There is after all some kind of mechanism between the built world and people. However, the machine is not the building. *Space is the machine*" (Hillier, 1996., p. 300).

SPACE SYNTAX: CITIES AS COGNITIVE OBJECTS

To understand how space may become a machine, we need to better understand properties of space in relation to basic human capacities and how humans by making use of these properties, have rearranged the environment to their own purposes. Hillier maintains that people interact with space in cities both through their capacity as bodies and as minds and argues that: "in bodily terms the city exist for us as a system of *metric distances,*" while we mentally interact with it primarily by seeing: "as a system of *visual distances*" (Hillier, 2012, p. 4). We here see the theoretical foundations for the axial line, which simply is a geometric representation of an urban space structured and limited by built form, that is possible to physically access and visually overlook for a generic human.

However, Hillier also argues that: "we also need to reflect on the fact that cities are also collective artifacts which bring together and relate very large collections of people. The critical spatial properties of cities are not then just the relation of one part to another, but of *all parts to all others*" (Hillier, 2012, p. 4). Here we see the need to expand the axial line to an axial map, which is a set of axial lines covering all spaces accessible for a generic human within a spatial system structured and limited by built form. As a means to measure distances within such a system, Hillier next proposes the notion of *universal distance* as opposed to *specific distance* (Hillier, 1996, p. 104–108). Where specific distance concerns the distance between an origin A and a destination B, universal distance concerns the distance from all possible origins to all possible destinations in a spatial system. Hence, universal distance comes close to the concept *centrality*, for instance found in network analysis (Newman, 2010).

According to Hillier, universal distance behaves differently from regular ideas about distance (Hillier, 2012, p. 5). He illustrates by filling a bounded space with a set of rectangular objects, resembling urban blocks, in such a way that the remaining space takes a form that looks like a street grid (**Figure 1**). By moving the blocks slightly, so that some of the lines of sight are broken, Hillier shows how visual distances are increased dramatically, while the metric distances changes only marginally. This reflects the common experience that the same metric distance can be experienced very differently depending on the particular spatial situation; for instance, one can imagine how trips in the second system will both take more time as well as represent a greater effort than in the first system; that is, not a much greater physical effort but a much greater mental effort.

The argument for the axial line as a distance unit can then be made: If we make a straight line crooked "we do not add significantly to the energy effort required to move along it,

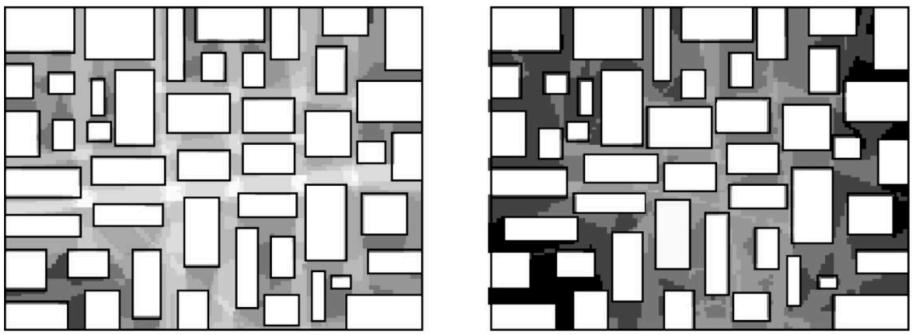

FIGURE 1 | Analysis of universal visual distance in a grid-like bounded space, where small displacements of the blocks cause dramatic increase in universal visual distance (Hillier, 2012).

but we do add greatly to the informational effort required" (Hillier, 2003, p. 3). Based on the idea that cities, as products of bottom-up incremental processes over long time (see Alexander, 1964), have tended to evolve toward environments that support human intelligibility, Hillier concludes that: "human geometric intuitions seem to be *embedded* in the city itself" and in extension that: "cities are in a profound sense *cognitive*—and so human—objects before they are economic and social objects" (Hillier, 2012, p. 18). We may then, at least in part, also identify a possible explanation to the failure of the large-sale housing programs of the 1960's, which typically did not evolve in relation to human practice over large time spans, but rather were rapid large-scale interventions, little informed about human cognition or use of the environment.

On this basis, we can begin to more precisely understand what the axial map represents (**Figure 2**). It is a representation of continuous urban space, structured by built form such as buildings, infrastructure and landscape elements, which specifically captures a vital set of affordances (accessibility and visibility) that the environment gives rise to in relation to a moving human subject. It does so by representing urban space as the least amount of straight (axial) lines that completely covers the whole system under analysis. Hence, the axial map can be interpreted as an attempt, with the simplest geometry possible, to represent this set of affordances. Finally, each axial line can then be used as a unit for topological measurement of distances, which can be argued to be based in human perception and cognition.

We here see the essential importance in choice of geometric representation in urban modeling, where the axial line in this case, despite its' mundane appearance, on the one hand, constitutes a kind of *cognitive geometry*, in that it represents the spatial environment (the object) from the point of view of a perceiving and cognizing human (the subject), that is, a representation that neither is a representation of the subject or the object, but rather a representation that overcomes the categorical separation of the two. On the other hand, this representation opens for precise description, analysis, and even quantification of this geometrically constructed entity. For instance, we may topologically measure the number of axial lines between two locations or, in the same manner, measure the centrality of a location in a spatial system, which we in both cases may call an analysis of *cognitive distance*. It is this manner of measuring distance, that is, as topological steps of axial lines in an urban environment represented as an axial map, that in repeated empirical investigations has proven to capture both pedestrian and vehicular movement better than other distance measures (e.g., Hillier and Iida, 2005).

FIGURE 2 | The axial map as a representation of spatial.

SPACE SYNTAX: A COPERNICAN SHIFT IN URBAN NETWORK ANALYSIS

When we come to analysis, axial maps and later developments into segment maps etc. (see note 1), are all treated as networks, and as such formally described by graphs and thereby part of a long tradition of applying graph theory in spatial analysis and

urban modeling (Batty, 2013). A common procedure here is to represent urban elements, such as buildings, parks, or retail, as nodes and the relations between these as links in a network matrix (Batty, 2013). When embedding such a network in a real urban setting, however, one most often make use of the street network for setting urban elements in spatial relations to each other. When representing such street networks as graphs one normally represents street-junctions as nodes and the street-segments connecting these as links. Peculiar to the axial map, however, is that this is done the other way around; streets are represented as nodes and junctions as links. In formal graph terms, there is always such a *dual graph* to a network, the mirror image of the *primal graph* (**Figure 3**), and it is this dual graph that is made use of in space syntax.

This procedure is logical to the conception of space we find in space syntax, since it means that we represent urban space as a set of spaces defined by a certain set of affordances (accessibility and visibility), where each such space is represented as a node in the graph and each junction of such spaces is represented as a link. Representing the axial lines as nodes and the junctions between axial lines as links, rather than the opposite, means that the cognizing subject, so to speak, is shifted from the street-junctions to the street-segments and, moreover, from being represented as a point to being represented as a line. We propose that this has far greater consequences than what it seems and actually constitutes something of a Copernican shift in urban network modeling.

This is especially true, since what is represented by the axial lines, as we have seen, are spaces possible for a human to physically access and visually overlook, and such spaces are normally not limited to the space of a street segment, but regularly extend beyond such segments, while at times also being shorter than a segment. This has the rather contradictory effect that an axial line can be connected to several other axial lines, while these lines, in turn, not are connected to each other. In relation to human perception, however, this makes sense; even though we in a physical sense are located at a specific point, we may visually overlook a much larger area, potentially including several street-junctions, and in that visual sense be present also at these other street-junctions—the axial line in an original manner captures both of these dimensions.

Hence, we see a different conception of space in space syntax compared to regular urban modeling, a conception, we will argue, comes very close to what Gibson has called an ecological conception of space in contrast to the conception of space in physics, which is what we normally encounter in urban modeling.

ECOLOGICAL SPACE: ENTERING THE WORLD OF MEANINGFUL THINGS

Gibson's particular point of departure is well-captured by the title of his book: An Ecological Approach to Visual Perception (1986). The term "ecological" marks a break with physicist conceptions of the environment and point to our habit to speak about reality as the physical world and, as a consequence, the risk of uncritically adopting physicist conceptions of the environment. In contrast to such conceptions he states the rather obvious fact that from the point of view of psychology: "we are concerned here with things at the ecological level, with the habitat of animals and men" (Gibson, 1986, p. 9), which concerning our understanding of space constitutes a subsection of physics, albeit a subsection we need to understand better.

In Gibson's own words, his theory "provides a counterbalance to those theories of cognitive mapping that have focused mainly or only on the internal cognitive processing of environmental information, to the exclusion of any interaction of the individual and the environment" (Gibson, 1986, p. 13). More precisely, he wants to open for an understanding of the body as an extension of the mind, together constituting an integrated perceptual system, rather than a sequence where the one follows upon the other.

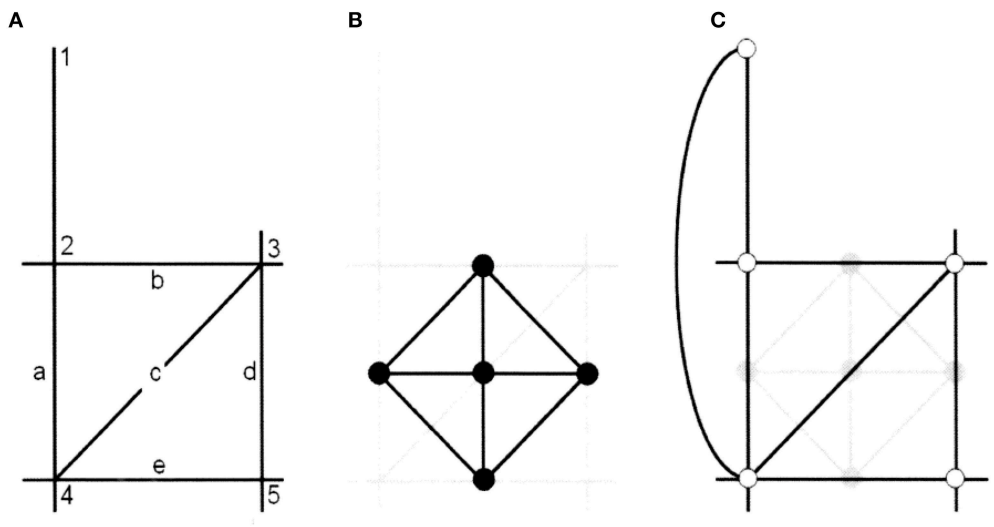

FIGURE 3 | The Copernican shift in graph representations of urban space in space syntax (Batty 2013). **(A)** The street network as an axial map. **(B)** The primal syntax between streets/lines. **(C)** The dual syntax between junctions/points.

It also explains Gibson's unwillingness to make a distinction between perception and cognition. He argues: "Our reasons for supposing that seeing something is quite unlike knowing something come from the old doctrine that seeing something is having temporary sensations one after another at the passing moment of present time, whereas knowing is having permanent concepts stored in the memory" (Gibson, 1986 p. 258).

Consequently, Gibson constructs a new ontology, based in an ecological conception of the world rather than a physical one. To give an example of what the difference here implies, we can compare the isotropic conception of space in physics, defined by an x, y, and z-axis, with ecological space conceptualized as what surrounds living organisms, where the latter immediately need to acknowledge the primacy of the ground, for instance; for an experiencing human, there simply is no spatial isotropism, the way physics tend to deal with space. In Gibson's words: "The world of physical reality does not consist of meaningful things. The world of ecological reality, as I have been trying to describe it, does" (Gibson, 1986 p. 33).

First of all, Gibson instigates the mutuality of *animals*, which includes humans, and *the environment*, the fact that: "each term implies the other" (Gibson, 1986 p. 8). This conception of mutuality between animal an environment gives rise to the basic elements of his ontology: *medium*, *substances* and the *surfaces* that separate them, where the typical "media" are air and water, which allow animal movement, while the earth, and other hard materials that do not allow such movement, are "substances." Interfaces between these, whether between different media or different substances or between a medium and a substance, all constitutes "surfaces" (Gibson, 1986 p. 16). The latter plays a critical role for perception in that they give structure to the light that surrounds us and thus allows for vision. Gibson calls this *ambient light*, which maintains its particular property from the fact that it concerns light in an environment, which causes rays of light, even though we assume a primary source of light such as the sun, to continuously reflect so that we can think of them as coming from every direction, thus filling the medium. However, this also implies that an environment, constituted by a particular configuration of surfaces, typically will structure the ambient light in a certain way and give rise to what Gibson calls an *ambient optic array* that, in principle, is unique for every location (Gibson, 1986 p. 51). It is this structured array of light that enables light to carry information that can specify the environment for a perceiving animal, that is, that light from a point of observation simply will have different forms in different directions.

Of specific importance to architecture and urban design is Gibson's discussion about how the structure and shape of the environment creates what he famously has called *affordances* (Gibson, 1986 pp. 127–143). This concerns how a given environment affords, that is, presents certain potentials for behavior depending on the constitution of the bodies of different animals: "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or for ill" (Gibson, 1986 p. 127). While we primarily may think of affordances as given by the natural environment it is obvious that many species, not only humans, invest a lot of energy and resources into transforming the environment according to their purposes, that is, they transform the environment to increase its affordance in relation to the needs of their own species. As Gibson notes (Gibson, 1986 p. 37), this can also concern the creation of obstacles in the environment, a form of "disaffordance," to protect from or exclude other species. When it comes to the human species, such investments in affordances have taken on tremendous proportions transforming large parts of the Earth's surface.

Gibson's shift toward a conception of the mind and the body as an integrated perceptual system also implies that movement is essential to any kind of perception; from the movement of the eye balls in the head, over to the movement of the head at the top of the neck, to the movement of the body through the environment by means of walking: "Vision is a whole perceptual system"; in short, even though: "one surely *looks* with the eyes [. . .] one does not *see* with the eyes" (Gibson, 1986 p. 205). With the idea of the body as a perceptual system, Gibson makes a decisive break with conventional cognitive science, especially as developed in neuro science, where the body and the head in many experiments, at least traditionally, were forced to keep still in the aim to investigate the brains reaction to different controlled stimuli. His point here is that these experiments may be useful if we want to understand how the brain works, but they are not realistic if we want to understand how humans perceive their environment. In the latter case movement is essential, and in the end what distinguishes animals from other organisms is that they can move—it is their competitive advantage.

Human movement, especially bodily locomotion, is what sets Gibson's ontology into action, so to speak. The medium affords human locomotion but is structured by substances. The substances, however, are not mere obstacles but offer permanence against which movement can be sensed and controlled. More specifically this happens through the changing configuration of surfaces that continuously come into and move out of the field of vision, hence structuring and restructuring the ambient light which thereby carries information about the environment to the perceiving human. From the information point of view the tension between change through human locomotion and permanence offered by the environment is critical: "The optic array changes, of course, as the point of observation moves. But it also does *not* change, not completely. Some features of the array do not persist and some do. The changes come from the locomotion, and the non-changes come from the rigid layout of the environmental surfaces. Hence, the non-changes specify the layout and count as information about it; the changes specify locomotion and count as another kind of information, about the locomotion itself" (Gibson, 1986 p. 73). As a matter of fact, all individual perception is in this sense continuous, why each moment of perception, in principle, happens against the background of earlier moments of perception, why these are part of the present moment of perception. We simply cannot exclude memory from perception and, therefore, the distinct divide between perception and cognition proves difficult to sustain, according to Gibson.

If we acknowledge the fact that humans primarily perceive the environment under movement and that arrested vision rather is the limiting case, this proves to have quite radical implications. First, as we have seen, that the past somehow is present in the present, so to speak; what we just saw help us perceive what we see now, that is, that we cannot discount memory in perception. While this manner of understanding perception, hence, dislocates the *moment* of observation, as it were, it similarly, second, also dislocates the *location* of observation: "Seeing the world at a traveling point of observation, over a long enough time for a sufficiently extended set of paths, begins to be perceiving the world at *all* points of observation, as if one could be everywhere at once" (Gibson, 1986 p. 197). While this at first seems to be an odd conclusion, upon reflection it seems to be a rather apposite description. What we perceive when we move around the environment cannot really be said to be a series of images of this environment, but rather a complete conception of that environment, however imperfect, where certain parts stand out more than others, that is, closer to a 3D-model.

COGNITIVE GEOMETRY: REPRESENTING HUMAN-ENVIRONMENT RELATIONS AS THINGS

We clearly see connections between the two conceptions of the relation between humans and the environment in the two discussions above; space syntax looking for powerful representations that capture humans embedded in the environment and Gibson identifying affordances as an immediate link between humans and the environment. Most interestingly in this respect, Gibson states: "An observer who is getting around in the course of daily life sees from what I will call a *path* of observation" and, furthermore: "the medium can be thought of as composed not so much of points as of paths" (Gibson, 1986 p. 197). If we earlier have seen how what Gibson calls the medium, in an urban setting is structured by particular configurations of surfaces into spatial form, we can see how what Gibson is saying here is that such spatial form, can be represented by a line, or, potentially, a set of lines.

Gibson develops this idea in the context of animal orientation, which he grounds in what he calls the theory of *reversible occlusion*. He describes this in great detail, which proves very supportive for our attempt to link his ideas to space syntax representations, such as the axial map:

"An alley in a maze, a room in a house, a street in a town and a valley in a countryside each constitutes a place, and a place often constitutes a vista, a semienclosure, a set of unhidden surfaces. A vista is what is seen from here, with the proviso that 'here' is not a point but an extended region. Vistas are serially connected since at the end of an alley the next alley open up [. . .]. To go from one place to another involves the opening up of the vista ahead and closing in of the vista behind [. . .] When the vistas have been put in order by exploratory locomotion, the invariant structure of the house, the town, or the whole habitat will be apprehended. [. . .] It is not so much having a bird's-eye view of the terrain as it is being everywhere at once". (Gibson, 1986 p. 198).

It is this perception under movement and the sense of the environment it generates that he means explains the capability of orientation: "To the extent that one has moved from place to place, from vista to vista, one can stand still in one place and see where one is, which means where one is relative to where one might be" (Gibson, 1986 p. 200). Since what we do, according to Gibson's argument, is to continuously scan the environment rather than take snapshots of it, we are in the end able to generate a, more or less, shared perception of the world.

Upon closer examination, the axial map turns out to be something that comes very close to Gibson's description above (**Figure 2**); a network representation of spatial form from the point of view of what we may call a cognitive subject, that is, a perceiving human being moving through space. This is almost an identical description to the one we find when Gibson attempts to illustrate his theory of reversible occlusion (**Figure 4**) (Gibson, 1986, p. 199). In the figure, we see how the "perceptual spatial unit" continuously changes as the observer moves through space (the medium), due to the physical structure of built form (the substance), that is, particular configurations of built form (surfaces) come into and goes out of sight for the observer, creating a continuous set of vistas. This captures Gibson's idea that we do not perceive a sequence of discrete vistas when moving through the environment, but rather a spatial continuum where large parts of the environment typically remain invariable so that what we develop is a conception of the environment as perceived from everywhere.

Now, what we find in the axial map is not a representation of such a spatial continuum but the least amount of "perceptual spatial units" that cover the area we want to represent (**Figure 2**). These units are represented as lines distinctly crossing each other as to both connect to each other as a form of continuous path and to not leave any space possible to access and perceive outside the representation. The axial map thus constitutes a kind of representation, of great economy, of what an urban

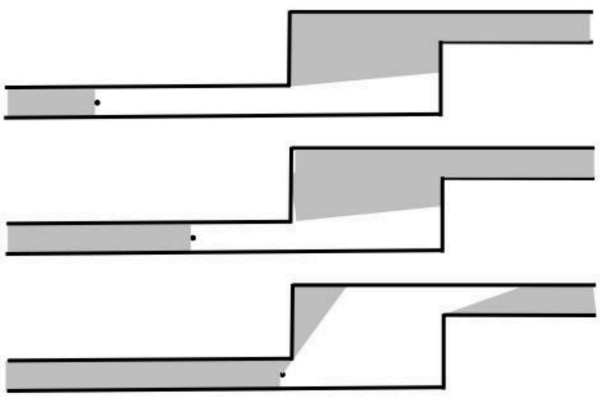

FIGURE 4 | The opening up of a vista at an occluding edge, as seen from above (After Gibson, 1986).

environment *affords* the visibility and accessibility of a generic human. The representation of this continuous medium in the form of the least possible amount of "spatial units" of course represents a reduction of reality, typical for any modeling, but the gain is that the continuous medium of space, which is highly difficult to analyse as such, is transformed into a distinct set of elements possible to represent as a network and also to analyse as such.

Informed by this discussion we may now return to the ontological nature of the axial map. We may ask: is it a representation of the human subject's conception of urban space or is it a representation of the environmental object's spatial reality. We propose, that it is neither, or rather both, that is, a representation of urban space that by starting in the perception of a human moving in such space, captures what the environment affords its perception. Hence, affordances are neither part of the environment or of humans, but rather belong to a human-environment system. The axial map is then not only a representation of a spatial network where the individual lines represent different spatial units tied together at their crossings, but rather a network of affordances, that is, a series of human-environment relations, where each line in itself represents such a relation between humans and the environment; hence the human subject is written into the axial map to the same degree as the physical environment.

CONCLUSIONS: LINKING PSYCHOLOGY TO THE URBAN PLANNING AND DESIGN OF SUSTAINABLE CITIES

From the discussion above we can draw some important conclusions. From the point of view of space syntax, we, first, see that, in contrast to most representations of urban space, the axial map deals with ecological space in Gibson's meaning of the word, rather than physical space. Second, what is represented by the axial map is not space but the situated affordances that emerge in the encounter between human abilities and environmental features. This means, third, that we have a theory about what it is in these representations that has proven so powerful in empirical studies of human movement, which in turn could form the basis for precise empirical tests of this theory. Fourth, this also opens for the possibility that developments of the axial map, such as the segment map or continuity line maps, also can be scrutinized and tested as representations of human affordances, where they may be found as improvements of the axial map in this regard.

From the point of view of psychology, we may conclude, first, that space syntax, and especially the axial map, offers a unique link between psychological theory and urban modeling, which in turn means a link between psychology and the practices in urban planning and design. Second, we see how space syntax can be useful both in relation to behaviorist and cognitive approaches in psychology to increased sustainable behavior. On the one hand, we have seen how it has proven successful in capturing, what we may call, the behavioral substratum for sustainable behavior in a more direct sense, in the form of movement patterns and the distribution of co-presences in urban space. But also, on the other hand, how these situations of co-presence create the foundations for specific design of human encounter with urban green, where particular cognitive experiences relating to values, beliefs, and norms can be generated.

Hence, we see a highly interesting link between a field concerned with understanding the relation between humans and their environment and a field that generate knowledge about how to intervene and change urban environments, at a time when we urgently need to redirect our cities into more sustainable trajectories.

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The author confirms being the sole contributor of this work and approved it for publication.

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frontiers in Psychology

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Making Sense of Biodiversity: The Affordances of Systems Ecology

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We see two related, but not well-linked fields that together could help us better understand biodiversity and how it, over time, provides benefits to people. The affordances approach in environmental psychology offers a way to understand our perceptual appraisal of landscapes and biodiversity and, to some extent, intentional choice or behavior, i.e., a way of relating the individual to the system s/he/it lives in. In the field of ecology, organism-specific functional traits are similarly understood as the physiological and behavioral characteristics of an organism that informs the way it interacts with its surroundings. Here, we review the often overlooked role of traits in the provisioning of ecosystem services as a potential bridge between affordance theory and applied systems ecology. We propose that many traits can be understood as the basis for the affordances offered by biodiversity, and that they offer a more fruitful way to discuss human–biodiversity relations than do the taxonomic information most often used. Moreover, as emerging transdisciplinary studies indicate, connecting affordances to functional traits allows us to ask questions about the temporal and two-way nature of affordances and perhaps most importantly, can serve as a starting point for more fully bridging the fields of ecology and environmental psychology with respect to how we understand human–biodiversity relationships.

Keywords: functional traits, reciprocal interactions, ecosystem function, ecosystem services, biodiversity, affordances

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INTRODUCTION

Biodiversity and Human Affordances

Biodiversity provides the principal basis for ecosystem services important for human life and well-being (Cardinale et al., 2012; Bennett et al., 2015). Despite substantial scholarly progress, we do not adequately understand the relationship between different types and levels of ecosystem, functional, or species diversity and the many aspects of human well-being, whether they are in agricultural, urban, or other landscape contexts (McPhearson et al., 2016; Bennett, 2017). At the same time, there is growing awareness and consensus that human-induced biodiversity loss is elevating socioeconomic risks and costs, undermining human well-being, and the unique opportunities afforded by ecosystems (Steffen et al., 2015; Ouyang et al., 2016).

We need to better understand (1) biodiversity and how it contributes to human wellbeing, (2) how human use in turn influences biodiversity, and (3) pathways for pro-environmental behavior. *Affordance theory,* based on extensive scholarly work in environmental psychology

(Chemero, 2009; Kaaronen, 2017), provides a systemic framework for analyzing interactions as relational and situation specific outcomes. Affordances are defined in this paper as the "relations between *abilities* to perceive and act and *features* of the environment" (Chemero, 2009, p. 252, our emphasis), and we follow Chemero (2003, 2009) in that we take affordances to mean functionally meaningful whole situations. Interactions with species and ecosystems have the potential to support or afford multiple human well-being outcomes (Díaz et al., 2018). However, human–biodiversity interactions are reciprocal and the biodiversity response to human activity (i.e., human-driven species loss) will eventually influence which affordances will be available in the future (Chapin et al., 2000). The existing environmental psychology literature recognizes the role of ecosystems, but, we argue, does not adequately capture enough ecological detail to influence the management of these "features of the environment" for improved human health and well-being, nor for making sure these opportunities are resilient over time in the face of local and global environmental change.

Indirect Effects and Time Dynamics

Ecosystems are not static, nor are they a single entity that humans interact with. Rather, ecosystems have species, processes, and functions, all of which are both acting upon each other and reacting to abiotic and biotic change. As we interact with our surroundings, we change (and are changed by) them, and many of the environmental problems we face are results of careless or deliberate exploitation of opportunity. For example, policy and management decisions in the past could have been made to maintain sustainable supply of fish in many regional fisheries over time, thus requiring limits on the amount of fish caught. However, what is much more common is the rampant exploitation to the point of depletion of fish stocks in fisheries all over the world that has driven global fish stocks near ecological collapse (e.g., Pinsky et al., 2011). Digging deeper into the ecological outcomes of human–biodiversity relationships is critical if we are to understand them well enough to improve both ecosystem health and the ecological contribution to human well-being. While recognized in affordance theory, this ecological side of dynamic interactions is explored more in depth in ecology.

In this paper, we describe the role of *functional traits* in ecosystem functioning and for human affordances, and explore the concept's potential to further bridge the fields of ecology and environmental psychology. Below, we outline some of the central insights and considerations from the functional traits literature, especially where it has engaged with human perceptions and values. We then use *sense of place* and *focal species* to illustrate ongoing research where elements of affordance theory and ecology are already now used together to better capture the dynamics of social–ecological systems. Finally, we build on these to identify some of the most promising areas where a joint research agenda could support sustained ecological integrity together with diverse human affordances.

FUNCTIONAL TRAITS FOR UNDERSTANDING SYSTEM DYNAMICS AND AFFORDANCES

What Biodiversity Affords

Essentially, ecological functions and dynamics over time are mediated by biodiversity and complex interactions between organisms and their surroundings (Chapin et al., 1997; Norberg, 1999). Organisms have an effect on the environment they live in by creating or contributing certain attributes, abilities, and opportunities for interactions, which may serve as the basis for ecosystem services and thus human affordances (Díaz and Cabido, 2001; de Bello et al., 2010; Stokols, 2017). Early studies trying to connect biodiversity to ecosystem dynamics and function used species richness (the number of different species in a community), with some success (e.g., Tilman et al., 1997; Tilman, 1999). However, taxonomic biodiversity has since been criticized as being a blunt analytical framework for describing and understanding species interactions and their outcomes (Mori et al., 2013). Multiple studies (e.g., Díaz and Cabido, 2001; Cornelissen et al., 2003; Vandewalle et al., 2010; McDonnell and Hahs, 2013) suggest instead that functional traits – those abilities and features of organisms with demonstrable links to its ecosystem role and performance and, in turn, fitness – may provide a useful and more mechanistically informative alternative. The approach has been adopted historically for descriptive reasons (McDonnell and Hahs, 2013), to enable broader global comparisons that transcend the constraints placed on such studies by regional taxonomic diversity, and allow for the types of generalizations (e.g., responses to environmental change, ecological implications of trends and patterns) sought after in ecology (Cornelissen et al., 2003; Blaum et al., 2011).

Affordance theory and ecology share many meta-theoretical components: Both view the environment as produced through ongoing, adaptive interactions (e.g., trophic interactions), between organisms (humans included) mediated through abilities and features set in time-specific situational contexts (Pickett et al., 2005; Heft, 2013). And while some traits-based work still uses traits primarily as functional attributes of discrete objects (e.g., comparative studies), especially studies of traits connected to ecosystem services (Díaz et al., 2007; de Bello et al., 2010; Lavorel et al., 2011) have taken on an organismic or even (if to a lesser degree) transactional ontological stance (*sensu* Altman and Rogoff, 1987). Similar to affordances, functional traits describe how and why an organism interacts with its surroundings, capturing and detailing both abilities and features. For example, birds have been grouped and described according to factors such as beak shape, wing length, migratory status, territorial behavior, diet, and foraging strategies (e.g., Simberloff and Dayan, 1991). These factors have a direct bearing on how the ecosystem functions (Sekercioglu et al., 2004) and may serve as mediators of interactive change (e.g., seed dispersal and competition).

The recent expansion of traits-based work to include a more explicit treatment of human views, values, and

perspectives (Goodness et al., 2016) and discuss how these demand new traits to be added to the developing trait lists. Díaz et al. (2011) have described a number of tools now available to quantify functional diversity and link it with ecosystem properties and services. For example, the literature contains a growing evidence based on functional traits that influence ecosystem properties in predictable ways (Lavorel and Garnier, 2002; Cornelissen et al., 2003). These traits include leaf size and chemical composition, seed size and longevity, and canopy and root architecture which affect the ability of a plant species to establish, grow quickly, be productive, reproduce, and respond to disturbances. Standardized low-tech protocols are available for the measurement of these traits (Cornelissen et al., 2003) and the number of metrics for the quantification of traits are growing quickly (Villéger et al., 2008).

We can then use the functional traits approach to better understand which affordances a specific setting may offer and what ecosystem services may or may not exist. The diversity of traits opens up possibilities and multiple species with similar traits offer potential redundancy in the ecological set-up and support of different affordances.

Feedback and Temporal Dynamics

At the landscape scale, where most of our actions play out, knowledge on traits could inform management and planning so that it effectively improves the functioning and resilience of the ecological palette upon which human well-being is dependent (e.g., Díaz et al., 2011). Perception–action processes are not static; they happen over time and their actualization changes the subsequent patterns of relations between humans and biodiversity (Chemero, 2009), and reciprocal effects can potentially affect the future opportunities to have the same type of interaction (**Figure 1**). Researchers have documented how people consciously and unconsciously protect, conserve, use, contest, alter, exploit, destroy, change, and rehabilitate ecosystems, either for their own or someone else's benefit, and all such actions have implications for ecosystem functions and services. At present, there is little systematic understanding about the particular combinations of different human actions and different ecological systems that provide ecosystem services and even less knowledge about service provisioning that is sustainable, efficient, and equitably now and in the future (Bennett et al., 2015). The functional traits approach can help use disentangle such feedback mechanisms (Tomimatsu et al., 2013). The nature of direct human–biodiversity interaction (frequency, intensity, and timing all matter) offers a way to assess its relative strength compared to the abiotic (climatic, resource availability, disturbance) and biotic (competition, predation, mutualisms) factors that over time influence the local pool of species and traits (reviewed in Diaz et al., 1999). Lavorel and Garnier (2002) argue that we should be able to predict the trait pool of a species community by combining the knowledge of the nature and strength of different factors with the trait-mediated response to each factor.

By having redundant options among suites of species with particular traits, we have choices, and stand a better chance

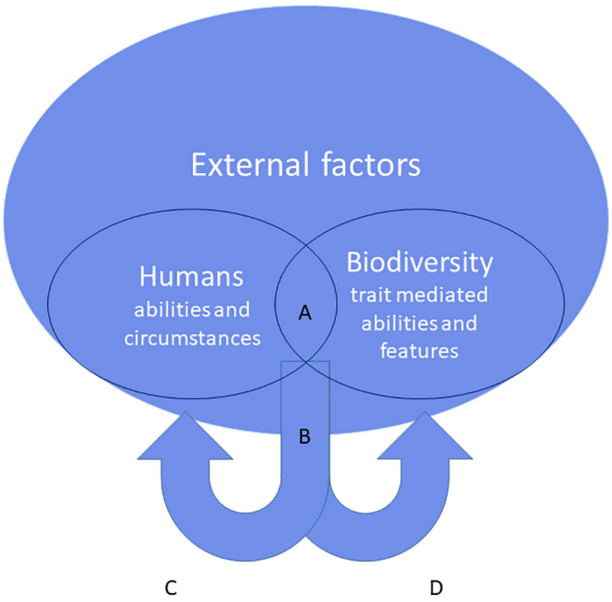

FIGURE 1 | The reciprocal interaction between people and biodiversity. Through their features and abilities (mediated by functional traits) organisms create opportunities for affordances **(A)**. These become real when they are complemented by human abilities and external factors. Realization of affordances **(B)** through an interaction between the organism and a person may ultimately confer direct and indirect benefits for human health and well-being **(C)**. The response of the organism to the same interaction is again mediated by functional traits **(D)**. The interaction and its outcomes may change the future availability of the initial set of affordances.

that the affordance desired will remain present in the system over time and have the necessary traits or diversity of traits to be resilient to disturbance or stress (Walker, 1992). If the different species offering the same affordance differ in their responses to external factors, it is more likely that one will have a diversity of responses to any stress or change that the system it is exposed to (Mori et al., 2013). For example, urban trees that can tolerate air pollution, drought, and soil compaction are more likely to persist in urban environments, for example as street trees, thus providing opportunity for affordances in ways trees without these traits may not offer the same opportunities. This response diversity is the most direct linkage between biodiversity and the overtime resilience of system function and structure (Elmqvist et al., 2003), and is thus a critically important prerequisite for making sure affordances remain in the system.

CO-PRODUCTION AND SENSE MAKING

As recognized in affordance theory, nuances in meaning and the range of affordances offered by any ecosystem are connected to ecological attributes at different levels, from landscapes down to genes (Stokols, 2017), and current ecological communities are products of social–ecological dynamics. In addition to offering direct affordances, the biophysical environment also provide

one of the foundations for registering and conceptualizing change. There are several examples in transdisciplinary studies where differences in ecological character (which are often made up by suites of traits) have been coupled with external as well as internal human factors. We have chosen two of these to serve as illustrations of the questions we can start asking by combining in-depth disciplinary knowledge and approaches.

Sense of Place

Research on the connections between people and places has sought to capture how emotional, experiential and cultural connections mediate human perception and response to change, among other things. Place meanings were initially understood as primarily social constructs, a view that was challenged by Stedman (2003), who argued that the biophysical world imposes both clear constraints and opportunities for creating different meanings. Following this line of understanding, sense of place can be said to capture both the attachment to place and the qualities and descriptive meanings one is attached to (Masterson et al., 2017). Scholars have distinguished between place attachment and place meaning (Scannell and Gifford, 2010), emphasizing the different meanings and affordances place has to the people directly or indirectly connected to it. Where place attachment focuses on our emotional bond, place dependence and reciprocally informed identity, place meaning emphasizes the descriptive cognitive description of what a place is and what meanings it holds. Both are clearly the results of multiple internal and external factors, and especially place identity and place meaning are strongly influenced by the character of the biophysical setting (Stedman, 2002; Masterson et al., 2017). The sense of place literature has also shown how perceived changes in available affordances (often with specific traits serving as cues) can serve as triggers for direct action grounded in a deep sense of care and responsibility (Enqvist, 2017). This idea of "cues" or "triggers" has also been taken up by conservation biology as well as conservation psychology (e.g., Charles Vlek, 2007; Gifford, 2007; Chapin et al., 2012).

Conservation Biology and the Use of Focal Species

Conservation biology has long used individual species as foci for different discussions and campaigns, for example pandas or polar bears. The choice of species is based on different attributes that are seen as mediators of meaning beyond the biological organism itself. This literature offers both clear evidence of the value of combining psychological, social, and ecological aspects, and the challenges amidst this complexity. From an ecological integrity perspective, the focus has been on species that have a particularly significant impact on the state of a community or an ecosystem, either based on significant life history traits or niche (e.g., keystone predators), or because the species is highly interactive and abundant (Soule et al., 2003). Alternatively, when less is known about ecological relationships, species with relatively extensive habitat requirements serve as "umbrellas" for conservation (Simberloff, 1998). The choice of focal species may also be grounded in traits that relate to its appearance, charisma, behavior and utility (Walpole and Leader-Williams, 2002; Serpell, 2004; Lorimer, 2007; Martín-López et al., 2008), characteristics that relate to the importance of affect as a vital motivating force for people to get involved in conservation efforts (Lorimer, 2007).

This approach to conservation suggests that efforts should focus on key endangered interactions between species (humans included), not just on endangered species. Further, we suggest that the different meanings and different traits can be combined to capture biodiversity responses to various interactions with people, cascading effects of ecological change, as well as what the consequences might be for people. Kronenberg et al. (2017) suggested that a "social-ecological keystone species is likely to be more meaningful for broader conservation objectives because it complements the ecological importance with the social perception of a species, thereby opening an opportunity to connect various dimensions of social/cultural value that people attribute to nature to ecological quality and dynamics." Similar to sense of place, this combination of extended biophysical and socio-cultural meanings and relations highlights our own role as stewards, framing conservation as not only needed to preserve species and ecosystems, but because we impact the different avenues for meaningful human interactions with these ecological components. In the language of this article, this means that recognizable, legible functional traits are important to use (analytically as well as actively) to understand and support pro-environmental affordances.

CONCLUSION: WHAT IS BIODIVERSITY TO US? AN OPEN INVITATION TO JOIN IN THE EXPLORATION OF MEANINGFUL INTERACTIONS

There is much work remaining to integrate the affordances perspective with research on ecosystem dynamics and ecosystem services (Raymond et al., 2017). In this mini-review we have presented functional traits as a bridge for connecting affordances to biodiversity and the real dynamics of ecosystems, and thus add an in-depth ecological perspective to the environmental psychology field and the complex topic of human–environment interactions. There are two areas in particular where we see a clear benefit in trying to combine the two frameworks. First, biodiversity studies have long grappled with the cultural understanding and making sense of biodiversity, and insights from environmental psychology may help us understand why and under what circumstances an opportunity leads to interaction and the human ability to process sensory input. Intrinsic, deeply embedded, and culturally framed meanings have long been recognized for ecosystems in general, but the ties with biodiversity remain tenuous. Second, for environmental psychology to have impact on management, design, or planning to improve the functions and services of ecosystems, it needs improved ecological specificity, which can be helped with a traits-focused approach.

Both the reasons for and the benefits of a certain human action – the realization of an affordance – are complex bundles of contingencies and the nature of reciprocal interaction is important. The theory of affordances stem from an ontology where the nature of the interaction is as important as the underlying factors that constitute an affordance (Gibson and James, 1979), and ecosystem services are increasingly seen as co-produced (e.g., Andersson et al., 2015; Palomo et al., 2016). However, this understanding has yet to strongly connect to the functional traits studies. An affordance is dependent on not just one detail of the system (e.g., species or conceptualization of an ecosystem, or presence of a specific trait), but on a number of factors, some internal, some external, some ecological, and some socio-cultural. Kyttä (2004) pointed to the need to better understand and account for the full suite of factors influencing whether or not an affordance is realized. Once an individual has perceived an opportunity for action afforded by the environment, the actual realization only emerges when the different characteristics of the individual, such as his or her physical abilities, social needs, and personal intentions, align with and match the opportunity space (Kaaronen, 2017). In addition to the embodied perspective offered by affordance theory, there are layers of sense making and social constructs like institutional regulations and norms that all influence which affordances are recognized and how they are realized, and thereby what the implications are for the biodiversity involved in the interaction.

By harnessing the dual aspects of functional traits, we can better understand the implications of people responding to desired or attractive traits. The attractive trait expression (perceived at any level of biodiversity, genes, species, communities, and ecosystems) comes with sets of individual species response traits that will inform both how an organism may respond to the realization of an affordance and how sensitive different affordances are to larger-scale environmental changes. Additionally, the ecological literature tells us that there are alternative biodiversity configurations that may offer the same affordances. The affordance literature in turn reinforce that there are numerous ways in which an affordance can be realized. Affordances are only *opportunities* for action; the outcomes are complex and not necessarily that well-recognized beyond the direct experience of the interaction and final service provided by the dynamics of the environment. Many of the indirect and less desirable outcomes remain less obvious.

Linking environmental psychology and systems ecology together can help us:

- Bridge the scales of human perception and the often more detailed information about species traits;
- Understand when, why, and how an affordance is realized;
- Seek redundancy and resilience in the functions of environments by establishing redundant affordances that inspire interaction pathways with low negative impact;
- Explore indirect benefits, e.g., pro-environmental behavior of biologically diverse everyday landscapes;
- Co-produce environmentally friendly affordances by combining biodiversity with design and sense-making.

Advancing such research requires interdisciplinary collaboration and deepening the understanding of complex dynamics in ecosystems, but also new data sources to build more extensive and relevant trait databases to advance the linkages between systems ecology and environmental psychology.

AUTHOR CONTRIBUTIONS

Both authors have substantially contributed to the conception or design of the work and provided critically important intellectual content. The outline and design of the study was led by EA. Both authors approved the submitted version of the manuscript and both agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Fostering Children's Connection to Nature Through Authentic Situations: The Case of Saving Salamanders at School

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The aim of this paper is to explore how children learn to form new relationships with nature. It draws on a longitudinal case study of children participating in a stewardship project involving the conservation of salamanders during the school day in Stockholm, Sweden. The qualitative method includes two waves of data collection: when a group of 10-year-old children participated in the project (2015) and 2 years after they participated (2017). We conducted 49 interviews with children as well as using participant observations and questionnaires. We found indications that children developed sympathy for salamanders and increased concern and care for nature, and that such relationships persisted 2 years after participation. Our rich qualitative data suggest that whole situations of sufficient unpredictability triggering free exploration of the area, direct sensory contact and significant experiences of interacting with a species were important for children's development of *affective relationships* with the salamander species and with nature in an open-ended sense. Saving the lives of trapped animals enabled direct sensory interaction, feedback, increased understanding, and development of new skills for dynamically exploring further ways of saving species in an interactive process experienced as deeply meaningful, enjoyable and connecting. The behavioral setting instilled a sense of pride and commitment, and the high degree of responsibility given to the children while exploring the habitat during authentic situations enriched children's enjoyment. The study has implications for the design of education programs that aim to connect children with nature and for a child-sensitive urban policy that supports authentic nature situations in close spatial proximity to preschools and schools.

Keywords: nature experience, affordances, affective relationships with nature, urban, situated learning, stewardship, qualitative methods, longitudinal approach

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INTRODUCTION

Globally, the number of urban dwellers is projected to increase from 3.2 billion in 2005 to about 6.4 billion by 2050 (UN-Habitat, 2016). This unpreceded rate and scale of urbanization may embark civilization on a development trajectory with limited possibilities for people, and especially for children, to experience natural environments on a regular basis (Giusti, 2016;

Colding and Barthel, 2017; Hand et al., 2017). Such a development trajectory, if not carefully designed, may lead to a shift in baseline related to connection to nature (Miller, 2005; Giusti, 2016; Hartig and Kahn, 2016; Soga and Gaston, 2016), defined as 'one's affective, experiential relationship to the natural world' (Mayer and Frantz, 2004, p. 504).

Multiple studies in distinct scientific traditions have considered adults' connectedness to nature, otherwise termed human-nature connections, and its relationship to pro-environmental behavior (e.g., Raymond et al., 2010; Brehm et al., 2013; Restall and Conrad, 2015; Ives et al., 2017). In the environmental psychology literature, connectedness with nature can be seen as a psychological construct that reflects the degree to which individuals perceive that they are part of the natural environment (Schultz, 2001, 2002), and such perception arguably influences adults' motivations to engage in pro-environmental behavior (Kals et al., 1999; Chawla, 2007; Ernst and Theimer, 2011; Cheng and Monroe, 2012; Liefländer et al., 2013; Mayer and Frantz, 2014; Richardson et al., 2016). For example, environmental activists report greater connectedness with nature compared to college students, suggesting that connectedness with nature may be related to pro-environmental attitudes and behaviors (Bruni and Schultz, 2010). However, recent studies indicate that the attitude–action gap is still an unresolved scientific problem in sustainability planning and management (Sörqvist, 2016; Kaaronen, 2017; Linder et al., 2018).

Scholars have recently begun to unpack the meaning of children's connection to nature and its association to different nature-based activities (Ernst and Theimer, 2011; Cheng and Monroe, 2012; Giusti et al., 2014, 2018; Giusti, 2016). For example, the findings of Cheng and Monroe's research (2012) suggest that learning, understanding, and experiencing nature are all factors that can positively influence the development of a child's affective relationship. However, the many studies aiming to evaluate an activity's effectiveness in enhancing children's connection to nature employ quantitative methods (usually performing pre- and post-activity tests), with results indicating no, or very little, change (Ernst and Theimer, 2011; Bruni et al., 2015; Giusti, 2016).

In response to this shortcoming, there is a need for longitudinal studies for assessing the changes in children's connections to nature across time. Furthermore, research is needed to assess what specific aspects of environmental education programs encourage positive shifts in connection to nature (Ernst and Theimer, 2011; Kossack and Bogner, 2012; Liefländer et al., 2013).

In this paper, we focus on if and how urban children strengthen their connection to nature, used here open-endedly as an affective relationship with nature characterized by empathy for creatures, enjoyment of nature, sense of oneness, and sense of responsibility (cf. Cheng and Monroe, 2012). We focus on a case where young children take part in a stewardship project aiming to save endangered species, the Salamander Project, and how their participation shapes their connection to nature. Our focus on children is important given that people acquire strong connections to nature most easily during childhood, by participating in social action, but also by first-hand sensory interaction with natural environments and species (Kahn and Kellert, 2002; Mayer and Frantz, 2004; Chawla, 2006, 2007; Wells and Lekies, 2006; Chawla and Cushing, 2007; Evans et al., 2007; Cheng and Monroe, 2012).

The aim of this paper is to increase our understanding about *if*, *how* and *by which means* children's affective relationships with nature change by taking part in a nature conservation project during school hours, and if such a shift persists 2 years post-participation. Does participating in the Salamander Project at school strengthen children's connection to nature? If so, how do children learn to create affective relations with nature? Which specific situations might encourage or enable stronger affective relationships with nature? Do affective relations persist 2 years after the project? This paper studies fourth graders (age 10–11) who, during an 8-week period, took part in saving salamanders near their school in Stockholm. It started with a master's thesis study (Belton, 2016), which then transformed into a longitudinal study to explore whether changes in affective relationships with nature detected in these children persisted long after their actual hands-on engagement.

Theory on Learning, Behavior and Change

Our work is firmly rooted in evolutionary thinking and framed by a social-ecological systems approach that assumes that learning emanates from human behavior in interplay with features of both the biophysical and social environment. It views human beings like other creatures in the web of life with which they have co-evolved, claiming that people, like other organisms, encounter the physical world directly with all senses, with the ability to perceive qualities of the world that are really there rather than merely mental constructions about the world (Chawla, 2006). At the same time it does not deny the powerful influence of socialization and culture (Wenger, 1998; Clark and Uzzell, 2002). Instead the frame views socio-cultural influences to shape, rather than to prevent, how we select and use the information that we receive about the world's true qualities. Affordance theory (Gibson, 1979; Kaaronen, 2017) and situated learning (Lave and Wenger, 1991), specifically fit well with such a social-ecological approach.

An Affordance Approach to Environmental Behavior and Learning

Affordance theory is grounded in ecological psychology and interprets human behavior from a dynamic and coupled systems approach (Gibson, 1979). Ecological psychology is interested in environmental learning and action in every setting, and is particularly well adapted to describe what happens when children learn through autonomous movement and exploration, such as children at play outdoors (Kyttä, 2004; Chawla, 2006). An affordance, in its simplest understanding, refers to the action possibilities provided by objects or environments. However, a more nuanced understanding of affordances does not consider affordances as properties of objects or environments, but rather in terms of *whole situations* (Chemero, 2003, 2009). Affordances are defined as the 'relations between abilities to perceive and act

and features of the environment' (Chemero, 2009, p. 150). For actualisation to occur different characteristics of the individual, such as his/her physical abilities, emotions and intentions must be matched with properties of the physical environment (Kyttä, 2004; Chemero, 2009; Roe and Aspinall, 2011; Withagen et al., 2012).

Children are most likely to stay attentive and engaged when perceiving affordances that provide them with immediate, pleasurable experiential feedback about the effects of their actions (Heft and Chawla, 2006; Beery and Jørgensen, 2016). Such feedback may be perceived if children are allowed, and are able, to shape features of the physical environment and experience with all five senses changes in their environment as a result of their actions, such as when building a dam with small rocks in a stream (Chawla, 2006), or when saving the life of an animal that is trapped. Kyttä (2004) notes that these situations are characterized by positive interactive cycles: the more widely that children move through and experience their world, the more satisfying encounters they have with engaging affordances, which motivates them to explore them even further. Even if the socio-cultural aspects of the environment always have been present in affordance theory (Gibson, 1979), it has of late been brought more to the foreground (Raymond et al., 2017). Affordances are dynamic and coupled human-environment relations (Kaaronen, 2017), where behavior is probabilistic and actualisation of affordances may occur when the right social circumstances are present (Clark and Uzzell, 2002; Kyttä, 2004). A situated learning approach is used below to explore how affordances are related to connection to nature and learning about nature.

A Situated Approach to Learning

Several well-established theories and disciplines are nested under a situated (ecological) approach to learning (Lave and Wenger, 1991; Barab and Roth, 2006; Durning and Artino, 2011). In brief, situated learning understands all learning and thinking as inevitably located in activity (in doing) and, therefore, *inseparable from experience* (Brown et al., 1989; Lave and Wenger, 1991; Barab and Roth, 2006; Bendt et al., 2013). Many of the skills required in everyday settings are learned mainly through behavior, or through practice (Lave, 1988; Saxe, 1991), whether tacit and unconscious or explicit and codified (Leonard-Barton and Sensiper, 1998). Skills are not always articulated, it is simply what we do, or 'what changes our ability to engage in practice, the understanding of why we engage in it, and the resources we have at our disposal to do so' (Wenger, 1998, p. 97). If the concept of culture can be defined as a system that gives meaning and significance (Geertz, 1993), learning from a situated view is innately connected to the production of identity and meaning (Lawrence, 2009).

Learning can therefore be viewed as a product of people's enculturation, in turn related to the accepted norms and values of groups, within which the individual acts (such as a stewardship group) (Lave and Wenger, 1991; Wenger, 1998, 2000). If environmental values of a participator are also reflected in the shared norms of the group, pro-environmental behavior is supported by positive feedback mechanisms provided by other group members, for instance, by way of comments, bodily postures or rewards. The social norms of the group form part of the individual member's choice architecture, in combination with properties of the physical environment. The more authentic a situation is experienced to be (i.e., the closer the situation is to resembling real life), the better a learning opportunity it provides (Reed, 1996; Boyer and Roth, 2006; Durning and Artino, 2011). As far as 'real life' situations go, scholars of environmental education and child development point to nature experiences as being particularly rich in opportunities for meaningful learning activities (Kyttä, 2002; Chawla, 2007; Moore, 2014; Beery and Jørgensen, 2016). This theory increasingly acknowledges socio-material features to shape situations for learning (Godden and Baddeley, 1975; Smith and Vela, 2001; Barab and Roth, 2006; Muro and Jeffrey, 2008). Hence, urban environmental education is one means by which children actualize the affordances offered by nature in cities (Chawla, 2006; Delia and Krasny, 2018).

The Salamander Project

A pond in Olovslunds Park in Bromma (a suburb of Stockholm) is one of the most important breeding habitats within the greater Stockholm region for the two species of salamander found in Sweden[1], the common newt (*Lissotriton vulgaris*) and the great crested newt (*Triturus cristatus*)*. The pond, being shallow, relatively warm and free from aquatic predators, provides an ideal habitat for these amphibians to reproduce. However, salamanders often fall in a concrete wading pool (located adjacent to the pond) during their annual migration to spawn in the pond in spring (**Figure 2**). The salamanders are unable to escape the wading pool because it is drained of water at that time of the year, and therefore dry out and die.

In 2007 the local authorities, realizing how serious an issue this was, developed a pond management plan. Both salamander species are protected under national law (Länsstyrelsen, 2015) and the great crested newt (**Figure 1**) is listed in both the Bern Convention and Annex IV of the EU Habitats Directive requiring a 'strict protection regime' by member states (Lundberg and Kiibus, 2014; European Commission, 2015). Under the pond management plan, a number of technical strategies were implemented in an attempt to solve the trap problem. These, however, were not sufficiently effective, leading the local authorities to ask for help from a nearby school in 2008 (Kiibus, 2011). Bromma, where the school is located and the project takes place, is 8 km west of Stockholm. This predominantly middle to high-income residential area has a population of 70,000 (Belton, 2016).

Every year since 2008, the fourth grade students of Olovslund School participate in the Salamander Project (60–70 students yearly). The aim is to save salamanders and simultaneously to teach the students about conservation issues. Every school lunch break of the salamander breeding season (April/May), a small group of children carefully search through piles of leaves scattered around the wading pool with sticks and place any salamanders found in a bucket of water. The piles of leaves are placed inside the concrete wading pool with its sharp edges to provide habitat for

[1]Salamander is the common name for the order of Caudata, which includes newts and sirens.

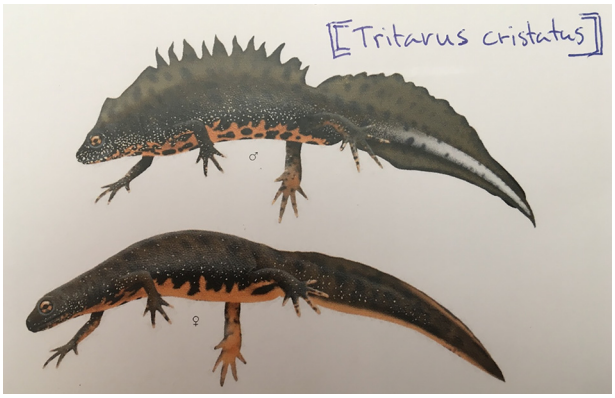

FIGURE 1 | The protected great crested newt (*Triturus cristatus*). Photo of postcard, Source: ArtDatabanken.

FIGURE 2 | Olovslund Park with the pond on the right and the paddling pool to its left. The school is just a short walk away (source: Google Maps).

the salamanders to hide and escape the sun, but they ultimately dry out, or are cleared as the pool season starts, making the pool a kind of death trap. Before releasing them into the nearby pond, the children document the number, species and sex of the salamanders found, as well as from which pile of leaves each was found. These daily reports are then communicated by the teacher to a biologist enabling the tracking of migration trends, the number of salamanders trapped and saved and monitoring the effectiveness of the project.

Over the 10 years that the project has been running, 1204 great crested newts and 3715 common newts have been rescued by Olovslund School (personal communication, 2017), allowing the local salamander population to remain stable in a time when urbanization and habitat loss pose a threat to many urban amphibian species (Lundberg and Kiibus, 2014). Another measure of success from an ecological perspective is the successful re-introduction of the great crested newt species from this pond into a nearby pond in 2009, leading to the set-up of an identical operation in 2015 (Kiibus, 2011; Lundberg and Kiibus, 2014). This meant an extra task for the participants: taking the 'saved' great crested newts back to school (instead of releasing them into the pond). In order to do this, the school was granted special permission by the county authorities (Länsstyrelsen, 2015), it otherwise being illegal to collect this species in Sweden.

METHOD: QUALITATIVE AND LONGITUDINAL RESEARCH DESIGN

Given the ample room for improving theory and understanding about children's connection to nature over time, we decided upon a qualitative and longitudinal research design (Beery and Wolf-Watz, 2014; Chawla, 2015; Beery and Jørgensen, 2016). Qualitative data was collated through semi-structured interview questions and open-ended questions included in a questionnaire administered to the school children. Our attempt was to elicit experiences of the participants both by listening to, and analyzing, their own words, which helped us gain a more in-depth, 'inside' understanding of the *how* and *why* lines of inquiry (Patton, 2002; Yin, 2009). We also consistently observed their behavior and activities in the field.

The theoretical starting point for this study was Chawla's (1998, 2006) framework on children's development of affective relationships with nature. This framework includes how humans acquire affective relationships with nature most easily during childhood in situations that trigger behavior and immediate feedback, which are experienced to be of significance. In recognition that connection to nature is still a contested concept in the environmental psychology and environmental management literatures (Ives et al., 2017), we explore multiple facets of affective relationships with nature and its change over time. To support a rich and deep understanding of aspects of affective relationships with nature, we sought in part for themes to emerge from the open-ended interview and survey responses. The interview script consisted of sections that sought to explore how such relationships may be shaped by aspects both of the biophysical environment and also by the social context. Follow-up open-ended and ordinal level survey questions on the same topic enabled these patterns to be examined in further depth.

The interviews and questionnaires were administered across two waves of data collection conducted 2 years apart (2015 and 2017) in order to study if changes in children's affective relationships with nature persisted 2 years after participation in the Salamander Project (see **Table 1**). In accordance with triangulation in qualitative research, we employ a range of data sources to explore and explain themes that cut across several sources (Creswell, 2014).

Contact with the school had been established prior to this study in the form of a pilot study in 2014. Alongside consent from the school principal and concerned teachers, full written parental consent was obtained for all participating students. Furthermore,

TABLE 1 | Temporal phases of the empirical field study.

	Month	**April – May**	**Early June**	**Late June**
Wave 1 2015	Method	**Field observations** of the children participating in the project, classroom lesson and Salamander Evening (9)	**Questionnaire** Mostly open-ended questions about participants' views on the project, post-participation (n = 57)	**Face to face semi-structured individual interviews** With children just after participating in the project (n = 25)
	Month	**March**	**May**	
Wave 2 2017	Method	**Face to face semi-structured individual interviews** With children 2 years after participating in the project (n = 24)	**Questionnaire** Mostly open-ended questions about participants' memories and views of the project 2 years after participation (n = 49)	

Two waves of data collection 2 years apart (2015 and 2017).

the research design was approved in an ethical review process conducted by a Swedish university.

Data Collection Wave One – Spring 2015

Field Observations of the Salamander Project

During the first round of data collection, nine field observations of the conservation project took place over a 2-month period (Appendix A). The first of these was of an initial information lesson given in the classroom by the teacher in charge of the project, explaining and preparing the students for their involvement in the project.

Seven field observations involved meeting the group of children and the teacher at the school and walking with them to the park to observe them partake in the project (about 45 min each time). These observations were spread out over the length of the project in order to capture differences across time and in differing conditions (such as weather and number of salamanders found). The same groups of children were observed at different points in time enabling us to note changes between children's first, second, and third (final) participation. While the first of these observations was a general observation of the learning environment, the following were participant observations allowing us to experience the hands-on work, mingle with the children and ask informal questions. This participant observation was helpful because it allowed the children to become familiar with us before being interviewed. Detailed notes were taken after each observation in order to have a written record to refer back to.

Lastly, we attended the local 'Salamander Evening' as participant observers (see **Table 1**). This is an annual community event at the pond in Olovslunds Park where Stockholm biologists give an informal talk about the project, thank the school for their work, and proceed, with the help of all people present (children and adults), to count the salamanders in the pond.

The general aim of these observations was to witness the unfolding of the conservation project in its fullness to better understand what it embodied from the point of view of the participants (DeWalt and DeWalt, 2011). We took note of what the children did, how they did it (e.g., with what level of engagement/concentration and what type of body language), what they talked about while participating, what the atmosphere was, and how these attributes changed over time. The observations acted as springboards for developing interview questions as well as a means to verify themes and/or insights that emerged from interview and questionnaire data (Patton, 2002).

Salamander Project Questionnaire

Students completed a short questionnaire after completion of the Salamander Project (June 2015) during regular class time (see **Table 1**). Questions were designed to mostly collect information on nominal level data (e.g., 'Pick three words that best describe the Salamander project for you'), mixed with certain questions of more 'closed' character (e.g., 'How many salamanders did you find in total?') (Appendix B). As mentioned above, questionnaires enabled a larger sample size for us than the interviews (n = 57 vs. 25 in 2015 and n = 49 vs. 24 in 2017), which was helpful in determining whether emergent interview patterns were consistent across data sources.

Semi-Structured Face-to-Face Interviews

During the final days of the project, 25 children who had participated in the project were interviewed (see **Table 1**). Selection criteria for the interviews (Appendix C) were based on: (1) full parental consent to interview, record and use their child's quotes; (2) an even spread of students across the three classes so as to account for the possibility of a teacher's pedagogical influence on children's views about nature/the project; (3) equal gender representation; and (4) a variety in the number of times children had participated in the project (two to five times).

The purpose of the interviews was to uncover the experience of participating in the project from the children's perspective, and to understand whether it strengthened their affective relationships with nature. The focus was on how it felt to be part of the project, what changes (if any) they had experienced during the course of the project (changes in feelings toward salamanders and nature as well as changes in themselves) and what they had learnt

from it. Interviews were conducted in an informal manner in a comfortable setting (one-on-one, in Swedish, at school during school time) and, given the age of the participants, were kept short (10 min). Interviews were semi-structured following an interview guide (Appendix D), at the same time allowing the conversation to follow its natural course and for new questions to arise spontaneously (Kvale, 1996; Patton, 2002).

Data Collection Wave 2 – Spring 2017

The second wave of data collection occurred exactly 2 years later, in spring 2017, when the participants were in sixth grade and their final months of Olovslund School (see **Table 1**). This round of data collection consisted in 24 interviews (of the same nature as in 2015: short, one-on-one, at school and during school time, see Appendix F) and a questionnaire. The focus for both the interviews and questionnaire was on: (1) what the children remembered/retained and what they had learnt from their participation in the Salamander project in 2015; (2) whether their view of salamanders, other animals and nature had changed/shifted with the project and if so, how; and (3) whether or not they feel their connection to nature had changed with their time in the project and, if so, how.

The questionnaire was a combination of open-ended and box-checking questions (Appendix E). The 24 interviewees were selected evenly across the three classrooms, and were a mixture of children that had previously been interviewed in 2015 and those that hadn't (Appendix C). Hence, a mixture of children researched on both waves of data collection and those only partaking 1 year formed part of our unit of analysis. This unit was chosen because we wanted our unit of analysis to represent a fair gender balance and simply for practical reasons (voluntary to participate), and also to explore a wide range of views. In 2017 no observations took place, as the participants did not take part in the Salamander Project (a fourth-grade activity only).

Analysis of Data

Interviews from both waves of data collections were transcribed verbatim and coded for emerging themes, using the software program Dedoose (version 6.2.17). Quotes were then translated into English. Coding was done in two ways. Firstly, in terms of exploring qualitative aspects of affective relationships with nature, we coded the interview data for three of the four sub-constructs of connection to nature as developed by Cheng and Monroe (2012): enjoyment of nature, empathy for creatures and sense of responsibility. The fourth sub-construct (sense of oneness) did not work well for this age group in our opinion.

Secondly, we were interested in exploring the conservation project's specific features that appeared to have facilitated the development of affective relationships. Here, coding was done in terms of emergent themes that surface from analysis of the interview data—an iterative process that required several rounds of analysis. The written texts from the children in the questionnaire data were first translated into English and then analyzed looking for recurring themes with the help of the software program NVivo (version 11) and the website Woodle. Themes that emerged from any of the data sources were compared with our other data sources whenever feasible. For example, interview codes were considered when analyzing questionnaire data and vice versa, leading to code/theme refining. Additional gray and scientific literature, informal written and verbal conversations with the children's teachers, the local biologist and the teacher in charge of the project, were equally analyzed in light of themes that emerged from primary data.

RESULTS

Interview and questionnaire results from 2015 point to a self-observed change in children's connection to nature after project participation. This change was described as a positive one: increased concern, interest in and/or care for nature. Answering interview questions about how they had changed with the project, 16 children (out of 25) expressed increased empathy toward salamanders ('feeling' and 'caring' more for them). They explained that they had developed a better understanding for salamanders, both in terms of facts about them (e.g., how to differentiate amongst species and sex), but also how to 'help' and 'care for' them. An emergent finding from our empirical material was that 17 children (out of 25) noted that they had learnt more. Furthermore, in the questionnaire, 93% of children answered 'yes' to caring more about salamanders after the project than before. When talking about changes in how they felt toward salamanders and changes in themselves many children talked about going from not knowing or caring much about these amphibians to being closer to them, much more aware of them and thinking more about them:

> *I have more — okay, respect is a big word but I have to use it because there isn't another one — respect for how they [salamanders] live because it's quite. . . I wouldn't survive if I were a salamander!. . . Now I see them in a different way. Before I thought they were like animals. Now it's like they are beings that, well, they need help, just like people can need help sometimes.*
> (Participant 1)
> *We got to know them.*
> (Participant 11)

Shifting experiences of touching the species in question was an emergent theme from the interviews. In time, several children got over their initial fear of touching salamanders. Eight children experienced a change from being scared of, or nervous about salamanders, or finding them 'creepy,' to feeling more comfortable with them and daring to hold them as this following quote depicts:

> Interviewer: *Do you think that you have changed with the project?*
> Participant 4: *Umm. . . before, I was a bit scared of salamanders. They were, like, a bit slimy. I didn't dare to hold one and now I can hold one without any problem. . . I have, like, stopped being scared of them.*

This increased 'connection' to salamanders was mirrored by strengthened relationships with nature in a broader, more open-ended sense. Children typically expressed thinking and caring

more about other animals as well as about nature (in the wider meaning of the concept) after the project. The following quotes exemplify common answers to the question 'Do you think you have changed with the project?'

> *I have learnt to take care of animals. I'm maybe thinking about doing something like that maybe. . . to fix things so that everything is good with nature. . . . Yes. . . I have become more nature-friendly.*
> (Participant 6)

> *Yes, well, I have much more of a sense for nature and salamanders.*
> (Participant 3)

> *That's a hard question!... Well, I have started to think more about animals and nature. Actually a lot more than what I did before.*
> (Participant 25)

> *Well, it's like I'm less scared and I feel more... confident in nature.*
> (Participant 23)

The main result from 2017 shows that the affective relationships that formed in 2015 remain. When asked directly if they cared about salamanders and if they would help a salamander if they saw someone hurting it, all interviewees answered 'yes.' The vast majority of children expressed that their feelings toward salamanders had changed with the project, reflected in an increased empathy toward salamanders (83% of interviewees), as the following quote from 2017 expresses:

> Interviewer: *Did your feelings for salamanders change with your time in the project?*
> Participant 23: *Yes they did actually. I hardly knew what a salamander was before the project so. . . they have. I know what a salamander is now and I care more about them!*

Even as 12 or 13-year-olds, in 2017, the majority of children (71%) expressed that the Salamander Project had changed the way they view other animals: they think and care more about them as well. Also, the majority of children (75% of interviewees, 54% of questionnaire respondents) confirmed that their view of nature (in the broader sense) had changed with the Salamander Project: it had helped them understand how important nature is and particularly how important it is for animals. Some children had more place-connected answers, thinking more of nature as a home for salamanders since the project, or explaining that their view of nature as a whole hadn't changed, but that their view of the specific salamander habitat had.

As the findings above show, the Salamander Project has helped children relate to salamanders but also to other animals (albeit to a lesser extent) and even to nature (in a more theoretical, less concrete way). This is further confirmed by the answers to the question 'Do you feel you, as a person, have changed with the Salamander Project, and, if so, how?' Out of the 79% of interviewees who answered yes, the vast majority of answers were salamander-specific (i.e., I care more about salamanders now), followed by animal-specific answers (i.e., I think more about animals now), and lastly answers that were about nature or something broad (i.e., I am more careful now, I know more about nature now). Indicators of shared memories include that 75% of interviewees in 2017 had thought about salamanders or the project, and 83% had talked about salamanders or the project during the last 2 years. When asked to recount their memories, interviewees spoke fondly about the project and 83% thought that they would remember it when they are older. An indicator that emerged from our empirical material of increased sensitivity toward salamanders is that 91% of interviewees had observed salamanders in the nearby surroundings during the 2 years that had passed.

Participating in Something of Significance With a Sense of Responsibility

Children highly valued being 'part of' the project, being given the opportunity to 'participate' in or be 'included' in an important real-world project. For example, the contributing/helping aspect of the project (the word 'saving' was recurrent in both interviews and questionnaires) emerged as important for the children not only in terms of physically helping salamanders, but also with regards to having a role in the wider community by helping the municipality with its duty of biodiversity protection. This finding is supported by situated learning that stresses the importance of goal-driven activity for meaningful learning (Chawla, 2006; Durning and Artino, 2011).

> Participant 21: *I think it's really nice that we can help out. . .. The teacher explained that. . . only our school has permission to take the great crested newts and I think that that's pretty cool.*
> Interviewer*: It is!*
> Participant 21: *And we can talk about it later when we are big, to our children.*

Being part of a 'bigger' project and community context (participating in an adult activity, beyond school) gave children a sense of importance, responsibility and pride. Children clearly expressed their sense of responsibility toward the Salamander Project and their appreciation for being given this responsibility. This was apparent throughout the interviews but was also recognized by the teachers who noticed how committed their students were to the project and the sense of importance that stemmed from it. This was further confirmed by observations in the field of children's careful concentration and thoroughness in the tasks (**Figure 3**).

Children talked about how things changed over the course of the project and how they had an increasing amount of responsibility, as the teacher trusted them to do the job well. One student called this 'freedom with responsibility' (Participant 25). This increased responsibility, trust and freedom allowed the children to get closer to and be sensitized to the salamanders in their own time and manner, and also to gain increased skills by repeatedly performing the tasks.

FIGURE 3 | Developing affective relationships with nature by way of significant experiences when saving the life of an animal, here by handling the species: carrying a great crested newt in one's hand. Photo: Martina Kiibus.

> *Well it was nice that she [the teacher] didn't come and watch over us, rather she thought we could do it and we could! We had to take responsibility but it was, like, fun to have it.*
> (Participant 9)

Results from 2017, show, just like in 2015, that children valued 'participating in,' 'being part of,' and contributing to an activity they felt was useful and important. Having responsibility in a bigger-than-school project was still seen in many instances as something special or different, as exemplified by the following quote from 2017:

> *It felt important. It felt like we were helping out and that it was important.*
> (Participant 30)

The Project Provided Authentic Situations

An emergent finding was the importance of the fact that the project was a real, on-the-ground conservation project. That was highly appreciated by the children and the teacher in charge also reported that the children appreciated connecting with living organisms during authentic situations. Had it been set up as a normal 'school' project, she explained, they would have made sure to place salamanders in the wading pool daily to be found by the students. Instead, being an authentic project, located within the salamander migration corridor, one never knew what one would find and while most days some salamanders were found, (the record find was 70 although the usual find was less than 10), there were also days when none were found (Appendix A).

We found two specific features that illustrate how the Salamander Project provided authentic situations: its complex nature and the variability of conditions. Firstly, the Salamander Project was established as a social-ecological solution to the issue of a protected species dying because of a socially valued wading pool. The pool was the 'death-trap' located inside the natural breading ground of the salamanders, but this 'trap' also afforded the conservation of native species by children. Although a more effective strategy may have been to remove the pool entirely, authorities were unwilling to do so due to its high recreational and aesthetic value, resulting in the current solution and its reliance on Olovslund School. This situation also provided the children with a rich opportunity to reflect on the pros and cons of this arrangement. When asked what their preferred solution to the paddling pool 'trap' would be, their answers typically conveyed a clear understanding of the complexity of the issue:

> *Well, on the one hand it would be good to take it away so that no salamanders could fall in it at night but it is still pretty fun to play in the wading pool in the summer. On the one hand, it would be good to remove it but on the other hand it's really fun for us to keep the project up, that we, Olovslund School, can save salamanders.*
> (Participant 9)

Secondly, the different and varying conditions of each participation in the project (e.g., number of salamanders found, weather, group dynamics, unexpected events) expanded opportunities for reflection and meaning-making. This finding was first identified from field observations and then followed up in interview questions. An example of this was when the children found a dead headless salamander. This allowed them to think about what could have happened to it and, with the help of the teacher, brainstorm which animals prey on salamanders. Another example is of finding a juvenile salamander in the pool. This allowed the children to see for themselves how it is impossible to identify the sex of a juvenile and provided the teacher with a good opportunity to explain salamanders' lifecycle. These kinds of unique events, with each occurrence depending entirely on the particular conditions of the day, allowed for spontaneous opportunities to enrich children's overall experience of the project.

Experiencing different and varying conditions was enabled by the projects' length (2 months), which may have influenced how the children became familiar with the salamanders and the tasks involved in the project. Indeed, when asked about the differences between the first and last time in the project, 15 children (out of 25) described how they had gotten more used to the project, felt

more confident in the tasks, and knew more about the scope of the project as well as about salamanders.

The 2017 interviews revealed, again, the extent to which the children recalled the project's authentic situations, as something very special. Students talked enthusiastically about moments during the project that were unusual or surprising such as finding a baby salamander or a dead salamander, or a particular time when very many salamanders were found. These types of moments were made possible due to the ever-changing conditions provided by the conservation project, which also seemed to have enabled enjoyable and exciting experiences.

Fun and Excitement

All but one of the children interviewed in 2015 considered the project 'fun' and readily expressed the enjoyment they got from it. The 2015 questionnaire showed that 'fun' was chosen by 66% of children as one of the three words that best described the project for them. Although the project took place during lunch break (meaning that children skipped their usual break activities), 91% of questionnaire respondents said that it didn't feel like they had lost a break. Field observations and informal conversations with the students' teachers supported interview and questionnaire results. The teachers noted the joy and enthusiasm their students got out of the project, particularly evident directly after their turn participating. This quote captures these findings:

> *It's fun to feel that you have done something important. Something that is actually good for the environment, something that makes a difference.*
> (Participant 1)

Children gave several reasons for why the project was 'fun' of which the most common were: having responsibility, being included in something 'big' and the fact that the project was 'real.' This 'fun' element is therefore tightly linked to the other features described previously. The different descriptions of why the project was 'fun' suggest that this word has a multi-dimensional meaning for these children, encompassing many positive and complementary qualities.

In 2017, all children interviewed expressed the enjoyment that they got from the project, making this the aspect of the experience that appeared to have stuck most vividly in their memory. The 2017 questionnaire results confirmed this finding, as 94% answered that they had liked taking part, and 69% used the word 'fun' to describe their experiences. An emergent finding was that 'helping' was the most common reason for why children enjoyed the project (51%). It was fun to help/save salamanders (the most common answer) but also to 'help out,' to help animals and to help nature. The second most common explanation for it being fun was because it was interesting (20.4%).

Self-Reflection on Methodological Approach and Results

Our methodological approach has some important limitations that need to be mentioned. One significant study limitation relates to the challenge of children age 10 or 11 having to translate their experiences into words. We understand if readers cannot ascertain whether our findings are related more to changes in skills in for instance handling of salamanders, or to changes in deep seated *emotional components* of connection to nature (Kals et al., 1999; Cheng and Monroe, 2012). To mitigate this methodological weakness, we tried to verify patterns that emerged from interview data by using (1) observations of behavior in the field; (2) questionnaires; and (3) interviewing the children 2 years later when their verbal skills are more developed (see **Table 1**). Participant observations detected change in children's *feelings* toward salamanders, as much as is possible from an observation (feelings are, of course, deeply internal and personal and cannot be conveyed entirely 'outwardly' through, for example, actions, facial expressions, body language or verbally). Through examining these characteristics, however, we did detect that children (1) became more comfortable with handling salamanders (some children went from being scared of them and finding them 'yucky' to being unafraid and finding them 'normal' or even 'sweet'); and (2) showed more interest in and affection toward them. The questionnaire results pointed to a self-observed positive change in children's *feelings* toward (as well as knowledge of) both salamanders and nature. Patterns from the first wave of interviews were also apparent in the second wave of interviews 2 years later. In fact, we observed that, in 2017, the children (now 12 or 13 years old) expressed themselves in a considerably more concise way and with greater ability to discuss and reflect upon their experience in the project, which reaffirms our findings and increases their credibility.

Here we considered respondents from both waves of data collection, and those that were interviewed only one of the years as the same unit of analysis. We analyzed differences in views and meanings in the empirical material and no deviating patterns were found in responses from children that were studied during both 2015 and 2017, and those studied only in 2017. We acknowledge, however, that not restricting the unit of analysis to participants that took part in both waves of data collection limits our evidence concerning changes in affective relationships with nature at the individual level, compared to a strict 'within person research design.' We also acknowledge that ample room exists for developing better tools and methods for gathering data both on learning as embodied in, and produced through, practice and to capture changes in affective relationships in this age group. Furthermore, the qualitative nature of the study, in combination with the limited number of children available for investigation, means that our findings are not deemed general beyond the context of this study, which is why we phrase our results as indicative rather than conclusive.

DISCUSSION

The main finding is that learning through taking part in a local species conservation project (the Salamander Project) during school hours was associated with strengthened connection to nature and, specifically, to the salamander species. We observed a self-reported new and personal meaning for the children who expressed both increased empathy for the species in question and an increased concern for nature. These findings are consistent

with previous work (Louv, 2005; Chawla, 2006; Beery and Jørgensen, 2016). However, we build on existing theory by demonstrating that these new affective relationships with nature can persist over time. The main result from 2017 shows that the strengthened affective relations observed in 2015 remain, as represented by the self-reported change in connection to nature. This shift was more discernible in 2017 when the participants were 12–13 years of age: they showed deeper reflection and talked more about the consequences of their actions, compared with when they were 10 or 11 years old.

We have no causal evidence, and there may be a plurality of explanations for why such a shift persisted (Bogner, 1998; Liddicoat and Krasny, 2013), but previous literature has showed that the developmental phase of the children likely played a part in enabling a shift in affective relationships with nature (e.g., Liefländer and Bogner, 2018). Sobel (1993) argues that the ages between 6 and 11 are particularly important for children to form relationships with nature, and for understanding themselves in relation to nature. Liefländer and Bogner (2014) found that children older than 11 years of age tend to experience nature mainly through social relations, whereas children younger than 11 seem to experience nature mainly through exploration and direct sensory contact. Indeed, the fourth graders in this study were at a stage in their developmental process where they also began to experience the natural world indirectly by participation in social action. For example, in 2017 the children showed signs of being closer to puberty and more tuned into 'the social.'

In the following sections, we discuss our findings with reference to situated learning and affordance theories. Such a theoretical frame is used when responding to the *how* and *why* lines of inquiry in this manuscript. We further relate our insights with challenges in urban sustainability. For this we use three sub-headings:

> *Exploration and experience under authentic situations; The culture of the behavioral setting; Counteracting broad-based processes toward weaker connection to nature.*

Exploration and Experience Under Authentic Situations

We interpret from our data a dynamic development of increased competence in stewardship actions. The behavioral setting of the Salamander Project enabled the children to move around relatively freely (crawl, walk, and run) and explore the salamander habitat, which we theoretically link to interactive cycles of learning-by-doing (cf. Kyttä, 2004). Such interactive cycles have been characterized by a safe world for learning constituted of responsive affordances and graduated challenges that children learn to master. As children move around and explore affordances and features of the environment, and as they overcome challenges in their environment, they build environmental sensitivity and at the same time personal competence (Kyttä, 2004; Chawla, 2006; Beery and Jørgensen, 2016). We observed positive interactive cycles of exploring the area while developing abilities over time. Under shifting situations, children were searching in the piles of leaves with a stick; finding, discovering, holding the animals in their hands; carrying and releasing salamanders into the nearby pond, and watering the piles of leaves before leaving the park, so that the salamanders falling into the pool during the night would not dry out (**Figure 4**).

Interpreted through the lens of situated learning, such learning-by-doing activities are inseparable from experience (Brown et al., 1989; Lave and Wenger, 1991; Barab and Roth, 2006). Significant sensory experiences observed include overcoming initial feelings of disgust for salamanders, shifting to emotions of empathy. Experiences of taking part in something important, and feelings of responsibility, pride and having fun were also reported. Significant sensory experiences have been identified as important transformative moments since these may create long-term effects on environmental commitment (Chawla, 2001, 2007). In environmental education, it is argued that children's connection to nature can become strengthened as a complex ability that can come about through a series of situations that generate significant sensory experiences (Chawla, 1998; Beery and Jørgensen, 2016; Giusti et al., 2018).

Unlike a typical school activity, the Salamander Project afforded first-hand sensory explorations during authentic situations. Reflective, emotional and physiological experiences were intertwined with learning about salamanders as a species, their behavior, their habitat requirements, and how to personally

FIGURE 4 | Illustration of the authentic situation of the Salamander Project. Fourth graders searching for salamanders in a pile of leaves in the wading pool during the lunch break on a chilly spring day. Consent received from parents of the children. Photo: Sophie Belton.

relate to them. Therefore, the uncertainty inherent in the project may have been an important factor that engaged children to create stronger affective relationships with nature (Chawla et al., 2014; Moore, 2014). Moore (2014) calls the variation in environmental factors 'sufficient unpredictability' and understands this as important in maintaining a child's fascination and attention (see also Chawla et al., 2014). The Salamander Project provides a good example of its unpredictable nature upholding a child's excitement for, and interest in, stewardship practices.

Our rich qualitative data suggest that whole situations of sufficient unpredictability, triggering free exploration of the area, direct sensory contact and significant experiences of interacting with species, had a role in enabling children's development of *affective relationships* with the salamander species and with nature in an open-ended sense. The sensory interaction was observed to enrich the children's immediate experiential feedback about the effects of their actions. Heft and Chawla (2006) report that such feedback may be perceived if children are allowed, and are able, to shape features of the physical environment and experience with all five senses changes in their environment as a result of their actions. Here saving the lives of trapped animals gave them such feedback, which in turned seemed to have triggered interactive cycles of: direct sensory interaction, experiential feedback about the effects of actions, increased understanding, and development of new skills for dynamically exploring further ways of saving species. These observations support previous work on links between learning and sensory experiences in nature-based activity (Kyttä, 2002; Chawla, 2007; Chawla et al., 2014; Moore, 2014; Giusti et al., 2014; Beery and Jørgensen, 2016).

The Culture of the Behavioral Setting

Behavioral settings are recurring patterns of behavior in designated places where people gather to engage in particular activities at particular times (Barker, 1968). The culture of stewardship in this school played a part in teaching the children about the accepted norms and values of the project, which also seemed to have played a part in the actualisation of affordances congruent with stewardship behavior. Indeed, most students participated even though it was not compulsory to do so. The social interactions that occur within these settings are constituted by social cues upheld by the communities in question (Lave and Wenger, 1991). Any individual member of a community of practice is affected by such social structures (Wenger, 1998), which form part in the shaping of choices (Linder et al., 2018), which further may re-constitute the behavioral setting in question. Indeed, the Salamander Project has been running for 10 years and has become a part of the school's culture and identity, embedded in the school's routines and engaging not only the fourth graders, but also teachers. The particular school values and pride around this project, where the school logo is a salamander and the project is mentioned on its website, appear to have encouraged children's commitment to the project.

The behavioral setting also seemed to have made pupils stay attuned during the entire 2-month period, despite the fact that the actual amount of hands-on participation time was relatively short: on average 2.25 h per child (3 × 45-min sessions). Between the hands-on engagement, they were, however, involved in social action that potentially could remind them of the project. They studied the salamander data records and took part in classroom teaching about the species and its habitat. Despite the project running over a 2-month period, the teachers continued to talk about the project regularly after lunch asking students about the daily finds. Furthermore, not all children participated at the same time (one small group of children per day), but even the days when they did not participate, friends would return to the schoolyard with their stories to tell about the 'catch of the day.' Such social feedback meant that interest and involvement (even if by proxy) in the project seemed to have been kept alive. Also, the Salamander Evening (a ceremony outside school hours) seemed to have functioned as a sort of 'memory' (Barthel et al., 2010), which potentially reminded them of their part in the project. The Salamander Evening also seemed to have played a part in instilling a sense of pride in partaking in a 'bigger-than-school' societal activity. Indeed, previous research suggests that experiences of intimate interaction with nature in educational behavioral settings provide children with important learning opportunities, including actions that may help shape their relations with, and knowledge about, biodiversity (Chawla, 2001; Fjørtoft, 2004; Herbert, 2008; Ernst and Tornabene, 2012; Beery and Jørgensen, 2016).

Multiple co-benefits of the project became apparent through observations and conversations with the teachers. These included: improved science learning, the spread of local species knowledge (often from child to parent), and increased interest in the wider community. In this sense, the project can be viewed as a driver of important processes within, and a component of, a larger social-ecological system. This finding is supported by resilience scholars and reinforces their view that environmental education and learning should not be viewed in isolation from building resilient social-ecological urban systems but as an integrated and necessary part of it (Krasny et al., 2010; Russ and Krasny, 2017).

Counteracting Broad-Based Processes Toward Weaker Connection to Nature

In terms of practical policy advice, this paper shows that involving 10 and 11-year-old children in authentic stewardship actions as an activity at school, while urban planners consider potential for learning in nature environments in close proximity to schools and kindergartens, may be a promising combination for societies to counteract broad-based processes toward weaker connection to nature (Giusti et al., 2014, 2018). Obligatory stewardship projects during school hours can be implemented more broadly in a society compared to projects that are voluntary after school. Such obligatory policy may be a necessary step if urban civilisation will stay emotionally connected to the biosphere, while simultaneously fostering social health and pleasurable feedback cycles between children and nature (Chawla et al., 2014; Chawla, 2015; Carrus et al., 2015; Collado and Staats, 2016; Samuelsson et al., 2018). As the result herein is indicative, more research is needed in order to generalize whether such policy advice has the potential to

function as a deep leverage point, by supporting much needed sustainability transitions of broad-based socio-cultural processes of self-concept change and social norm formation (Meadows, 2008; Westley et al., 2011; Abson et al., 2017; Görg et al., 2017).

CONCLUSION

Our findings support Cheng and Monroe's (2012) suggestion that learning, understanding, and experiencing nature are all factors that can positively influence the development of a child's connection to nature, here operationalized as an affective connection. This paper also develops, with emphasis put on the participants' own views and words, an understanding about how, and by which means, the participating children's connection to nature shifted over time. The study highlights:

- The behavioral setting of the bigger-than-school project instilled a sense of pride and responsibility.
- Children's free exploration of the habitat during situations characterized by unpredictability enriched their enjoyment.
- Contact with species triggered direct sensory feedback of actions and enabled significant experiences.
- Significant experiences when developing sympathy in the process of going from viewing species as 'yucky' to viewing them as 'sweet.'
- Experiences were intertwined with learning about endangered species and their habitat.
- Sixth graders observed salamanders even 2-years after participating in the project.

The *affective relationships* that the children formed with the salamander species and with nature in an open-ended sense, seemed to have emanated from whole and authentic situations that granted the children immediate feedback about the effects of their actions when saving the lives of trapped animals. Such situations triggered positive interactive feedback cycles of direct sensory interaction, experiential feedback as well as social feedback about the effects of actions, increased understanding, and development of new skills for dynamically exploring further ways of saving species—self-reported to generate significant and fun experiences. These complex and relational dynamics between mind, body, culture and the environment have been reported elsewhere (Kyttä, 2002, 2004; Raymond et al., 2017), but not often in the context of children's conservation of protected species inside an urban landscape.

ETHICS STATEMENT

Ethical implications of this study were carefully considered prior to fieldwork. Although the topic is not deemed to be of a sensitive nature, the study involved children and therefore followed specific guidelines relating to researching children (Graue and Walsh, 1998; The Research Ethics Guidebook, 2014; UNICEF guidelines for interviewing children, 2014). Furthermore, an ethical review of the research project was carried out by education staff of the Stockholm Resilience Centre, Stockholm University as a requirement. The protocol was approved by them.

All subjects gave written informed consent in accordance with the Declaration of Helsinki. Firstly, background police checks were provided to all schools involved once relevant teachers and/or principals had agreed to participate in the study. Secondly, an information letter and a consent form were sent out to all 4th grade students' and 6th grade students' parents/caregivers. The letter explained what the study involved, the terms of student confidentiality and anonymity, as well as how the data would be handled. Consent was asked for their child's participation in both: (1) the classroom sessions and (2) recorded interviews where quotes could be used. Fieldwork commenced only once consent forms were collected and involved only those students whose caregivers had given consent.

Participants were met at all times with respect and study methods were adapted to the specific age groups and chosen so as to be fun and engaging activities in a familiar atmosphere (their school). Before being interviewed, students were explained that their participation was fully voluntary and that they didn't have to answers questions if they chose not to. They were encouraged to ask questions and were explained both prior to the classroom sessions and interviews that there were no 'right' or 'wrong' answers but that we were instead interested in their personal views and feelings.

AUTHOR CONTRIBUTIONS

SBa was the project leader and the corresponding author. SBe did most of the field-work and did together with SBa most of the writing. MG participated in some of the early field work 2015, and he contributed with discussing the theoretical view-points together with CR.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.00928/full#supplementary-material

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Are California Elementary School Test Scores More Strongly Associated With Urban Trees Than Poverty?

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Unprecedented rates of urbanization are changing our understanding of the ways in which children build connections to the natural world, including the importance of educational settings in affecting this relationship. In addition to influencing human-nature connection, greenspace around school grounds has been associated with benefits to students' cognitive function. Questions remain regarding the size of this benefit relative to other factors, and which features of greenspace are responsible for these effects. We conducted a large-scale correlative study subsampling elementary schools (n = 495) in ecologically, socially and economically diverse California. After controlling for common educational determinants (e.g., socio-economic status, race/ethnicity, student teacher ratio, and gender ratio) we found a significant, positive association between test scores and tree and shrub cover within 750 and 1000 m of urban schools. Tree and shrub cover was not associated with test scores in rural schools or five buffers closer to urban schools (10, 50, 100, 300, and 500 m). Two other greenspace variables (NDVI and agricultural area) were not associated with test performance at any of the analyzed buffer distances for rural or urban schools. Minority representation had the largest effect size on standardized test scores (8.1% difference in scores with 2SD difference in variable), followed by tree and shrub cover around urban schools, which had a large effect size (2.9–3.0% at 750 and 1000 m) with variance from minority representation and socioeconomic status (effect size 2.4%) included. Within our urban sample, average tree-cover schools performed 4.2% (3.9–4.4, and 95% CI) better in terms of standardized test scores than low tree-cover urban schools. Our findings support the conclusion that neighborhood-scale (750–1000 m) urban tree and shrub cover is associated with school performance, and indicate that this element of greenspace may be an important factor to consider when studying the cognitive impacts of the learning environment. These results support the design of experimental tests of tree planting interventions for educational benefits.

Keywords: attention restoration theory, ecosystem services, conservation, urban green space, education

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INTRODUCTION

In response to the limited nature contact that many humans experience in modern life, research has brought an increased focus to the ways in which children form relationships with the natural world. Recent efforts include the development of a framework describing the locations and specificities of the processes underlying the nurturing of these connections (Giusti et al., 2018). Specific pathways for the development of child-nature connections have been described in urban environmental education settings (Delia and Krasny, 2018), including how affective connections can develop with animal life on elementary school grounds (Barthel et al., 2018). In addition to increasing connection and care for the natural world, research on the association between nature contact and education has documented that outdoor learning and play can improve student academic performance (Tranter and Malone, 2004; Matsouka, 2010). This contact can include many different types of interaction with nature, such as outdoor active learning, engagement with school gardens or the viewing of nature from a window. Previous studies have shown that viewing of nature may increase attention, memory and impulse inhibition, and decrease stress (Kaplan and Kaplan, 1989; Bratman et al., 2012; Lee et al., 2015).

A prominent environmental psychology theory called Attention Restoration Theory (ART) (Kaplan and Kaplan, 1989; Lee et al., 2015) posits that our directed attention is overtaxed by the sensory demands of urban environments. In these contexts, to adequately focus on relevant stimuli, cognitive resources must be engaged to block out unrelated distractions. In contrast, natural environments typically provide opportunities for a replenishment of this directed attention, due to the greater engagement of involuntary attention and the associated restorative processes that these environments encourage. Perceived restorative qualities of nature include visual and auditory stimuli (Levain et al., 2015; Krzywicka and Byrka, 2017), and the replenishment of directed attention can be measured via improved performance on certain types of cognitive performance tasks, including those that involve working memory, impulse inhibition, and other capacities. Thus, certain types of nature experience may be most impactful in urban settings where demands on an individual's directed attention capacities are most acute, as they work to block out large amounts of urban stimuli (noise, vehicular traffic, etc.).

Research is underway regarding the association of nature exposure with cognitive benefits, including how widespread and large the impacts are, which features of greenspace are most impactful, and at what spatial scale. Studies in this area vary across social and ecological contexts (Tanner, 2009; Bratman et al., 2012; Wu et al., 2014; Dadvand et al., 2015), but only a subset place the relative association of greenspace with test scores in the context of other variables shown to influence student performance. Such variables include socio-economic status (SES) of an individual student, or of peers (Coleman et al., 1996; Caldas and Bankston, 1997; Agirdag et al., 2012; Wu et al., 2014), class size (Finn and Achilles, 1999), teacher experience (Henry et al., 1999), per-pupil expenditures (Hedges et al., 1994), race/ethnicity (Caldas and Bankston, 1997; Agirdag et al., 2012; Boonen et al., 2014), and elements of the school context including day lighting (Heschong Mahone Group, 1999; Tanner, 2009) and being in an urban versus rural setting (Wu et al., 2014).

While other correlative studies of greenspace and school performance commonly control for these other variables, they often do not compare the effect size of greenspace versus other predictors, making it difficult to interpret whether statistically significant findings are likely to be educationally meaningful. Two recent studies do report beta coefficients, showing that tree cover beta coefficients are about half as large as school level student socioeconomic status (the variable explaining most variance in both studies) (Hodson and Sander, 2017; Kweon et al., 2017). These findings provide indications that greenspace around schools may have an educationally meaningful influence on students relative to that of other education variables. While these studies sampled a relatively large number of schools (approximately 200 schools in each case), they have captured a limited range of ecological conditions [e.g., two dominant hardwood forest ecoregions across Massachusetts (Wu et al., 2014), two plains ecoregions in southeast Michigan (Matsouka, 2010), one forest ecoregion in Minnesota (Hodson and Sander, 2017), one plains ecoregion around Washington DC (Kweon et al., 2017), and an unidentifiable number of ecoregions in Georgia, though the state is dominated by one plains ecoregion and Piedmont (Tanner, 2009)].

In this study, we used an exploratory approach to examine a subset of Californian elementary schools to ask whether any of three different greenspace indicators at any of seven distances around schools had an association with school-level test scores. Staging the study in California allowed us to examine these associations across a large and socioeconomically diverse population and a diverse set of natural ecosystems. Our main question was whether any of these greenspace variables at any of our tested distances had an association similar to that of other known, strong determinants of student performance.

MATERIALS AND METHODS

California was chosen as a study area because of its large and diverse human population, large degree of variation in social and economic conditions, and environmental heterogeneity. Working with data from 2012, we considered all public, private, magnet and charter schools, excluding small (<25 students in fifth grade), special education, and alternative schools. We focused on fifth grade students, as early childhood experience has been strongly linked to later-life outcomes including high school and higher education outcomes, income, socioeconomic status, health insurance coverage, crime and substance abuse (Shonkoff and Phillips, 2000). Although we could readily obtain test scores, school demographics and socio-economic information from all California schools, processing of satellite imagery to characterize school surroundings was time consuming, limiting the total number of schools we could analyze. From a total of 3,233 elementary schools, we chose a subset of 495 through stratified random sampling across student body SES, urban versus rural

setting and ecoregion. The California Standardized Testing and Reporting (STAR) (California STAR, 2012) data set was used to define school type (e.g., private, public, and magnet), student body size in fifth grade, and the SES of the student body (% students on free or reduced lunch).

As the ART suggests that nature exposure may have a greater magnitude of impact in urban contexts (Tanner, 2009; Wu et al., 2014), we intentionally differentiated urban and rural schools in our sample set. The 2010 Census Urban and Rural Classification was used to define urban (population >2500) and rural schools (United States Census Bureau, 2010). The majority of schools in California are urban, so stratified sampling on this factor led to a high proportional sub-sampling of rural schools. Our final set of sample schools included 336 urban schools and 159 non-urban schools.

Common and Greenspace Predictor Variables

We conducted our statistical analyses in two phases. First, we established how much variation in fifth grade student performance was explained by socio-economic factors commonly known to influence student achievement (described below in "common variables"). We then asked if considering the condition of greenspace around schools added explanatory power to models of student achievement (described below in "greenspace variables"). In all analyses, we used the California STAR data on student achievement from 2012 (California STAR, 2012). California conducts standardized tests in the subjects of science, mathematics and English language. Scores for these three subjects were highly correlated (Pearson correlation coefficients for all pairs >0.79, all $p < 0.0001$), so instead of treating them separately in statistical analysis, we added the scores of all three subjects into a single composite indicator of student achievement.

Common Variables

School achievement studies have established the importance of several across-school variables in determining student outcomes, including factors related to the socio-economic characteristics of the student body and to the school learning environment. Variables we included concerning the socio-economic character of the student body included indicators of SES, gender, and ethnicity. Key variables regarding the school environment included the student teacher ratio, urban versus rural settings, and solar irradiance. Enrollment data (number of students in each school) were available, but significantly correlated with student teacher ratio (Pearson correlation 0.41, $p < 0.0001$), so only student teacher ratio was included. Data on student body SES (represented by % student body on free or reduced school lunch programs), gender ratio, ethnicity and student teacher ratio were all taken from the California STAR data (California STAR, 2012).

We used two characterizations of ethnicity, as there are conceptual hypotheses for at least two different effects of cultural diversity on student outcomes. Some studies show a positive effect of peer ethnic diversity within a classroom (Agirdag et al., 2012), so we calculated an indicator of overall ethnic diversity following the Shannon-Weiner index to represent both number of ethnicities present in a school's fifth grade student body, and the evenness of representation across those ethnicities. A second hypothesis states that students from ethnicities under-represented in higher education will show poorer performance in earlier education, so we also included the percentage of students per school in under-represented minorities (all non-white and non-Asian categories). Ethnic classifications used in the source data set were American Indian/Alaska Native, Asian or Asian/Pacific Islander, Hispanic, Black, White, Hawaiian National/Pacific Islander, and two or more races.

To capture the range of daylight across the large range of latitude California occupies (almost 10 degrees latitude), we used average monthly mean horizontal irradiance (kWh m^{-2} d^{-1}) data from the United States Department of Energy National Renewable Energy Laboratory. To capture irradiance over the school year, we averaged monthly values from September 2012 to May 2013 (Perez et al., 2009). Most correlations among established variables were weak (Pearson correlations <0.3) and none exceeded 0.43 (percent under-represented minorities and irradiance; see (**Supplementary Table S5**).

To establish which of these commonly studied variables were consistently and strongly associated with mean school test scores, we used multi-model inference with a constrained set of models. Details of candidate models are described below.

Greenspace Variables

Controlling for common variables driving student achievement, we asked whether several aspects of greenspace around schools were associated with test scores. Previous studies have taken one of two approaches to defining the 'greenness' of school surroundings. Some focused on classroom views, and visited individual classrooms, applying a multi-criteria characterization to each classroom's view (Tanner, 2009; Matsouka, 2010). A second method has used remotely sensed data, allowing more rapid classification of a larger set of schools (Wu et al., 2014; Kweon et al., 2017). We expanded on previous remote sensing-based methods to explore three greenspace variables simultaneously.

Greenness

For 'greenness' we used the natural difference vegetation index (NDVI) as a descriptor of vegetation color in school surroundings. NDVI data were extracted from United States Department of Agriculture National Agriculture Imagery Program (NAIP) 1 m resolution aerial photos. We used ArcGIS (ESRI) to compute NDVI from near-infrared and red spectral bands. Images reflect conditions from April 23–July 20, 2012, with the date range selected to encompass the time during which standardized testing takes place. In California, 2012 was a moderately dry year. The period of study falls within the dry season, so less variation is expected in NDVI, tree or shrub cover between drought and non-drought years since peak vegetation cover in most California ecoregions occurs outside the study window. In addition, the majority of grassy areas on California's

anthropogenic school grounds are irrigated, dampening the effect of seasonal wetness on vegetation greenness.

Agricultural

Crop fields can be as green as forests, so we included a variable to differentiate agricultural areas from non-agricultural areas. Using the same NAIP imagery we used an automated supervised classification to extract cropland features. Across the subset of selected schools, agricultural percent cover was not normally distributed, with a high proportion of schools having zero percent agricultural area in their surroundings (commensurate with the Census data showing a high proportion of urban schools in the study set). Given this skewed distribution, we converted agricultural percent cover to a binary variable and classified schools as having agriculture (>0% agriculture) or not having agriculture in their surroundings.

Trees and shrubs

Greenspace may vary in structure, or openness. Surroundings may be relatively un-structured, with fields or grasslands, or more structured with trees and shrubs. To reflect this variation in structure, we calculated the percentage of trees and shrubs around schools as a proxy, using the NAIP imagery. Image recognition software (ESRI ArcGIS) used spatial context, and spectral and pattern information to identify individual trees and shrubs around each school. Percent cover was calculated as the proportion of area occupied by trees or shrubs.

Buffer Distances

Choosing a distance to analyze is challenging, as the mechanism(s) for greenspace to impact learning is not known, and there is likely more than one, so a standard distance for impact is not obvious. If students are influenced by views, the active distance may be quite far in topographically complex areas (e.g., with tall mountain ranges) or quite limited in cities or areas with tall trees. Greenspace may impact students as they play outdoors on school grounds (near-school influence zone), while they commute to school or while at home (in both cases, near to far influence zone depending on home location).

Without clear means to identify mechanism in the present study, we chose buffers up to 1 km from schools because there are clear differences in policy interventions across that range of space. For example, significant affects associated with near-school buffers would imply that interventions on school grounds, such as gardens and greening school common areas could be beneficial. Alternatively, significant affects nearing the 1 km buffer distance imply a need for actions outside the school property, such as urban planning, greenspace or green belt creation, or other neighborhood greening programs. More rigorous treatment of the mechanism for learning benefits should be pursued in future studies.

Within the 1 km maximum buffer area, we delineated seven different buffer distances around each school at 10 m (which included all inter-building area for schools that have multiple buildings), 50, 100, 300, 500, 750, and 1000 m. To create school buffer zones, the building footprint of each elementary school was first delineated. In San Francisco and Los Angeles, building footprints were available from municipal government spatial data inventories. For all other schools, we manually digitized a polygon for each school encompassing the outer edges of all identifiable elementary school buildings present in the NAIP aerial photos. Buffers were created at each distance around each building polygon. The buffers were not sequential (e.g., 1000 m buffer representing area between 750 and 1000 m buffer), but instead, each buffer was inclusive of the full distance between the centroid of the school footprint polygon(s) and the outer buffer limit (e.g., the 1000 buffer included all area between the centroid of the building polygon and the 1000 m buffer extent).

A metric was then calculated for each greenspace variable in each school buffer zone. For greenness, the mean NDVI per buffer was calculated. For agriculture, the percentage of agricultural area in each buffer was calculated, then each buffer was re-coded in binary terms (agricultural and non-agricultural). Trees and shrubs were represented by the percent area within the buffer occupied by trees or shrubs. A small number of schools (n = 3) were dropped from analysis because school building locations could not accurately be determined.

Ecoregion

The final addition in this round of model selection was ecoregion. This was not a spatial variable calculated per school, but rather a single identifier assigned to each school, reflecting the ecoregion it resides in. California covers a large land area spanning nearly ten degrees of latitude (>1000 km) from north to south. This area encompasses dramatic ecological variability in 11 ecoregions, including two mountain ranges, massive deserts, extensive agricultural production regions, a coastal Mediterranean system, redwood and ponderosa forests and native grasslands. To account for this variation, we included ecoregion as a categorical variable, ordered from lowest to highest latitude.

Model Selection Analyses

In the first round of model selection, we considered only the common variables described above. We compared sets of linear regression models predicting total student test scores as a function of established variables (R Development Core Team, 2009). Interpretations of regression coefficients are sensitive to the different scales of the input variables (e.g., student teacher ratio and minority representation). Therefore, each continuous predictor variable (SES, gender ratio, ethnic diversity, percent under-represented minorities, student teacher ratio) was standardized by subtracting the mean and dividing by two standard deviations, while binary predictor variables (urban/rural) were centered to a mean of zero. We constrained all model selection analyses to include socioeconomic status (Coleman et al., 1996; Caldas and Bankston, 1997; Agirdag et al., 2012), percent under-represented minorities (Coleman et al., 1996), and irradiance [proxy for daylight (Tanner, 2009)] as there is strong evidence that these predictor variables commonly have strong associations with student performance. We allowed all possible combinations of the other established predictors in addition to these three, for a total of 16 models. No interactions between variables were considered. We did not apply a familywise alpha as our focus was not on significance tests, but parsimony, general direction and effect sizes.

Model performance was compared based on corrected Akaike Information Criterion (AIC_c), and the best set of models was defined as those with delta AIC values <4.0 (Burnham et al., 2014). Common predictors appearing in 90% or more of the best model set were carried forward into the greenspace variable analysis. The common predictors that met this criteria were socioeconomic status and percent under-represented minorities.

In the second round of model selection, we asked if any greenspace variable at any buffer distance added significantly to the ability to describe student performance, controlling for common variables arising from round one. Each greenspace variable was considered separately to isolate the influence of different environmental characteristics on student performance. We constrained all model selection analyses to include the two variables from the first round of model selection that were carried forward (socioeconomic status and percent under-represented minorities). In addition to these two fixed variables, we allowed all possible combinations of urban/rural, greenspace, ecoregion and the interaction between greenspace and urban/rural (per ART, we hypothesized that associations would be significant in urban environments). This created a set of 10 possible models for each greenspace variable at each buffer distance.

Greenspace variables at all buffer distances were not highly correlated with common variables (most Pearson correlations <0.3, highest = 0.41, see (**Supplementary Table S6**). Given the highly heterogeneous correlation among greenspace variables and common variables at different distances, all were retained in model explorations. Greenspace variables were also weakly correlated with each other at all buffer distances (all Pearson correlations <0.35, see (**Supplementary Table S7**). Subsequent buffers were highly correlated within a single greenspace variable, which is to be expected as farther buffers are inclusive of the closer buffers (e.g., 500 m includes the 10, 50, 100, and 300 m data). NDVI buffers were most highly correlated with each other (Pearson correlations 0.53–0.99, most >0.7), followed by percent tree and shrub cover (Pearson correlations 0.36–0.99, most >0.7) and cropland cover (Pearson correlation 0.27–0.99, most >0.5). No two greenspace variables or buffer distances were ever combined in a single possible model. Variables were standardized and best performing models were identified as above.

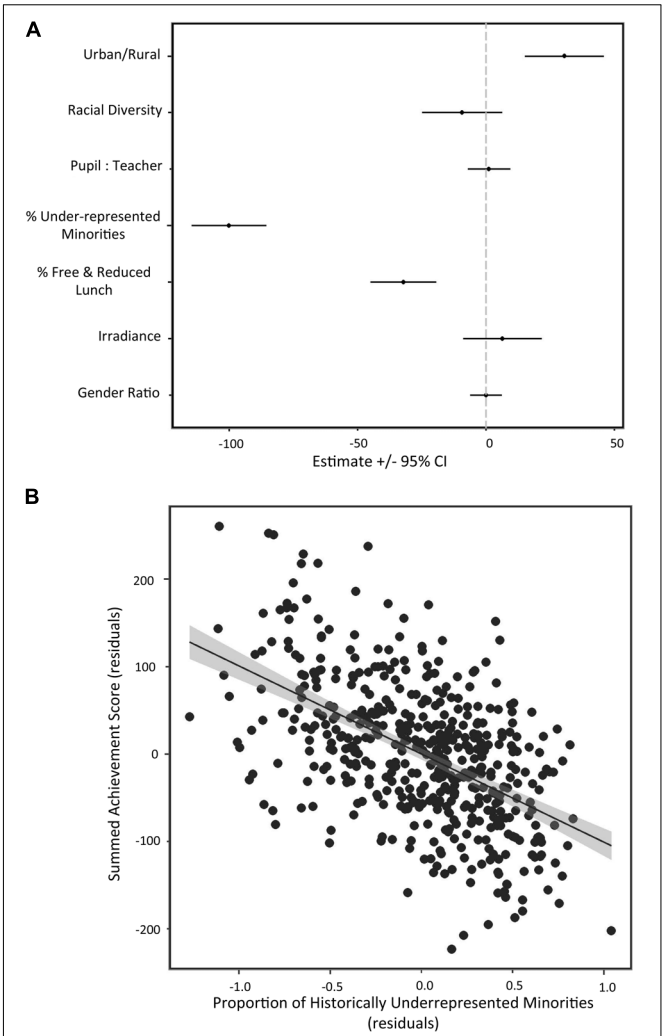

FIGURE 1 | Model selection results for several common variables for student test performance on a sample of California fifth grade classes. Effect sizes **(A)** were significant for urban/rural location, % minority representation and % student body on free and reduced lunches. Minority representation **(B)** showed the strongest signal, with a two SD difference in minorities associated with a 100 point difference in overall test scores.

RESULTS

Common Variables in Student Performance

To compare the strength of greenspace effects to that of other common variables related to student performance, we first used multi-model inference to ask which combination of several common education variables significantly and parsimoniously explained average fifth grade student performance across a subset of California schools in 2012. Across the 16 models explored, urban/rural location, SES of the student body (% fifth graders on free or reduced lunch) and minority representation (% non-Asian and non-White students to reflect historically under-represented minorities) were the only variables that consistently occurred in our best-fitting models (**Supplementary Table S1**, note we do not apply a familywise alpha), and had significant effect sizes (**Figure 1**). Pupil teacher ratio (highly correlated with class size), gender ratio, ethnic diversity (Shannon-Weiner index to reflect diversity and evenness across ethnicities), and daylight (solar irradiance) were considered, but were not chosen in our best models.

Test scores were generally higher in urban contexts, lower in schools with more students on free or reduced lunch (lower SES), and dramatically lower in schools with more historically under-represented minorities (**Figure 1**). Students at urban schools scored 31 points (2.3%) higher than students at rural schools on average. SES of the student body had a similar

effect size, with an increase in eligibility for free and reduced lunch from 17% (−1 SD) to 81% (+1 SD) of the student body associated with a 32 point decrease in test performance (2.4%). Minority representation had the largest effect size, roughly three times greater than urban/rural context and SES. Across a 56% (mean +/−1 SD) increase in representation, average student performance declined 100 points, or 7.4%. Hispanic students dominate under-represented minorities in our sample (75% of minorities), so this is largely a single group effect, the basis of which is discussed elsewhere (Hemphill et al., 2011).

These results generally align with other published findings. For example, a recent meta-analysis reported multiple studies showing a 1 SD difference in school level SES associated with a 0.04 to 0.25 SD difference in student test outcomes (van Ewijk and Sleegers, 2010). We found a 0.19 SD difference in test scores with a 1 SD difference in SES, within their reported range. Our best model accounted for 37% of variance in fifth grade scores across our sample of California schools, somewhat higher than previous studies (19.5–26%) (Coleman et al., 1996; Caldas and Bankston, 1997; Agirdag et al., 2012; Boonen et al., 2014).

Greenspace Variables and Student Performance

In our best model using common variables, over half of the variance in average test scores was left unexplained. We used a second round of multi-model inference to examine whether adding variables of school greenspace explained some of the remaining test score variance. Three greenspace variables, along with ecoregion, were used to represent different features of 'naturalness.' In addition to main effects, we tested for an interaction between any greenspace variable at any distance and urban context. Per ART, we included these interactions on the basis of our hypothesis that the association of nature contact with increased test performance would be most likely to exist within urban environments, given the higher likelihood of students interacting with stimuli throughout their day that tax their directed attention (Kaplan and Kaplan, 1989; Lee et al., 2015).

Fifth grade test scores were higher in urban schools with more trees and shrubs within 750 m (**Supplementary Table S2** and **Figure 2**) and 1000 m (**Supplementary Table S2** and **Supplementary Figure S1**). In line with other studies (e.g., Wu et al., 2014), this may be due to the fact that larger buffer distances more accurately capture the totality of nature exposure for students throughout their day (commutes from home to school, etc.).

This association was not present for rural schools (**Figure 2**). Tree and shrub cover was the only greenspace variable assessed that was significant at any distance (**Supplementary Tables S3, S4**, and **Supplementary Figures S2, S3**). Although we did not find a significant association in this sample, other studies in other contexts have found associations with the NDVI index and test scores (e.g., Wu et al., 2014; Dadvand et al., 2015). Our findings on this front were exploratory, and experiments, smaller-scale interventions, and other approaches are needed to help uncover possible underlying reasons why our tree and shrub cover factor

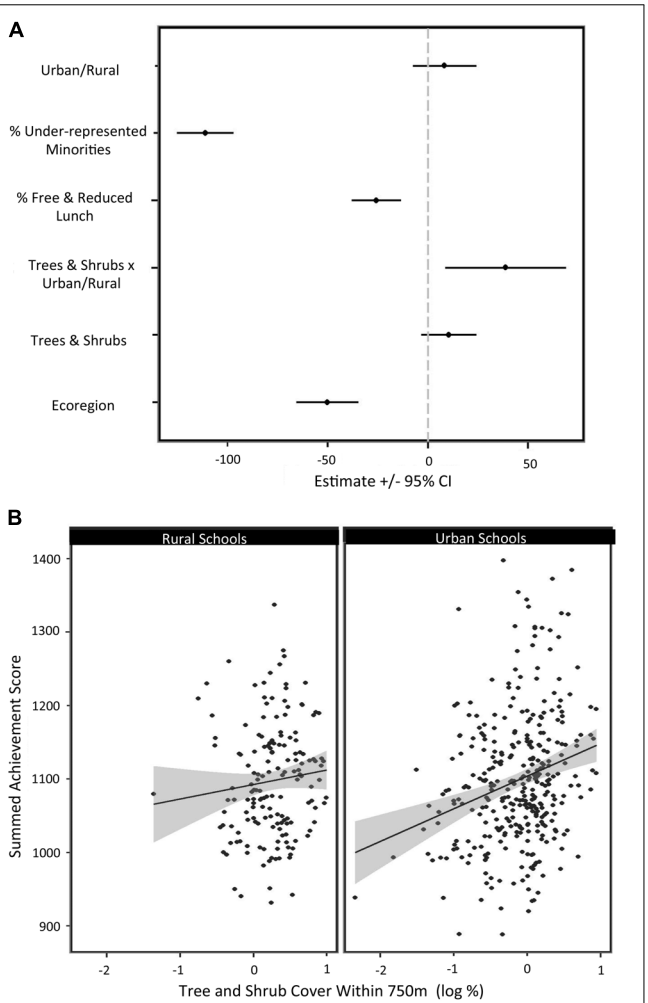

FIGURE 2 | Percent tree and shrub cover within 750 m of schools, showed a significant interaction with urban/rural context **(A)**. Higher tree and shrub cover was associated with higher test scores, but only around urban schools **(B)**.

was significantly associated with test scores, while NDVI was not. With trees and shrubs, the best models at both 750 and 1000 m explained 42% of the variance, capturing 5% more variance than models with the common variables alone.

DISCUSSION

From an educational policy and school-design perspective, our findings provide a foundation for further experimental work that could investigate whether the association between student performance and tree and shrub cover is causal. Such studies could explore whether an intervention as straightforward as planting trees and shrubs within relevant distances (750 and 1000 m) of urban schools could improve student performance.

Our correlative analyses were constructed to be exploratory, focusing on qualitative direction and effect sizes revealed (rather than significance, *per se*). The main findings suggest that the association between tree and shrub coverage may be on par

with the association of other common factors addressed by education policy, including smaller high schools (Barrow et al., 2015), physical activity breaks (Fedewa et al., 2015), and changes in schooling hour policies (Jez and Wassmer, 2015). After accounting for the effects of minority representation and SES, urban schools with higher surrounding tree and shrub cover had 3.0% higher scores (38.8 points at 750 m, 40.5 points at 1000 m). This difference in test scores is associated with a 64% difference (mean +/−1 SD) in tree and shrub cover. It is notable that this effect size is larger than that of student body SES (associated with a 2.4% difference in test performance over a +/−1 SD range of SES). In our sample population, having trees and shrubs around urban schools appears to be on par with the strength of the association of negative test performance with a lower-income student body. As these results are based on cross-sectional data, these inferences cannot be assumed to be causal and warrant further exploration.

In our sample, tree and shrub cover [not greenness (NDVI) or agricultural cover] farther from urban schools (750–1000 m and not closer) was associated with higher test performance. The significant interaction between tree and shrub cover and the urban context is in line with ART. While this theory emphasizes the demands on cognitive function from the taxing stimuli present in urban environments, little is known about how strong these stimuli need to be before replenishment will be realized through the restorative impacts of nature exposure. We used the United States Census definition of urban areas which included all areas with >2500 people (United States Census Bureau, 2010), suggesting that greenspace may provide restorative benefits even in relatively small population centers (and perhaps relatively low levels of the associated taxing stimuli existent in urban environments). It is important to note the low threshold for urbanicity here, and to consider that this definition of "urban" includes many locations with population densities that fall well below that of many cities and metropolitan areas. Even with this definition, however, an additional mechanism that may explain the association with education benefits and trees and shrubs in urban areas only could be that air pollution is worse in these urban areas (OECD, 2014), so greenspace reduction of air pollution and the associated effects may therefore be observed in urban but not rural schools. A study of schools in Barcelona implicates the potential importance of this mechanism within a city context (Dadvand et al., 2015).

Our exploratory findings inform one type of intervention that could be tested further for causality. The larger distance effects (750 and 1000 m) may be associated with (1) classroom views, (2) passive exposure to trees in the larger neighborhood area while commuting to school, (3) increased nature contact on school grounds or at home, if students live relatively close to school, or (4) improved air quality in the school vicinity as trees intercept particulate pollutants. The impacts of policy interventions that alter tree and shrub cover in the area encompassing school grounds (such as school gardens) and the larger neighborhood areas (such as urban planning decisions, and creation of urban green belts or neighborhood parks) should be explored through natural and controlled experiments in the future. Alternatively, the association with larger areas could be reflective of reaching some threshold in cumulative greenness over the larger distances, or of socioeconomic neighborhood conditions that were not perfectly captured by the socioeconomic variables used in this study.

As global education demand continues to grow and education budgets continue to lag [e.g., at least 30 United States' states provided less funding per student in the 2014 school year than they did before the 2008 recession (Leachman and Mai, 2014)], the possibility for urban greening to provide cost-effective educational benefits deserves further attention. Given that educational benefits may accrue from tree and shrub cover at the larger neighborhood scale (per our findings of an association with tree and shrub cover at larger distances from schools), urban greening for educational benefits has the potential to provide additional benefits to the environment (e.g., endangered species habitat, movement corridors for wide ranging species) and to people [e.g., reducing the heat island effect of cities, reducing air pollution and associated respiratory and heart disease (McDonald et al., 2016)]. Causal experimental tests to probe the relationship between urban greenspace and student performance and its causal pathways are needed, and could include explorations of these additional benefits. Joint experimentation in this space by education, conservation, public health and urban design researchers is warranted.

AUTHOR CONTRIBUTIONS

GB and JF acquired and cleaned the data and conducted analyses. JS designed and conducted the statistical analyses. HT drafted the manuscript. All authors contributed to study concept and design, interpretation of findings, and edited and revised the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02074/full#supplementary-material

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ORIGINAL RESEARCH
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Independent Mobility and Social Affordances of Places for Urban Neighborhoods: A Youth-Friendly Perspective

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Meaning of place is usually approached as slow social cognitive construction. However, grounded on the theory of affordances, it may also stem from direct perception-action processes, which enable the formation of immediate perceived functional, social or symbolic meaning of place (Raymond et al., 2017b). In the present study, affordances of places, which are perceived by a specific perceiver in a specific place, were mapped using a web-map survey. Each place offers opportunities for interaction, behavior, use, feeling or meaning, which is directly perceived and actualized there. This paper aims at identifying the degree of youth-friendliness of urban neighborhoods using the hypothetical intertwined model of independent mobility and actualized affordances (Kyttä, 2004) combined with place use and meaning (Broberg et al., 2013a). SoftGISchildren methodology (Broberg et al., 2013a) was adopted to carry out a cross-sectional research, involving 145 sixth to ninth graders of the Great Lisbon area. SoftGIS integrates Public Participation Geographic Information Systems (PPGIS), enabling collection and place mapping of daily subjective environmental experiences in the physical environment, consequently allowing for individuals to be actively engaged in public processes of participation (Brown and Kyttä, 2014). A place based web survey called "Ideal City: a game of graphic imagination" was adopted. Participants were asked to map their home place, select and mark social, functional, leisure and emotional place transactions, and report actual and ideal mobility to these places. Findings on mobility showed that shorter distances to meaningful affordances of places promote active and independent travel; ideally, youths would like to be more frequently active and more frequently autonomous. As for meaningful places, a total of 1632 affordances were localized, with a higher number on social category. Neighborhood area (500 m around home place) was assessed as youth-friendly, where active and independent travel occurred more frequently, and social affordances were the most expressive type. Relational and affectional experience in the neighborhood places was meaningful for youth. Municipalities should consider these features when planning, designing and managing residential areas aiming for the well-being and health of young citizens; and include youths as specialists of space (*spatialists*) in planning participatory processes (PPGIS).

Keywords: neighborhood, independent mobility, active travel, social affordances of places, SoftGIS methodology, youth-friendly

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INTRODUCTION

Theoretical Mosaic

According to the UNICEF report on the state of world children (United Nations for Children's Fund, 2012), childhood experience is becoming increasingly urban, since more than one billion children are living in cities and towns. Portugal is no exception, and statistics indicate that the largest population densities of children in Portugal (0–14 years old) is concentrated in urban municipalities, and in the Great Lisbon area this percentage is of 20.5% (Pordata Statistics Portugal, 2011). Independent mobility and person-place relationships are fundamental aspects of youth's daily lives in the urban environment and are key features that need to be addressed when conceptualizing and planning child and youth-friendly environments, settings, neighborhoods, and structures (Kyttä, 2004; Eisinger, 2012; Whitzman and Mizrachi, 2012; Broberg et al., 2013a; Carroll et al., 2015).

Independent mobility of children or youth in the urban setting can be defined as permission for children to move without adult supervision in their neighborhood and city (Hillman et al., 1990; Tranter, 1994) so that they can explore and learn about the environment at their own rhythm (Björklid and Nordstrom, 2004), toward a progressive and wider freedom of action and movement (Tonucci, 2005). Previous studies have shown Portugal with low levels of children's independent mobility (Cordovil et al., 2015) and ranked internationally in the 14th place among 16 countries (Bicket, 2013). Moreover, in urban centers, children and youths' restrictions on autonomous movement in Portugal are particularly augmented (Lopes et al., 2014). Children's independent mobility is fundamental for children and young people's health, well-being and overall development. Brown et al. (2008) summarize, from other relevant studies, such benefits: development of motor skills; increase in additional physical activity; influence on cognitive development by helping children to increase their way-finding abilities, and also the development of emotional bonds between children and the natural environment. On the other hand, restrictions on children's freedom to roam in the environment have been synthesized by Alparone and Pacilli (2012) as hindering the development of motor, spatial, social, and analytical competences; decrease of physical activity and difficulties controlling weight; increase of environmental fears and feelings of loneliness; and weaker sense of community. Moreover, the exclusion of children and of youths from public space constitutes a threat for meaningful participation of young citizens in the matters of the city governance (Tonucci and Rissotto, 2001).

Human movement through the environment becomes more complex throughout development simultaneously that person-place interactions gain further complexity and multidimensionality. Hart and Moore (1973) explain that the child constructs knowledge about the environment through "acting-in-space." Weston (2010) points out that physical movement through the environment is necessary for learning about it and that young people are physically able to travel independently and are psychologically prone to it. In this sense, the purpose of human mobility is very much related with place experience and vice-versa. Therefore, mobility, namely, independent mobility, is crucial for young people to gain access to diversified socio-physical spaces, where these person-place interactions take place. In this way, on a daily basis, young people roam through different socio-physical environmental settings, where life in places occurs within a complex range of internal and external features, processes, and activities. In this research, the youth-place relationship is addressed through the transactional approach within the field of Environmental Psychology. This theoretical perspective of person–environment phenomena considers them as holistic entities composed of an intrinsic and inter-related assemblage generated through the interplay of people in action, psychological processes, physical environment, and temporal qualities (Altman and Rogoff, 1987; Bonnes and Secchiaroli, 1995; Werner et al., 2002).

According to Gibson (1979/1986) and Heft (2012), an affordance is a psychological relational significant property perceived by the individual when interacting with the socio-physical environment. Thus, it means that when an individual perceives an affordance in a given space through an immediate sensory-action process, a significant feature or cue in the physical landscape specifies a possibility of action according to the individual's developmental characteristics and the specific feature within such space. Kyttä (2003, 2004) stresses that the environment offers the individual an infinite number of affordances which act as a potential for human multidimensional activity. It is within this range of environmental potential that intentional perception-action cycles take place. For this to happen a matching between the individual's corporality, expressed by his physical, social and psychological characteristics, skills and necessities, and the material and sociocultural features of the environment has to occur. This process is designated by the author as "actualization." In this sense, a perceived affordance implies signaling an opportunity in the environment for a transactional experience by a specific actor, while an actualized affordance refers to detecting and establishing a mutual embodied fit with such environmental opportunity or cue. Socio-cultural processes and psychological processes are mutually constitutive through on-going co-emergent human-environment transactions, which means that affordances are nested within the sociocultural tissue and vice-versa as a dynamical system (Heft, 2013). By applying the theory of affordances (Gibson, 1979/1986) in embodied cognition, Raymond et al. (2017a) refer to embodied ecosystems as relational, situational, and dynamical features between humans and the ecosystem. These are self-perpetuated and iteratively reconfigured over time as a consequence of perception-action processes that are actualized through co-constitutive relations between environment, culture, body and mind. These authors also stress that meanings and values of embodied ecosystems extend beyond instrumental functionality to a multiple and diverse array of psychological layers such as symbolic, social, cultural, spatial, etc. Likewise, several authors understand the concept of affordance as multidimensional, which manifests itself through social, emotional, cognitive and cultural properties that children and young people attribute to places, providing them with psychological relevant meaning

(Graumann, 2002; Christensen, 2003; Chatterjee, 2005; Min and Lee, 2006; Lim and Barton, 2010).

A more in depth approach to place experience is necessary to understand the complexity of immediate person-place perceptual processes of interaction. Drawing on the work of several scholars, Masterson et al. (2017) have reflected on the influence of sense of place to the research on socio-ecological systems. Such studies refer to sense of place as people's attachment and meaning to settings in the environment, where the former is an emotional, evaluative type of bond composed by place dependence and place identity; and the latter refers to imagistic descriptive, symbolic and interpretative descriptions of what places are like for individuals. We concur with Raymond et al. (2010) on the idea that the attributes of the socio-physical settings for a specific perceiver and user are intertwined with specific personalized emotions, which are grounded in the personal context of place attachment. Concerning "place meaning," or how do people create meanings to a place, according to Stedman (2008), settings have the potential for users to create multiple embodied cognitive meanings, referring to the descriptive symbolic meaning that people attribute to a place (Stedman, 2016).

Therefore, in sense of place research it is popular to refer to place attachment and place meaning as slow social constructive processes. Nevertheless, place may also be addressed as a direct perception-action process, grounded on the theory of affordances, which enables the formation of an immediate perceived meaning of place (Raymond et al., 2017b). Meaning of place is perceived directly, in real time, through a mutuality fit between the attributes of the environmental features and those of the perceiver. This perspective is grounded in the transactional perspective of environmental psychology where the person and setting are inseparable, acting as a socio-cultural cognitive embodied ecosystem, where dynamic, multilevel transactions co-emerge within the body, mind, culture and environment (Raymond et al., 2017a). It also means that all the information and meaning necessary for the affordance to be actualized by the perceiver is available in the specific setting to be perceived. In addition, places have intertwined multiple meanings, sensory, inherent, instrumental, socio-cultural and identity-expressive types. Through direct perception and action functional, social or symbolic place meanings are immediately perceived and actualized in the presence of environmental cues and perceptual components that exist in a specific setting. This is opposite to a slower process of creating meaning of places through social construction (Raymond et al., 2017b).

In the present study, the youth in place immediate experience and place meaning is theoretically hinged on actualized affordances of places. These are relational, situational and dynamical properties that temporally co-emerge within an entanglement of relations between the mind, body, culture and the environment, nested in embodied socio-cultural ecosystems (Raymond et al., 2017a). Also, our study is methodologically grounded on a place-based approach designated as SoftGIS, which is grounded on the person–environment transactional approach to place interactions.

SoftGIS integrates a wider spectrum of methods and processes addressed as Public Participation Geographic Information Systems (PPGIS). Brown and Reed (2009) refer to PPGIS as the process of using GIS technologies to produce local knowledge toward inclusion and empowerment of marginalized groups. According to Sieber (2006), PPGIS consist of methods that use GIS to foster participatory democracy by widening the spectrum of public involvement in policymaking and contribute for capacity building and social change undertaken by non-governmental organizations, grassroots groups, and community-based organizations.

In SoftGIS methodology, people's local knowledge of the environment is personal, place-based, action-driven and spatially referenced (Rantanen and Kahila, 2009), stemming from transactional interactions between person–environment. According to Brown and Kyttä (2014), PPGIS methods, which SoftGISchildren integrate, expresses a participatory mapping process that depends on participants' capacity to recall their experiences in the physical environment, leading to an attribution of meaning and value for specific places. Therefore, SoftGISchildren methodology is theoretically delimited by the transactional approach of people-environment relationships, which is supported by Gibson (1979/1986) concept of affordance.

The seminal work of Kyttä et al. (2012) that focused on mapping children's meaningful place, and revealing their mobility behaviors and perceived health was groundbreaking. In our view, this study was in fact forthcoming because it revealed that SoftGIS place-based methodology could be used by children and youth to characterize place interaction and child-friendliness of the environment. In our study, we refer to youth's meaningful places as actualized affordances of places that are categorized according to different types of place transactions. More specifically, by using a computer interface associated with a digital map, participants locate multi-place specific transactions (actions, activities, social behaviors, feelings, and meanings), which take place in the urban environment. This enables each participant to map his or her own specific affordances that are directly perceived and actualized in the different places. These types of interactions were previously determined and grouped by the researchers as social, functional, leisure and emotional categories, similarly to what Kyttä and colleagues did when operationalizing categories of place interaction in the SoftGISchildren study.

SoftGIS*children* methodology, which was designed for research with children and youth about environment quality (Kyttä et al., 2012; Broberg et al., 2013b), is underpinned by environmental child friendliness. This criteria is proposed by Moore (1986) as diversity of environmental resources and access to play and exploration. It was later revised by Kyttä (2003) where an hypothetical model composed by degree of independent mobility and number of actualized affordances defines child-friendliness of a place. In our view, there are more features that strongly contribute for this methodology to be child-centered and child-friendly. The content of the survey, its digital support, its user-friendly characteristics are included in these. Moreover, the communalities between its theoretical nature and the perspective of Sociology of Childhood of the children as active and competent social actors, knowledgeable of their spatial, social and cultural realities (Corsaro, 2011) are not

to be dismissed. Other research conducted with SoftGISchildren have proved the online interactive mapping methodology to be very effective in the study of child-place relationships (Broberg et al., 2013b; Bhosale et al., 2015; Stewart et al., 2015).

In this article we underline the neighborhood area as a meaningful environmental setting where youth-place transactions take place. According to Bronfenbrenner (1994), the neighborhood is an important *microsystem* where children and youth's social interactivity with multi-dimensional features (physical, social, and symbolic) enable or unable progressively complex interaction or activity in the immediate environment. Clark and Uzzell (2002) measured social affordances actualized by adolescents in several settings, and concluded that the neighborhood, school and town center are promoters of both social and retreat behaviors. More recently, Villanueva and colleagues reinforce the need to explore the effect of the neighborhood built environment on child development as fundamental for an urban planning that promotes a healthy development (Villanueva et al., 2016). Additionally, in New Zealand an ongoing research project, using SoftGIS methodology, is addressing the study of the associations between neighborhood built environments and children's independent mobility, active travel, physical activity and place interactions (Oliver et al., 2016). Therefore, the neighborhood is a pivotal setting to study children's and youth's independent mobility (Stewart et al., 2015; Tranter, 2015), which is a crucial aspect to promote health and healthy lifestyles. For the present study, neighborhood area was defined as a 500 m buffer around each participant's home. On this, Vanloon (2011) points out that the most popular approach to define a child's neighborhood is to define a circular buffer around home or school with size and shape informed by theory and/or empirical data. Similar studies, adopting the same methodology, used a 500 m residential buffer (Kyttä et al., 2012; Broberg and Sarjala, 2015).

Neighborhoods are conceived as embodied socio-cultural ecosystems which are relational, situational and dynamical, the same way affordances are (Raymond et al., 2017a). The neighborhood is composed by a diversified range of behavioral-settings that are characterized by a dynamical interdependence between subject and a specific socio, cultural and physical setting (Barker, 1968; Wicker, 2002). Children's meaningful places result through children's social participation, mediated by shared intersubjective collective actions, supported by affordances, in specific location, over a period of time (Heft, 2018). Thus, neighborhood places for children and youth are embodied ecosystems that are nested in specific affordances, which are in hand nested to specific places.

To assess youth-friendliness degree of the urban neighborhoods, we draw on two previous interrelated research works. Herein, Kyttä (2004) conducted a cross cultural study about assessing the child-friendliness of Finnish and Byelorussian urban neighborhoods, developing an hypothetical model comprised by the analysis of children's independent mobility and number of actualized affordances, which results in four possible types of settings. The *Bullerby* type is constituted by opportunities for independent mobility and diversity of actualized affordances, where children and young people establish a positive interrelated cycle between mobility licenses and the actualization of affordances leading to a continuous free roaming and perceived, utilized and shaping of affordances (most child-friendly). The *Glasshouse* type is constituted by the same number of actualized affordances as the previous one. This means that the spatial environment of the neighborhood is rich in transactional place experiences for children and youths to engage. However, due to independent mobility restrictions, the promoted and free fields of action are limited. The *Wasteland* type is composed by opportunities for independent mobility in the neighborhood and a low number of actualized affordances due to the monomorphic properties of the environment. The *Cell* type is any environment, or setting where children are trapped inside, constituted by restrictions to free roaming in the neighborhood, preventing children and youths of perceiving potential affordances. In the other aforementioned research (Broberg et al., 2013a), focus was set on the influence of built environment objectively measured features on environmental child friendliness, adopting SoftGISchildren methodology. It was concluded that independent mobility and richness of affordances are interconnected concepts; child and youth friendliness should be analyzed not as an attribute of the whole environmental context, but as place specific concept through place experience and place meaning.

Research Goal and Niche

The overarching goal of the present study was to identify youth-friendliness degree of the urban neighborhood through an assemblage of indicators on mobility behavioral patterns and affordances of places. These are conceptualized as immediate different types of place experiences and of place meanings. The focus is set on child-friendliness of places instead of an approach focused on child-friendliness of the environment as a whole. Affordances are mapped through the use of a youth-friendly participatory place–based survey (SoftGIS), which provides an individualized approach of person in place relations. This represents a leap from an immediate sensory experience that takes place when the person is physically and spatially in contact with the immediate environment, because the person is actually in front of a computer screen looking at the daily environment and locating affordances of places through the use of web-map survey. Such assumption poses a risk to the original conception of the "affordance" as a functional significant environmental property detected by the individual in the immediate environment which provides an opportunity for action (Gibson, 1979/1986; Heft, 1988; Gibson and Pick, 2000). In one hand, it is true that the SoftGISchildren survey does not allow for participants to use their sensory perceptual devices in the immediate socio-physical environment, and hence does not allow for the significant relational features between the perceiver and the immediate physical environment to be detected. In the other hand, if subjects are in fact able to digitally detect a mutuality fit between themselves and the displayed environment, by detecting web-localized meaningful spaces, which are then perceived as multi-dimensional affordances of places, they are then reporting place experience as a fast direct perception-action process, grounded on the theory of affordances, which enables

the formation of an immediate perceived meaning of place (Raymond et al., 2017b). Moreover, it implies that perceived place meanings are being actualized in the presence of environmental cues and perceptual components that exist in a specific socio-physical setting through a digital interface, and, simultaneously, that meaning of place can be detected immediately and directly through a place-based survey. Within this perspective SoftGIS surveys enable participants to recall their environmental place experiences and map them as actualized affordances of places.

Moreover, this research addresses the notion of actual versus ideal mobility in the urban environment according to youth's perspectives. To the best of our knowledge, this is the first study using SoftGIS methodology that provides such an approach. Additionally, place based interactions and meanings, and actual and ideal mobility to meaningful places are pivotal to address children's right to the city, in terms of place attachment, place meaning, social activity, play, leisure, and participation.

According to several scholars, the study of mobility and person-place relationships in the socio-physical environment as intertwined topics offers a valuable perspective of social meaningful research for the development of healthier and happier communities (Kyttä et al., 2015; Laatikainen et al., 2017). As an important social outcome, the present study aims to reinforce the need to include youth's perspectives when designing urban neighborhoods suitable for their developmental needs and rights as citizens; and, simultaneously, as a means to promote well-being and the development of healthier communities through SoftGIS methodology.

MATERIALS AND METHODS

Participants and Geographical Context

A total of 145 sixth to ninth graders, aged 11–17 years old (M_{age} = 12.41; SD = 1.43; girls = 48.3%), from three schools located in the Great Lisbon area, were included as participants of this research ("L" group). All places that were marked outside each participant's municipality were excluded.

The characterization of our sample was devised through consultation of the Statistics Portugal web site (INE) and of other official web sites of the municipalities and parishes where the three schools are located. Although each school represents different geographical locations, west, coastal and northeast of the Great Lisbon area, as a whole these three areas share a similar degree of urbanization and cultural trends and are representative of the social and built tissue that characterizes the urban environment of the Great Lisbon Area in its diversity and complexity. The school ($n_{participants}$ = 40; M_{age} = 13.03; SD = 1.73) in the west area is located in the parish of Belém, in Lisbon municipality. This parish has an area of 10.43 km^2 with 16551 inhabitants. The school ($n_{participants}$ = 52; M_{age} = 11.73; SD = 0.93) in the coastal area is located in the parish of Paço de Arcos, in Oeiras municipality. The municipality of Oeiras faces the river/sea front and it is spread over an area of 45.72 km^2, with a total of 172120 inhabitants. The school ($n_{participants}$ = 53; M_{age} = 12.57; SD = 1.32) in the northeast is located at the parish of Parque das Nações, in Lisbon municipality. This parish spreads over an area of 5.44 km^2 with a total of 21025 residents.

In order to conduct this study, Ethics approval was obtained from the Portuguese Data Protection Authority and from the Ethics Committee of Faculdade de Motricidade Humana, Universidade de Lisboa. Authorization was also granted from the General Department of Education-Portuguese Education and Science Ministry. Moreover, parental and children's consent was obtained.

Methods and Data Collection

"SoftGISchildren" methodology was adopted in a cross-sectional research. Data collection occurred during school hours in computer equipped classrooms with internet connection. Each session took between 45 min to 1 h and 8–20 children, filled in the SoftGIS survey at the same time. The researcher was always present in each data collection moment. A research assistant accompanied the researcher when there were more than 10 children. Before participants started to complete the survey, the researcher provided a brief explanation of the questionnaire and of the place mapping procedures. Additionally, the researcher made clear that when participants were selecting affordances to be localized in the web-map, each listed affordance should be interpreted as *"a place where I. . ."*. For example, the affordance *"being with friends"* should be interpreted as *"a place where I am with friends."* Moreover, the researcher and the research assistant helped those children who found difficulties completing the web-questionnaire, namely, by clarifying questions and helping them to locate meaningful places. Data collection occurred between October of 2013 and February of 2015.

SoftGISchildren Survey "Cidade Ideal: Um Jogo de Imaginação Gráfica!"

The "Cidade Ideal: um jogo de imaginação gráfica!" (Ideal City: a game of graphic imagination!) survey's content, including the grouping of affordances in each expressional category, was inspired in the work of Kyttä et al. (2012) about the use of SoftGIS to reveal children's behavioral patterns and meaningful places. The questionnaire was translated to Portuguese and its content was revised, reshaped and renamed according previous studies conducted in Portugal and abroad on children's independent mobility and place interactions (Arez and Neto, 1999; Lopes et al., 2011; Cordovil et al., 2012a,b; Shaw et al., 2012). SoftGISchildren "Ideal City: a game of graphic imagination!" web-map survey was structured in nine pages. Participants were asked to map their home place, select and mark meaningful place transactions, under each of the four available expressional categories (social, functional, leisure, and emotional), provided by Kyttä et al. (2012). In the present study, these meaningful places were designated "*multidimensional affordances of places.*" An innovative aspect of the "Ideal City" digital survey was the inclusion of questions related to what type of mobility participants would like to have when traveling to meaningful places in their ideal city.[1] To the best of our knowledge, it is the first time in a research work using SoftGISchildren methods, that

[1] • Single choice questions concerning actual and ideal travel mode from school to home were asked. Answers had to be selected from the

the web-map questionnaire has been used to analyse children's actual mobility vs. ideal mobility to meaningful places.

List of "Affordances of Places"

The list of social, functional, leisure, and emotional affordances of places (i.e., locations that youths reported to afford place-based specific social, functional, leisure, and emotional activities), is presented in **Tables 1–4**, accordingly. In **Figure 1**, an example of the selection panel of affordances of places available for the users in the "Ideal City" SoftGISchildren survey is available.

Taxonomy for Social, Functional, Leisure, and Emotional Expressional Categories of Affordances of Places

For each expressional category of interaction, it was made available an extensive number of affordances of places for participants to select and localize on the web-map (see **Tables 1–4** for the full list of affordances of places). Therefore, the main goal of the researchers when creating a hypothetical taxonomy for different expressional categories of affordances (social, functional, leisure, and emotional) was to provide a more analytical perspective of place experiences chosen by participants; and to display an extra qualitative layer of analysis to the current SoftGIS study, namely, in terms of characterizing place use and or place meaning. Also, grouping affordances into sub-sets within the same category of interaction provides an innovative research analysis framework in place based person–environment transactional studies. No statistical procedure was adopted to group affordances of each expressional category in different sub-sets. This procedure was solely empirically driven. For each *"affordance sub-set"* one criteria was devised and preceded by the phrase *"place interactions where"* (see **Tables 1–4**). Criteria for social, leisure, and emotional expressional categories of affordances was conceptualized based upon definitions of terminologies (Oxford University, 2015) used to name the sub-sets of affordances. As for the criteria for the expressional category of functional affordances it was used a *Playworker's Taxonomy of Play Types* (Hughes, 2006) due to the behavioral dimension of each affordance in this specific category[2].

following options, on foot; by bicycle; by bus/by public transport; by car; by other (skate, scooter, roller-skate, etc.). Single choice question concerning daily and ideal travel accompaniment from school to home were asked. Answers had to be selected from the following options (alone; with other children; with adults; with adults and other children).

- In what refers to affordances of places, after selecting one and locating it on the web-map, participants were asked about actual and ideal travel accompaniment to meaningful place where the affordance was located. For each one, multiple choice answers could be given. "I travel to this place" (actual) and "I would like to travel to this place" (ideal) according the following options, alone; with other children; with adults; with adults and other children. This procedure was repeated each time a place-affordance of any considered category (social, functional, leisure, or emotional) was located.

TABLE 1 | Taxonomy for expressional category of social affordances of places.

Social affordance sub-sets	Criteria (place interactions where)	Affordances of places
Privacy	It is mainly valued being alone and free from the public eye	Nobody is watching Being alone Hiding or secret place
Relational	It is mainly valued being connected with others	Being with adults Being with animals Being with friends New people Visit relatives
License	It is/isn't requested the permit from an authority to actualize it	Forbidden place Allowed place
Affectivity	It is mainly valued the social experience and consequent emotional outcome	Being mistreated Scary people Being myself Being in peace and quiet Place of arguing

TABLE 2 | Taxonomy for expressional category of functional affordances of places.

Functional affordance sub-sets	Criteria (place interactions where)	Affordances of places
Locomotor play	Action is mainly focused on *Locomotor Play "movement in any or every direction for its own sake"* (Hughes, 2006)	Playing hide and catch Jumping Running Climbing Walking Swimming
Object play	Action is mainly focused on *Object Play "play which uses infinite and interesting sequences of hand-eye manipulations and movements"* (Hughes, 2006)	Skating Riding a bike Playing ball games Going on the swings
Mastery play	Action is mainly focused on *Mastery Play "control of the physical and affective ingredients of the environments"* (Hughes, 2006)	Water playing Playing with sand or earth Building things

[2]Bellow, a more detailed explanation on the procedure for grouping the affordances in each expressional category is presented:

- A common denominator for all affordances of places which was "place interactions where" (as it is displayed in **Tables 1–4**) was designated by the authors.
- For the social, leisure and emotional expressional categories, affordances were grouped based on possible communalities content wise, on a trial and error basis. This enabled to stance out a specific, however, subjective, criteria between those affordances that shared similarities for each expressional category of affordances of places. (i.e.,

TABLE 3 | Taxonomy for expressional category of leisure affordances of places.

Leisure affordance sub-sets	Criteria (place interactions where)	Affordances of places
Cultural activities	Activities are mainly focused on engaging participants with ideas, customs and social behavior of societies	Cinema Museums or/and exhibition Library Show/concert/disco Musical events
Outdoor activities	Activities are mainly focused on the exploration of the outdoor environment	Adventuring Parks Gardens
Recreational activities	Activities are done for enjoyment	Playing Having fun Nothing to do Hobbies Hanging out Going out after dark Listening to music Leisure time center
Screen activities	Activities are mainly focused on the use of electronic devices	Playing computer/PlayStation/ electronic games
Physical and sport activities	Activities are mainly focused on physical activity and practice of sports	Sports (football, swimming or other) Dancing (hip-hop, ballet, or other)
Consumption activities	Activities are mainly focused on the use of goods and resources	Shopping Going out for a meal

TABLE 4 | Taxonomy for expressional category of emotional affordances of places.

Emotional affordance sub-sets	Criteria (place interactions where)	Affordances of places
Feelings	The experience of feelings is underlined	Fun Calm Good place to be Boring
Aesthetic	It is mainly valued the aesthetical experience	Pretty Ugly Untidy Tidy
Safety	It is mainly valued safety issues	Dangerous Unsafe Safe
Stressors	The experience of environmental stressors, such as light, noise, etc., is underlined	Dirty Clean Polluted Unpolluted Quiet Noisy Dark

Research Analysis Framework

A specific research framework was composed in three interconnected "layers," *mobility, affordances of places, neighborhood area,* aiming to provide one of possible transactional landscape on the youth-urban environment relationship in the Great Lisbon Area.

Direct data was imported from the SoftGIS*children* application *"Cidade Ideal: Um jogo de imaginação gráfica!"* to *QGIS 2.8.3.-Wien* and to *IBM SPSS Statistics 22* software. Statistical analysis was performed using SPSS and Excel software on two distinct datasheets, one focusing on the participants general characterization and questions on mobility in between home and school; and another one focusing on the selected meaningful places/affordances and mobility issues. Linear distances between home/school and meaningful places were calculated using *QGIS* software. This same software was used to generate map pictures of meaningful affordances of places. Indirect data provided by place-affordance classification according sub-sets on expressional categories of affordances of places were also added to the meaningful places' SPSS data sheet and imported to the QGIS software.

Research Variables

Age (3 age groups: "11–12 years old"; "13–14 years old" and "15–17 years old") and *Gender* (girls and boys) were operationalized as categorical variables in the SPSS data sheet.

School-home distance was calculated by determining mean linear distance (in meters and converted afterwards to kilometers) between participants' homes and the school which was attended by them.

Actual and ideal school-home mobility were determined by analyzing children's single choice answers on *travel mode* and *travel accompaniment*. For the former (descriptive purpose), *active travel*, when choice included "on foot," "by bicycle," or "by other (skate, scooter, roller-skate, etc.); *motorized travel*, when choice included "by car"; *hybrid travel*, when choice included "by bus/by public transport." When considering actual mobility vs. ideal mobility, travel mode was operationalized

"it is mainly valued being alone and free from the public eye," "it is mainly valued being connected with others"...).

- For the social, leisure and emotional categories of affordances, each common denominator that emerged (sub-set) and that specify each criteria in **Tables 1**, **3**, **4** was renamed according to a broader concept for each sub-set, which was also defined by the authors' subjective point of view (i.e., in social category, the proposed sub-sets were privacy, relation, license, affectivity).
- The "Oxford University, 2015" source was only consulted afterwards in order to reassure that the match between each specific criteria and each sub-set was possible. This was also a subjective analysis conducted by the authors.
- For the functional category of affordances, grouping of affordances was based on possible communalities content wise guided by the play types defined in Bob Hughes play taxonomy. The affordances were subjectively grouped but considering a possible inclusion of each action within with each considered play type. The criteria which was used is the definition of each considered play type and the sub-set is the designation of the play type itself.

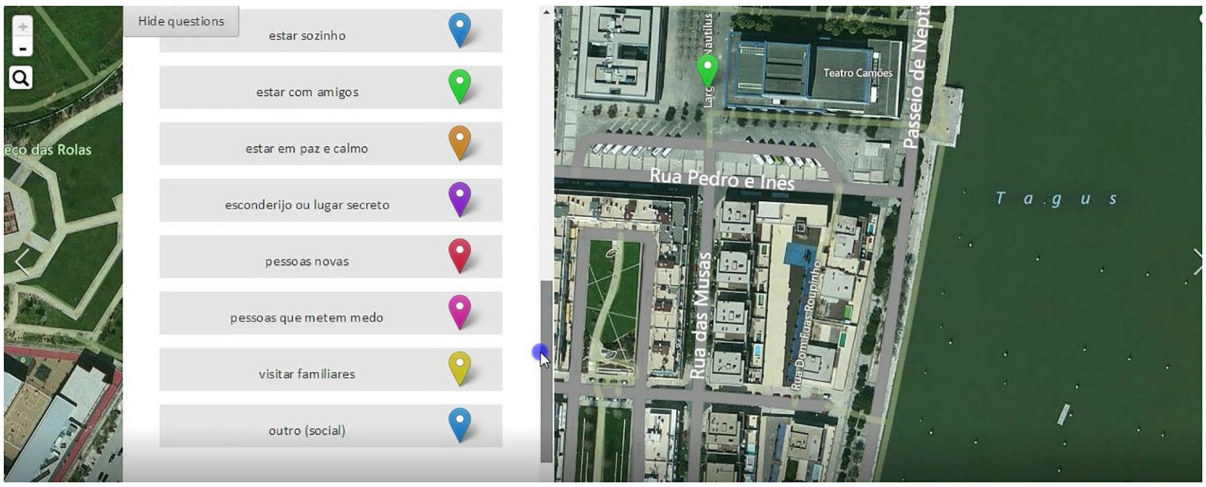

FIGURE 1 | Example of affordances of places available for selection using "Ideal City" SoftGISchildren survey. The figure describes examples of social place activities, experiences, places or meanings which become social affordances of places if selected and located in the web-map by participants. From top to bottom, these are being alone, being with friends, being in peace and quiet, hiding or secret place, new people, scary people, visit relatives, other (social).

as a dichotomous variable, *active travel* and *non-active travel* (*motorized* or *hybrid*). As for travel accompaniment, it was operationalized as *independent travel*, when choice included "alone" or "with other children"; and *non-Independent travel*- when choice included "with adults" or "with adults and other children."

Meaningful affordances of places were operationalized as actualized affordances located in the web-map environment considering four predetermined expressional categories, social, functional, leisure and emotional, which were selected by participants when completing the web-map questionnaire. More specifically they were designated as *social, functional, leisure, and emotional affordances of places* considering each designated expressional category of place interaction. Subsequently, all selected affordances within its expressional category were classified as nominal variables according the sub-sets proposed in each of those expressional categories. This data was then introduced in the SPSS data sheet and in the QGIS software.

Distance between home and meaningful places was operationalized as "*territorial distance*" and calculated using the QGIS software by determining mean linear distance (in meters and converted afterwards to kilometers) between participants' homes and meaningful places where affordances were actualized. Subsequently, this new variable was imported to the SPSS data sheet.

Neighborhood area was defined by a circular buffer of 500 m around each participant's home. This variable was created to classify affordances of places in terms of being located in or out of the neighborhood area. All affordances of places located within 500 m of the respective home place (linear distance) were classified as being "within the neighborhood," while others marked over 500 m were classified as "beyond the neighborhood."

Mobility to meaningful places other than school was determined by analyzing participants' multiple choice answers on travel mode and travel accompaniment, after locating each meaningful affordance in the web-map. This means that when analyzing mobility to meaningful places, focus is not on the actual participant but on the place determined via the location of an affordance, and its multiple possibilities of being traveled to regarding travel mode and travel accompaniment. Travel mode was operationalized as three variables (not mutually exclusive). *Active travel* if choice included "on foot," "by bicycle," or "by other (skate, scooter, roller-skate, etc); *motorized travel* if choice included "by car"; and *hybrid travel* if choice included "by bus/by public transport." Travel accompaniment was operationalized as two variables (not mutually exclusive). *Independent travel* if choice selection was "alone" or "with other children" and *non-independent travel* if it included "with adults" or "with adults and other children" (presence of both simultaneously and therefore not autonomous). In the SPSS data sheet, each of these variables was coded individually.

Research Topics, Research Questions, and Statistical Procedures

Mobility

Frequency analysis and Chi-square tests were performed to investigate whether participants' age groups or gender were associated with actual mobility and travel accompaniment in the school-home journey, and with actual mobility and travel accompaniment to meaningful places. A univariate analysis of variance was performed to determine if actual mobility (active, motorized, or hybrid) was related with school-home distance in the school-home journey. Concerning the home-school travel mode, participants' choice was attributed in three mutually exclusive available possibilities (active, motorized, and hybrid). The dependent variable was distance and the independent variable was each travel mode. Hence, statistically, three separate sub-groups (one according each travel mode) were constituted

from the whole research group (L). Independent samples *t*-tests were used to determine if travel accompaniment was related with traveling distance in the school-home journey and if actual mobility (active, non-active travel) was related with traveling distance to meaningful places. As for home-school accompaniment, participants' choice was attributed in two mutually exclusive available possibilities (independent travel and non-independent travel). The dependent variable was distance and the independent variable was each travel type of accompaniment. Hence, statistically, two separate sub-groups (one according each travel accompaniment) were constituted from the whole research group (L). The differences between actual and ideal school-home mobility and actual and ideal mobility to meaningful affordances of places were investigated using *McNemar* tests.

Affordances of places

Frequency analysis was performed to investigate: (i) which affordances of places were most actualized, (ii) how frequent was the actualization of each expressional category of affordances and (iii) which sub-sets of affordances of places were most actualized.

Neighborhood area

Frequency analysis was performed to investigate variations on (i) actual mobility to meaningful places and (ii) the actualization of different categories of affordances of places when roaming in the neighborhood area.

RESULTS

Mobility

Age Groups and Actual School-Home Mobility

A significant association was found between age groups and travel modes from home to school (Fisher's test, $p < 0.001$). Considering active travel mode (walking or cycling), this value rises as participants' age increases (23.5, 25, and 46.2%, for 11–12 years old, 13–14 years old and 15–17 years old, respectively). As for hybrid travel (public transportation), this value also rises with participants' age (9.9, 45, and 53.8%, according each of the previous mentioned age groups). Regarding motorized travel, conversely, and as expected, these values decrease as participants' age increases (66.7%; 29.5% and 0% from younger to older age groups). As for independent travel in the school-home journey, it was found to significantly increase as participants' age rises, with values of 29.3, 65.1, and 84.6%, in the 11–12, 13–14, and 15–17 years old groups, respectively [$\chi^2(2) = 23.39$, $p < 0.001$].

Gender and Actual School-Home Mobility

Results indicate that there was no statistical significance relationship between gender and children's actual school-home travel mode ($p > 0.05$) and travel accompaniment ($p > 0.05$).

School-Home Distance and Actual School-Home Mobility

It was found a significant effect of school distance on children's mode of travel from school to home in "L" research group [Welch's $F(2,72.92) = 8.65$, $p < 0.001$]. *Post hoc* comparisons indicated that: (i) significant differences were found comparing mean distance traveled by the group of youths using active travel mode with mean distance traveled by the group using hybrid travel mode; (ii) significant differences were found comparing mean distance traveled by the group of youths using active travel mode with mean distance traveled by the group of youths using motorized travel mode; (iii) no significant differences were found comparing mean distances traveled by the group of youths using hybrid travel mode with mean distance traveled by the group of youths using motorized travel mode. Hence, the mean distance traveled by youths adopting active travel mode is significantly smaller (M = 1125 m, SD = 2113) than mean distance traveled by youths using hybrid travel mode (M = 3174 m, SD = 2450) ($p = 0.001$); and the mean distance traveled by youths adopting active travel mode (M = 1125 m, SD = 2113) is also significant smaller than mean distance traveled by youths using motorized travel mode (M = 2578 m, SD = 2062) ($p = 0.003$). These results indicate that participants' active travel from school to home takes place if school-home mean distance is around 1.1 km. This is particularly relevant when taking in consideration that mean distance between school and home was found to be 2.3 km. In terms of school-home travel accompaniment, no significant differences were found comparing mean distance traveled by the group of youths who traveled independently with mean distance traveled by the group of youths who traveled non-independently.

Actual and Ideal School-Home Mobility

The *McNemar* test showed significant differences ($p < 0.001$) when comparing children's actual and ideal school-home mobility. Only a small percentage of children in the "L" research group traveled actively from home to school (27%), and nearly half of the children reported traveling autonomously in this journey (44.3%). Contrary, and ideally, the vast majority of children in "L" research group would like to be more active, decrease car transportation, and be more autonomous in the school-home journey (**Table 5**).

Age Groups and Actual Mobility to Meaningful Affordances of Places

In **Figure 2**, results on the interplay of age groups and mobility to places where children actualized affordances are fully presented. Our findings revealed that in all age groups active travel was the most frequently mode used to access meaningful places. Children aged 13–14 years old more frequently used active travel mode to meaningful places when compared with participants from the other two age groups [$\chi^2(2) = 24.18$, $p < 0.001$]. Children aged 15–17 years old significantly used more frequently hybrid travel mode to meaningful places when compared with participants from the other two age groups [$\chi^2(2) = 80.75$, $p < 0.001$]. Children aged 11–12 years old used motorized travel more often than children from the other two groups to access meaningful places [$\chi^2(2) = 88.01$, $p < 0.001$]. As for the relationship between age and travel type of accompaniment to meaningful places, traveling autonomously or in the company of other children (independent travel) was the most frequently used for the 13–14 years old and 15–17 years old age group; whereas for the

TABLE 5 | Actual and Ideal school-home mobility in L group.

		Real mobility (%)	Ideal mobility (%)	Statistical significance
Travel mode	Active travel	27.0	66.0	$p < 0.001$
	Non-Active travel	73.0	34.0	
Travel accompaniment	Independent travel	44.3	85.0	$p < 0.001$
	Non-Independent travel	55.7	15.0	

youngest age group of children (11–12 years old), more often they traveled to meaningful places in the company of adults. Also, it were found statistical significant differences between the three age groups in terms of independent travel [$\chi^2(2) = 71.69$, $p < 0.001$] and non-independent travel [$\chi^2(2) = 60.00$, $p < 0.001$] to meaningful places. Particularly, older children travel autonomously more frequently to meaningful places and less often in company of adults than younger children do.

Gender and Actual Mobility to Meaningful Affordances of Places

Gender was only found to be an influential variable when considering the option of hybrid travel to meaningful places, but not very significantly. More frequently girls (18.1%) used public transportation than boys (14.1%) when traveling to meaningful places [$\chi^2(1) = 3.83$, $p = 0.050$]. In terms of travel accompaniment to meaningful places, significant differences were found between girls and boys. Herein, more frequently boys (65.5%) than girls (59.9%) traveled independently (by themselves or in company of friends) to these places [$\chi^2(1) = 4.69$, $p = 0.030$]. Conversely, more frequently girls (60.4%) than boys (48.1%) traveled accompanied by adults (non-independently) to meaningful places [$\chi^2(1) = 22.27$, $p < 0.001$].

Distance and Actual Mobility to Meaningful Affordances of Places

Our results showed an interplay between distance and use of different travel modes to meaningful places. Significant differences were found comparing mean distances traveled when adopting active travel and mean distances traveled when not using active travel [$t(529) = 9.82$, $p < 0.001$]. Mean distance for active travel was of 1.3 km ($M = 1.337$, $SD = 1.806$), whereas for other modes of travel this value increased to 3 km ($M = 3.018$, $SD = 3.255$).

Actual and Ideal Mobility to Meaningful Affordances of Places

When comparing real and ideal travel modes used by participants when visiting meaningful places to actualize affordances, the McNemar's test showed significant differences on active travel with an increase from 68.7 to 79%, accordingly ($p < 0.001$). The opposite trend was found in motorized travel mode, diminishing from 43.9 to 27.7%, respectively. As for hybrid travel, no significant differences were found on the real and ideal settings. Considering travel type of accompaniment, a significant increase on real to ideal independent travel was found, 61.9–83.2%, respectively ($p < 0.001$); together with a significant decrease on non-independent travel on both settings, with the values of 54.6 and 31.8% ($p < 0.001$).

Affordances of Places

Actualization of Affordances of Places

A total of 1777 places were identified, 145 of them were home places corresponding to the total number of this research participants' and 1632 corresponding to affordances of places distributed in four expressional categories (social, functional, leisure, and emotional). A mean number of 12.26 affordances of places were actualized by each participant. In L group, the highest frequency of actualized affordances within the four conceptualized expressional categories was "social" (35.4%), followed by "leisure," "functional," and "emotional" types, with 27.7, 21.6, and 15.3%, respectively. This same decreasing trend in the actualized affordances of places was found for both boys and girls. **Figure 3** shows the total number of affordances of places identified by the participants in this study (left panel), and an example of the different expressional categories of affordances of places identified in a particular location (right panel).

Within social expressional category of affordances, those most actualized by participants in L group were "being with friends" (20.1%), "being myself" (13.5%), "being with adults" (8.8%), "being with animals " (8.8%) and "being in peace and quiet" (6.8%), as described in **Figure 4**. As for social sub-sets, those with higher expression were "relational" and "affectivity" with 47.3% and 30.7%, respectively.

In what concerns functional expressional category, most actualized affordances were "playing ball games" (13.9%), "riding a bike" (13.9%), "running" (13.3%) and "skating" (11%), as described in **Figure 5**. The most expressive functional sub-sets were "object play" (47.9%) and "locomotor play" (43.1%).

Considering leisure expressional category, most actualized affordances were "shopping" (18.8%), "cinema" (16.4%), "going out for a meal" (9.7%), "show/concert/disco" (6.9%), and "sports" (6.4%) as described in **Figure 6**. The most expressive leisure sub-sets were "cultural activities" and "consumption activities," with 30.5 and 28.5%, accordingly.

As for emotional type of affordances of places, the mostly expressive were "fun" (12%), "calm" (10%), "noisy" (8.8%), and "dangerous" (8.4%), as presented in **Figure 7**. The most expressive emotional sub-sets were "stressors" (34.4%) and "feelings" (31.6%).

Neighborhood Area

Neighborhood Area and Actual Mobility to Affordances of Places

Descriptive findings revealed an interplay between participants' actual mobility and territorial distance covered by their traveling to meaningful places in the urban environment (**Figure 8**). More

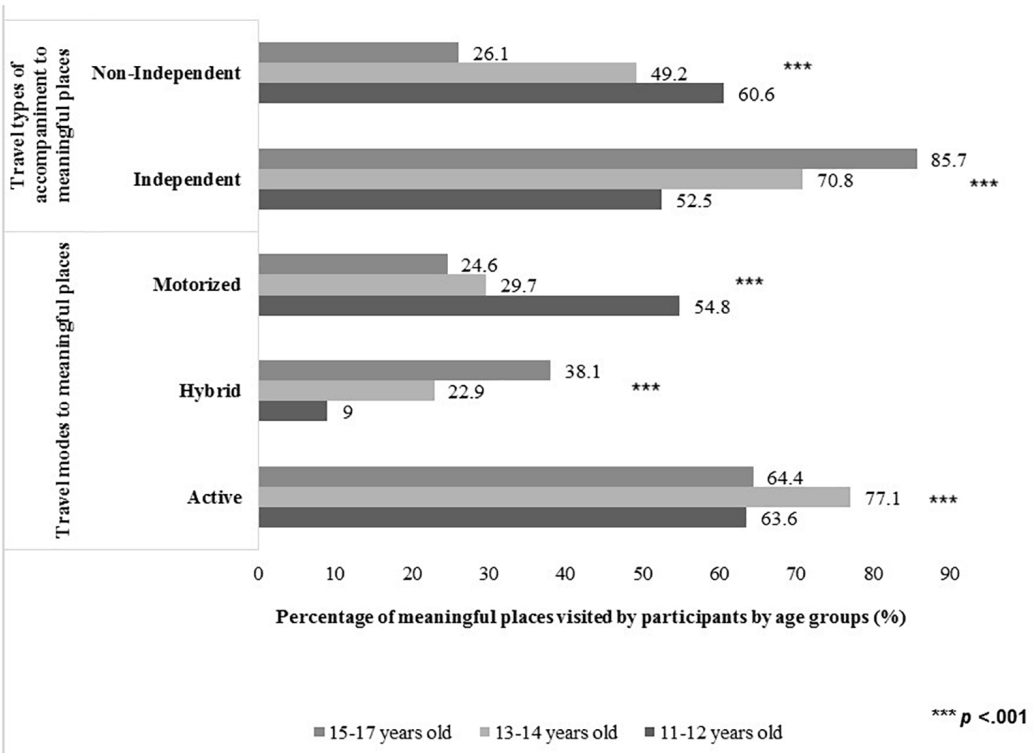

FIGURE 2 | Actual mobility to meaningful affordances of places according age in L group. The answers on travel modes and travel types of accompaniment are multiple choice and therefore they are not mutually exclusive.

specifically, most active travel (83.4%) and independent travel (68.9%) occurs within neighborhood area (500 m buffer around participants' home), whereas the majority of hybrid travel (90.9%) and most of motorized travel (67.1%) takes place beyond the neighborhood area.

Neighborhood Area and Expressional Categories of Affordances of Places

Considering the four expressional categories of affordances of places, descriptive results showed social affordances of places as the most expressive type (42.9%) within the neighborhood area (500 m around participants' home). The values found for the other three categories are very similar, 18.6%, 19.6%, and 18.8%, for functional, leisure and emotional place types of affordances, respectively.

DISCUSSION

The Interplay of Youth's Mobility and Affordances of Places in the Urban Environment Toward Assessing Youth-Friendliness Degree of Neighborhood

In the Great Lisbon area, when returning home from school, an increasing trend of active and independent travel as children grow older is similar to evidence found in other studies (Davison et al., 2008; Fyhri and Hjorthol, 2009; Fyhri et al., 2011). In the present investigation, shorter school-home distances was pivotal in terms of active travel promotion. Participants' active travel from school to home takes place if school-home mean distance is around 1.1 km. Although the threshold school-home distance for active travel is less than what it was found in a recent study which identified distances of 1.4 km for children at 10 years of age, 1.6 km at 11 years of age and 3 km at 14 years of age (Chillón et al., 2015). Our findings are similar to those found by Broberg and Sarjala (2015). More specifically, in the region of Helsinki, mean school-home distance was of 1.8 km; longer home-school distances decreased the likelihood of children and young people using active travel; and that within 1 km of school-home distance, majority of participants used active travel forms.

In terms of the school-home-journey, actions should be undertaken in order to increase levels of independent and active mobility for the younger ages.

In what concerns actual mobility to meaningful places in the Great Lisbon area, across all age groups active travel was the most frequently mode used to roam in the urban environment. It is interesting to notice that older children prefer hybrid travel mode to meaningful places, probably because it allows for them to move autonomously to further places, enhancing territorial range, and therefore mean distance traveling using hybrid mode was the highest one (3.3 km). Likewise, Broberg et al. (2013b), in a SoftGIS*children* study

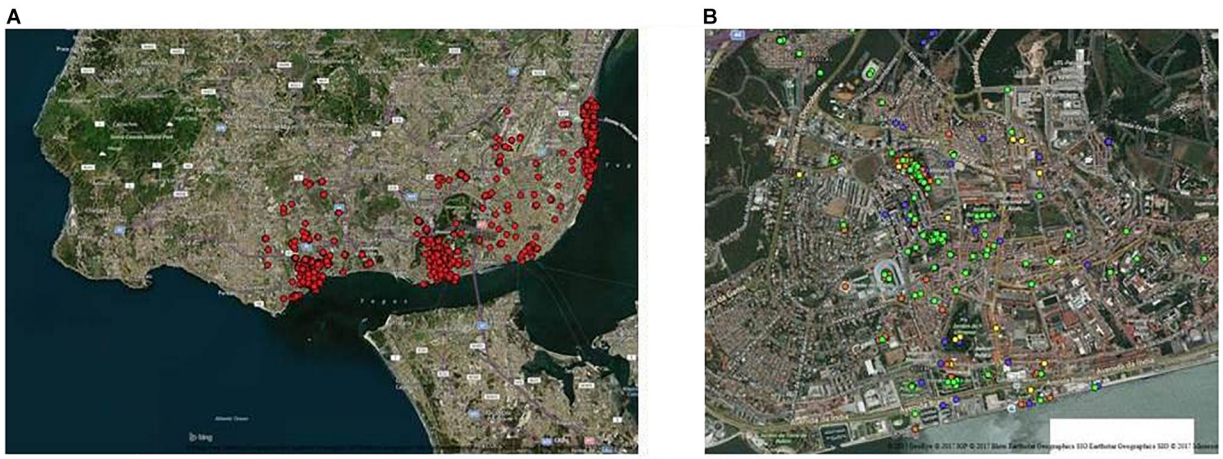

FIGURE 3 | Total number of affordances of places localized by participants in L group **(A)**. Example of social (green dots), functional (orange dots), leisure (yellow dots), and emotional (blue dots) expressional categories of affordances of places localized by participants from LW group **(B)**.

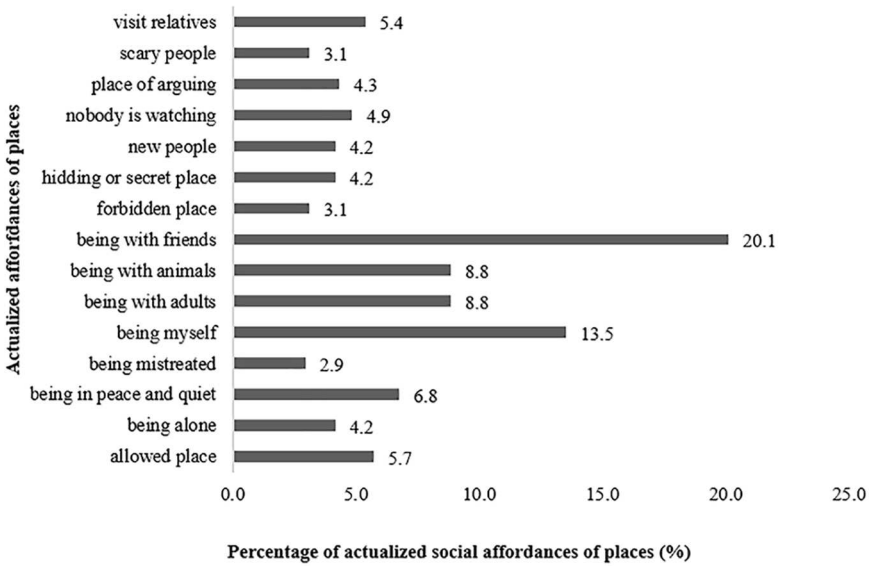

FIGURE 4 | Percentage of social affordances of places actualized by participants in L group.

found that children aged 11 years old traveled significantly more often to meaningful places adopting active travel modes; whereas older children (aged 14) used public transportation and motorized car travel. In the present study, older children traveled autonomously more frequently to meaningful places and less often in company of adults than younger children did. On the contrary, Broberg et al. (2013a) found no significant differences in terms of type of accompaniment when reaching meaningful places between the younger and older group of children.

Our results revealed gender as an influential variable in terms of travel accompaniment to meaningful places. More frequently boys than girls traveled independently (by themselves or in company of friends) to these places; and more frequently girls than boys traveled accompanied by adults, which is in accordance with previous studies (e.g., Broberg et al., 2013a). Nevertheless, in the school-home journey, no significant differences were found on actual mobility between boys and girls. Our findings showed that only 44.3% of participants traveled autonomously from school to home, while 68.7% traveled independently to meaningful places, which possibly means that freedom for youths to roam independently in the school-home journey is more constricted and dictated by the adults' agenda than when youths are running their own time. It is possible that parental fears and anxieties related with safety concerns and well-being are upheaved when children and youths have time and space to engage in contexts that afford their own agendas. In a study on gender differences and independent mobility of children aged

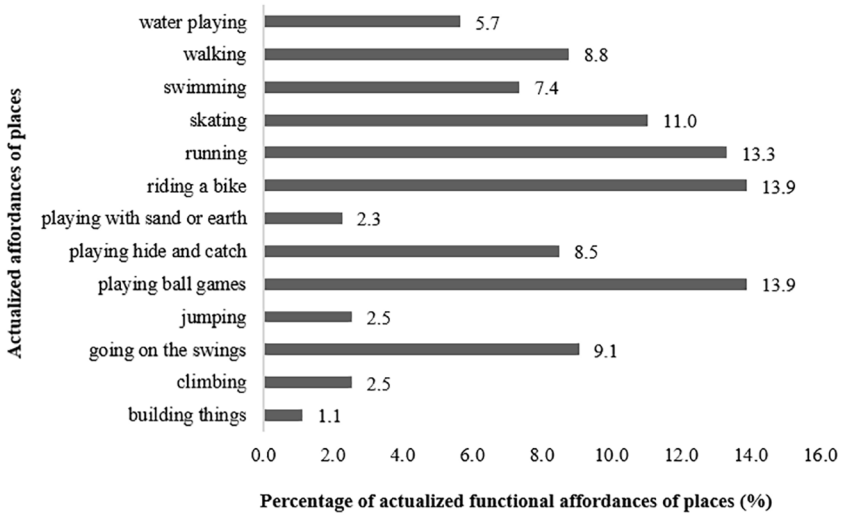

FIGURE 5 | Percentage of functional affordances of places actualized by participants in L group.

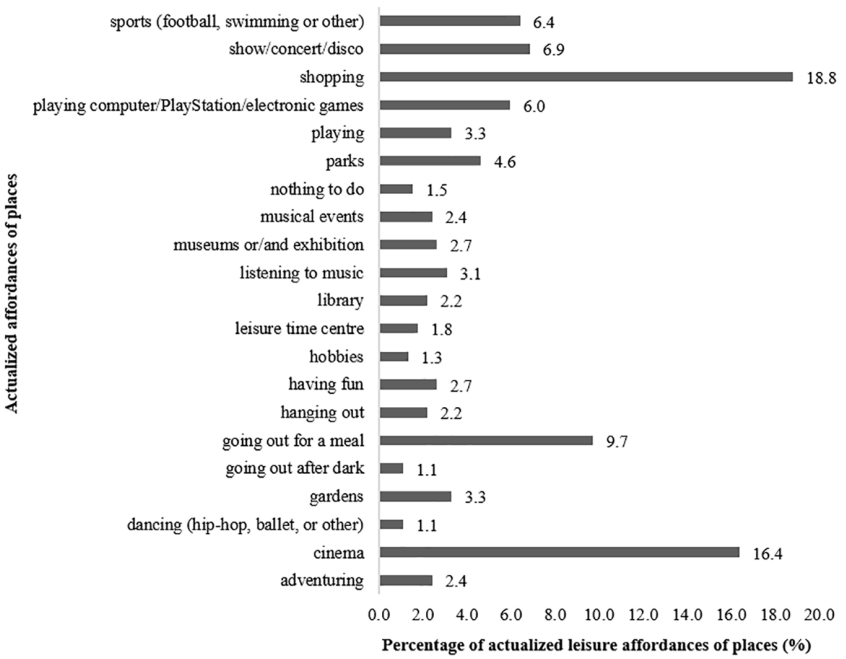

FIGURE 6 | Percentage of leisure affordances of places actualized by participants in L group.

8–12 years old living in urbanized areas, Brown et al. (2008) found that boys were more likely than girls to travel alone to the park, sports facilities, cinema, shopping center and to the local shops. Conversely, girls were more likely to travel with an adult to go to all places and were less likely to move around within their surrounding home area. A more comprehensive approach revealed that for girls, the pathway for independent mobility emerges from the need for social networks of peers, use of public transport to reach semi privatized public spaces (as shopping centers) that are localized at a greater distance from home. On the other hand, for boys, independent mobility emerges from roaming freely in the local area and from interactions with the physical environment that afford physical activity play. Therefore, it is possible that the gender differences we found in our research, where boys traveled more frequently alone to meaningful places than girls did, with the exception of the school-home journey, where no gender differences were found, not only relate to a greater parental protectiveness over girls (when they are running own agendas) but also to a different co-productive emerging pattern of independent mobility.

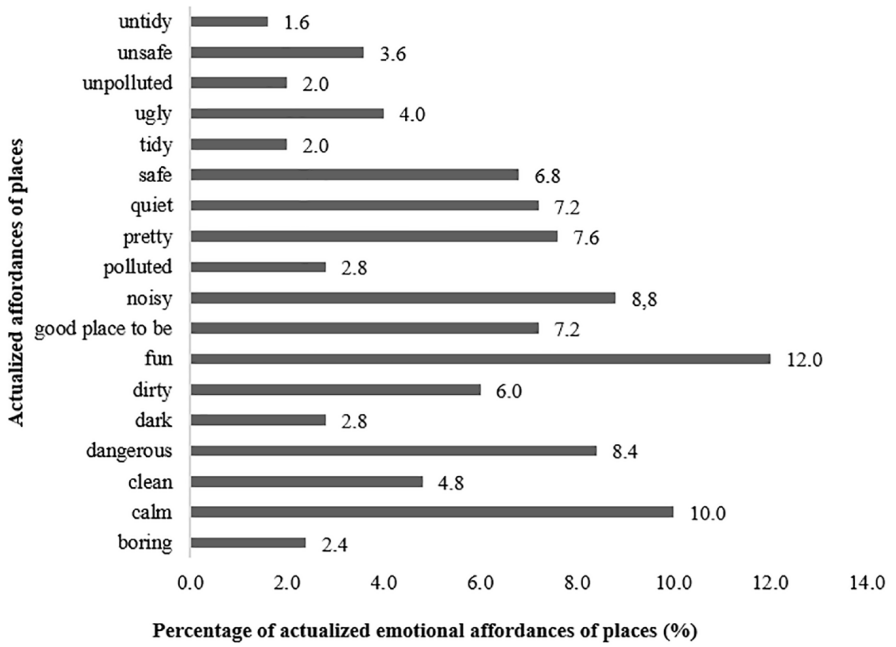

FIGURE 7 | Percentage of emotional affordances of places actualized by participants in L group.

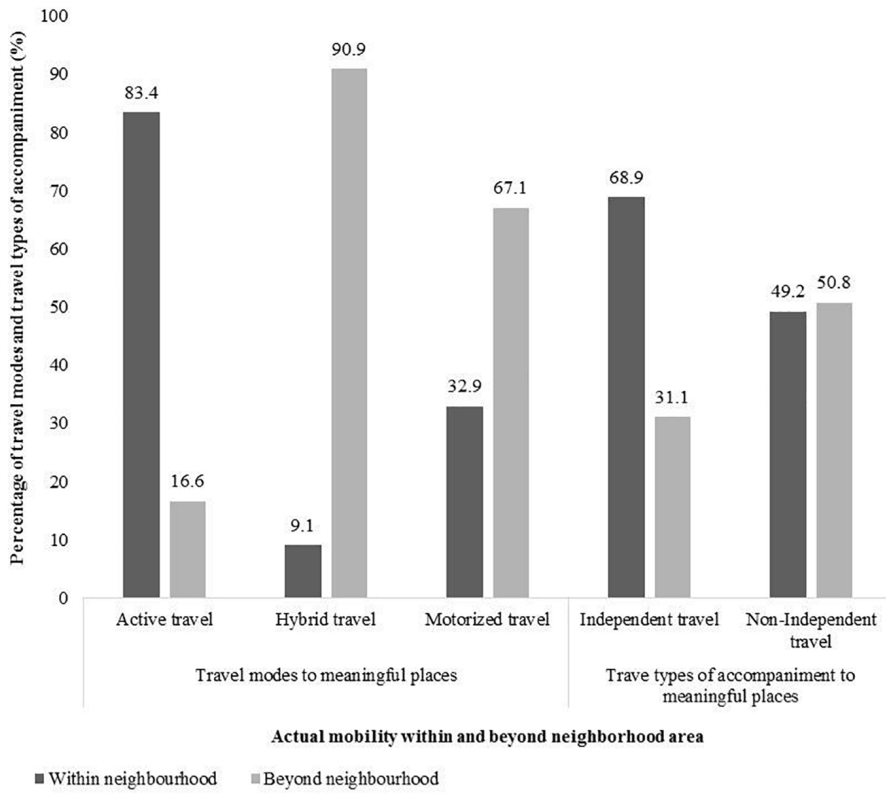

FIGURE 8 | Descriptive interplay of mobility and territorial distance to meaningful places in L group.

Our findings on mobility to meaningful affordances of places linked with previous results from other research lead us to conclude that it is important for local muncipalities to raise existing moderate levels of independent and active mobility for both boys and girls, and increase their territorial range, by making enviornments safer and less hostile for children and youth. In a study focused on children's independent mobility in three distinct urbanized environments (city, small town, and village), Lopes et al. (2014) have found that the percentage of Portuguese children living in the city of Lisbon who are granted freedom and autonomy to roam independently increases with age. In this same study, parents refer traffic danger and danger from adults as the main fears to grant autonomy of movement to children. Also, the influences of gender in parental fears regarding children's safety were only relevant in the city environment, where danger from adults was the most representative reason for parents to pick their daughters up from school. We believe that an increase on territorial range may invite youths to engage in a more diversified range of place experiences, which would contribute for more time spent in active and independent travel modes. Previous research has shown that active and independent travel mode has been linked to good health and well-being of children and youths (Mackett et al., 2005; Mackett, 2013). Therefore, we believe that an effort of municipalities to increase youth' territorial range could be perspective as health and well-being promoting measures within communities. Also distance from home to meaningful places must be considered when planning healthy and active environments for children and youths. In this sense we agree with Broberg (2015) that distance should always be considered when analyzing the relation between mobility, built environment characteristics and actualization of affordances. When comparing Portuguese children's independent mobility with the Northern European reality, namely with Finnish children and youth (Kyttä et al., 2012), Portuguese standards are still low, namely for younger children. Moreover, in a recent international comparative study conducted on 16 countries, children's independent mobility in Finland was found to be the highest (Shaw et al., 2015), whereas Portugal shares with Italy the 14th rank position. Also, our findings comparing real and ideal mobility, disclose that the vast majority of children would like to be more active, decrease car chauffeuring, and be more autonomous when traveling in the urban environment. Correspondingly, in Italy, at children's councils and planning participation sessions, children have reported a desire for playful cities that enable free roaming and bodily autonomy (Tonucci and Rissotto, 2001).

The participants of this study identified a total of 1777 meaningful places. Mean number of meaningful places by participant was of 12.26. Former research conducted by Kyttä et al. (2012) and Broberg et al. (2013b), both in larger sets of participants, adopted SoftGIS methodology, and obtained a mean number of meaningful places per participant of 7 and 6, respectively. The differences concerning number of actualized affordances of places located by participants using SoftGISchildren surveys between our findings and those found in Finland may derive from the some specificities of the data collection procedure. In the Portuguese case, as mentioned in Section "Methods and Data Collection," number of participants was much smaller (145) and each data collection sessions occurred with 10 participants and the co-presence of the researcher, or, when the number of participants was higher than 10, with the researcher and a research assistant. The role of the researcher and of the research assistant was to facilitate participants' use of the SoftGISchildren survey. Specifically, before participants were allowed to start responding to the questionnaire, the researcher presented an overview of the survey by projecting it to participants on the interactive board. The researcher browsed the survey from the first to the last questions, testing it and explaining how the SoftGIS application should be used in order to provide answers. Moreover, when participants were completing the survey, at any time, they could call the researcher or the research assistant to clarify any doubts concerning any question on the web-map questionnaire, or to help them to overcome obstacles, namely, and most frequently, zooming areas and using commands, buttons and props to select, locate and save affordances of places, when producing their answers. It is possible that the role of the researcher and the research assistant as facilitators of the participants' performance, when filling out the Ideal City SoftGISchildren survey, may have encouraged users to provide a more complete perspective of their psychological and spatial narratives of daily life in the urban environment. This was translated by an increase on the number of affordances of places identified in our investigation, when compared with those obtained by the Finnish studies.

In the present study, participants marked more social affordances of places, followed by leisure, functional and emotional types. Functional affordances of places, which are intertwined with physical activity play, were least frequent, possibly because our research participants are pre-adolescents and adolescents. Teenage behavior is very much characterized by social interaction among peers and social isolation (Clark and Uzzell, 2002) and by a decrease in physical activity play (Pellegrini and Smith, 1998). Nevertheless, our findings contrast with those by Sarjala et al. (2015) where most affordances of places marked by 5th and 8th graders were considered functional, tailed by emotional and social ones. The differences between our research findings concerning the expressive categories of place transactions (social, functional, leisure, and emotional) and the findings on the study conducted by Sarjala and colleagues may result from a combination of cultural factors. These relate to parental control and permission to engage in specific activities or behaviors; and simultaneously the type of features, elements and properties the immediate physical settings and the urban built environment offers youths in terms of actualized affordances. In a previous work (Lopes and Neto, 2014), the concept of "*Playgroundian City*" has been described as an urban environment which offers their citizens, including, children and youths, a transactional richness where actualization, shaping, reshaping and emergence of play, leisure, social, and emotional affordances are available across different urban spaces. It may be that the Finnish urban environment, due to urban planning and a conscious and deliberate design, offers more possibilities for youths to engage in functional affordances, and thus physical activity play and motor behaviors; as it does in

what concerns opportunities for independent mobility, as it is clearly demonstrated by the Finnish rank position (1st) and the Portuguese one (14th) in an international study involving 16 countries on children's independent mobility (Shaw et al., 2015).

In our investigation, within social categories of affordances, those with a higher expression of actualization were "being with friends," "being myself," "being with adults," "being with animals," and "being in peace and quiet." Some of these findings are similar to those presented in a seminal SoftGISchildren research in the city of Turku, in Finland, conducted by Kyttä et al. (2012) with 1387 participants aged between 10 and 15 years old. These researchers found that most frequent social affordances were "meeting with friends," "being yourself," and "being in peace and quiet." Generally, when comparing actualized meaningful affordances of places found in our research, in the Great Lisbon Area, and those from the city of Turku, it seems that social, functional and leisure experiences of Portuguese and Finnish children and youth are transversal in spite of country cultural specificities. In the present study, the innovative grouping of social affordances of places revealed that youths selected, more often, social places that allowed for "relational" and "affectivity" transactional experiences. The prevalence of the "relational" cluster reinforce Clark and Uzzell (2002) findings on neighborhood, school and town center as contexts that promote social interactivity and social withdrawal. Moreover, social interactions in the home, school and neighborhood environments are fundamental for the development of place identity and learning of social roles (Proshansky et al., 1983).

In the present study, the type of relational and affective immediate place experience and meanings that neighborhood area was found to afford youth are, in our perspective, key emotional features for place attachment to take place at the neighborhood level. According to Raymond et al. (2010), the attributes of the physical and social settings, which are personal contexts of place attachment, need to be included in the formation of individualized emotions in those same settings. In this way, social affordances of places that are actualized at the neighborhood level seem to be relevant for an *emotionalization* of place attachment. Kyttä (2003) refers to *emotionalization* as pivotal for the actualization of an affordance to take place and that every affordance has its own person-based emotionality fit. This means that the motivational basis for an actualization of an affordance relates to its *emotionalization.* According to Stedman (2008), settings have the potential for users to create multiple embodied cognitive meanings, referring to the descriptive symbolic meaning that people attribute to a place (Stedman, 2016). Our results on the neighborhood as a promoter of social affordances show that youths value this socio-physical context because it provides them with meaningful opportunities to be themselves, relate to each other and establish friendships and to be in peace and quiet. Some of the affordances of places that are most expressive for youths may be more related with place use, while others may refer more to place meaning. Either way, it seems that place use and place meaning, although they are different concepts, may be perceived directly and immediately by the person when actualizing a place-affordance. Therefore, the *emotionalization* of affordances of places also plays a role in terms of place meaning. In this way, the meaning of an affordance also resides on the intensity of the emotionality associated with its expressional multi-dimensions (functional, social, leisure, emotional, etc.) in consonance with the environment multidimensional character. Through the use of the hypothetical taxonomy adopted to categorize social affordances of places, it was found that the most expressive sub-categories which were actualized in the neighborhood were of relational and affectivity types of affordances. Therefore, we propose that the urban neighborhood enables youth to detect relational and affectional properties that are emotionally rich and meaningful.

Youth-Friendliness Degree of Neighborhoods: From Space to Place

In the present study, active and independent travel occurs mostly within neighborhood area (500 m around participants' home), whereas the majority of hybrid travel and most of motorized travel (takes place beyond this radius). Also, our results found neighborhood area as most prevalent in social affordances of places, since nearly half of them, within the four expressional categories, were actualized there. To assess the degree of youth-friendliness of neighborhoods, we used the hypothetical model proposed by Kyttä (2004). Here in, environments characterized with high levels of independent mobility and diversity of actualized affordances, where one correlates with the other, were designated as "*Bullerby*" and considered "child-friendly." Also, a more recent work (Broberg et al., 2013a) on assessing child-friendliness of places was included, where place experience and place meaning contribute to the quality of child-friendly places. In this sense, it is more realistic to refer to child or youth friendly places than environments. Based on the above, in our study, the neighborhood area is proposed as meaningful setting for social interaction and for independent and active travel of children and young people, whereas beyond neighborhood areas seem more capacitated to promote functional, leisure and emotional affordances of places, and hybrid and motorized travel. It is very positive that within these 500 m, children largely enjoy independent and active mobility to meaningful places where a high frequency of social affordances are perceived and actualized. Independent and active mobility has been associated with children's health and well-being (Mackett and Paskins, 2008; Fagerholm and Broberg, 2011) and as a correlate for physical activity (Schoeppe et al., 2013). In a systematic review, Sallis et al. (2000) found that time spent outdoors is consistently and positively associated with physical activity of children and adolescents. Moreover, in pre-adolescence and adolescence, youths are attuned with social activity as part of an internal and external social construction of childhood and place identity. It is therefore possible that when youths perceive and actualize affordances of places in the neighborhood area, the mutuality between the person and the environment is leading to a more socially dominant demeanor, thus making the "eco-niche" more socially meaningful. The eco-niche emerges from the interaction of the information that specifies the functions of the environment with the information that specifies the corporal aspects of the

person (Gibson, 1979/1986). Previous research concluded on the importance of the 500 m socio-built environment around young people's homes as a fundamental promoter of the neighborhood's free roaming (Fagerholm and Broberg, 2011); and another study reinforced the importance of the neighborhood as a promoter of youths social retreat behaviors (Clark and Uzzell, 2002). Also, and considering that within social affordances of places those more frequently actualized were "being with friends" and "being myself," such finding concurs with one presented in a previous research on children's independent mobility and degree of urbanization conducted in Portugal (Lopes et al., 2014). More specifically, it was found that within activity places children traveled to independently on their leisure time, "going to a friend's home" was among those mostly reported. Hence, in the present study, neighborhood areas were assessed as youth-friendly because they were found to be socially meaningful *bullerby* types of settings.

Concerning the production of places, Tuan (1983) sustains that abstract space becomes place as it is progressively experimented and practiced in daily life. Likewise, in a study about how girls create meaning of place through collective autonomy, Christensen and Mikkelsen (2013) synthetize ideas of previous scholars about place meaning sustaining that space becomes cultural and embedded of material, social and symbolic meanings through bodily presence and active co-participation in their immediate surroundings; through this process children create their own sense of place, dialogically and negotiating with others their material, social and cultural worlds. Moreover, neighborhoods are referred to as embodied socio-cultural ecosystems (Raymond et al., 2017a) nested in specific affordances and specific places (Heft, 2018). Drawing on the above, we suggest that recurrent daily actualization of affordances of places and free roaming over time through the neighborhood enable children and youths, collectively and progressively, to actively participate in the co-emergence of multi-dimensional place meanings, through an entanglement of body, mind, environment and culture, turning spaces to meaningful places. On this, Heft (2018) sustains that to understand human perception-action at a communal level it is indispensable to recognize that actions in the environment are nested to the affordances of objects and to the affordances of place, which emerge through social participation. The combination of autonomous corporeal movement and creation of multidimensional meanings of place through active place participation across the neighborhood allows youths to become *specialists of space*, or *spatialists*. Moreover, the use of SoftGISchildren surveys allows participants to inform about such place meanings and daily psycho-spatial narratives, which reinforces the perspective of youths as *spatialists*, in the sense of informing about their embodied *spatialism*.

Research Limitations and Future Investigation

We believe this research to be noteworthy as it provides a valuable and innovative insight to address the interplay of mobility, affordances of places and the neighborhood area. However, some limitations should be considered. Firstly, participants were asked to select affordances of places and localize them on the web map in the place where these interactions occurred. This means that some of the places which were marked on the web map may have been located in a nearby area, without really considering the place which was intended to. Consequently, it is possible to have existed place discrepancies between real intentioned place and the digital perspective of places. Nevertheless, and due to the nature of the research work and to the data collection instrument that was used, these limitations could not have been overcome. In spite of these setbacks, 1777 meaningful places were located. Secondly, the grouping of affordances on each of the expressional categories (social, functional, leisure, and emotional) was empirically driven and devised based on criteria defined by the author. Future studies should test these subsets of affordances using appropriate statistical based clustering. Likewise, other criteria for each category of affordances could have been selected. However, each of the four criteria was coherently justified and applied within those terms. Thirdly, most statistical analyzes used in this research were based on descriptive statistics and inferential statistics were just used when analyzing specific relations between variables. Although we believe that for the exploratory-descriptive kind of study this approach proved to be effective, we do realize that certain data assumptions which were made must be read bearing this statistical limitation.

A careful consideration related with the use of linear distances has to be made when interpreting our findings on the interplay of distance between home and school and mobility behaviors and between home and meaningful places; and on the interplay of distance and actualization of affordances of places, namely, when considering the 500 m neighborhood buffer. Linear distances do not correspond to the real distances traveled by youths, adopting any type of travel mode or of travel accompaniment, from home to school and from home to other meaningful places. Whichever ways youths use to move around, traveling is conducted using the street network and thus distance is not linear. A better measurement would have been to adopt the cognitive distance related to the street networks using space syntax or place syntax tools. Nevertheless, the use of linear distances, the shorter path between two points (crow-flies) has been adopted in other studies on active living research with children and youths, such as Broberg et al. (2013b) and Broberg and Sarjala (2015) when considering distance between home and meaningful places. As for the use of 500 m radius buffer around youths' home, the same procedure was applied by Kyttä et al. (2012) in a seminal research using SoftGISchildren methodology. In spite of the limitations, our findings, although just indicative, are a valuable contribution for municipalities when planning and designing youth-friendly ecosystems, such as the neighborhood area. Linear distances applied to the context of independent mobility and affordances may be very useful for municipalities to have access to the territorial boundaries of youths' spatial, place based narratives. This type of knowledge is important to implement measures that promote the extension and the enrichment of free roaming meaningful transactional territory for youths. Future studies on this topic should address this issue adopting an approach based on street networks and connectivity. Nevertheless, the approach

to distances between places adopted in the present research provides an important contribution for municipalities to design and manage youth-friendly ecosystems that promote well-being and contribute to a sustainable development.

In spite of these limitations, this study contemplates innovative aspects and offers interesting possibilities for future research in Environmental Psychology. To the best of our knowledge, this is the first investigation conducted in Portugal using SoftGIS*children* methodology to study children's independent mobility and child-place interactions in the environment; and, internationally, the first time where grouping of affordances within expressional categories was implemented. Future research, should explore grouping of affordances of places, validate, or redefine the used taxonomy for different expressional categories of affordances of places. Studies using SoftGISchildren methodology have focused on children's daily use of places, however, and as far as what we are concerned, less attention has been paid to how children's and youths' perspectives on how they would like their urban environment to be. Our research through the analyses of youth's actual mobility vs. ideal mobility to meaningful places provides a starting and seminal point to address these concerns using SoftGISchildren methodology. Also, in our opinion, future studies using SoftGISchildren methodology should include children and youths as co-designers of the web-map place based enquiries by integrating functionalities in the web-map survey to allow participants to graphically imagine child-friendly structures and settings. Moreover, SoftGIS*children* methodology should be combined with other data collection methods, such as, semi-structured interviews; mobility diaries, GPS data, accelerometers, photo-voice; neighborhood walking; etc. A very interesting example of this was the development of an application called *Mappiness* used in a study conducted in the United Kingdom. At random moments, participants were signaled through the app to answer to a small survey while their exact spatial location was recorded using GPS coordinates (MacKerron and Mourato, 2013).

Practical Implications

In an ever growing urbanized world and considering the recent agenda for sustainable development goals (United Nations, 2015), planning, designing, and redesigning urban landscapes toward the promotion of health and well-being of children and youths constitutes an immense challenge for governments, municipalities, policy makers and urban planners. In fact, it is concerning that over the past 50 years, there has been a decline of children's outdoor free play with other children, accompanied with the rise of psychopathologies in this population (Gray, 2011). Also, there has been a decrease of independent mobility and of social relations with others, which minimizes the access and use of residential streets in neighborhoods by children and youths for leisure, recreation and play activities (Shaw et al., 2015; Tranter, 2015). This is aggravated by an increase of overweight and obesity and decrease of physical activity among children (Whitzman et al., 2010). Hence, it is crucial to identify a set of practical implications that yield from the present study to tackle these problems.

Affordances of Places as Multidimensional Concepts

Affordances of places captured by place-based surveys offer the possibility for using them when planning environments that afford iteratively reconfigurations. When planning a neighborhood is important to create settings that are open-ended, where meaning of place results from diversified activities, feelings, values and uses, which also play a key role in the development of sense of place and identity.

Beyond Urban Neighborhoods That Privilege the Actualization of Social Affordances of Places

The findings of our study revealed the neighborhood area as most prevalent in social affordances of places. Although this represents a positive finding in line with the developmental needs of the study's participants (pre-adolescents and adolescents), we believe that neighborhoods should also be designed to youths with interesting, intriguing and challenging play, leisure and recreational opportunities.

Free Roaming of Youths as a Crucial Aspect of Daily Life in Urban Neighborhoods

Urban neighborhoods should be planned with places and routes that afford independent and active mobility of children and youths, which is associated with physical activity, health and well-being. This type of planning also promotes a diversified place experience of the territory.

Youths as Actors, Participants, and Co-designers of Planning Practices

SoftGISchildren methodology enables the empowerment of children and youths as active-participants by providing relevant information to planners about their perceptions and experiences in the urban spheres, by digitally detecting affordances of places and reporting actual *versus* ideal mobility to meaningful places.

CONCLUSION

The use of SoftGIS real-ideal survey mapping has proved to be an effective youth-friendly process that enables participants to digitally report about their immediate place experiences and place meanings as real life actors that simultaneously influence and are influenced by the close environment. This perceptual communality between the physical and the digital place experience and meaning stresses place-based mapping as a more ecological methodology than the use of more traditional methods such as interviews, questionnaires and diaries. It is important to address the neighborhood area as a youth-friendly embodied ecosystem that promotes free roaming and social meaningful places and the claim of increased autonomy of movement by young people. Also, children and young people ought to be considered as pivotal actors and providers of meaningful information for urban planning processes. Public polices to promote youngsters' health, well-being and happiness should therefore include active processes of

participation, where the real and ideal city is critically discussed by youths.

AUTHOR CONTRIBUTIONS

FL was the project leader and the corresponding author. FL did all of the field-work and did most of the writing with the contributions of RC. CN participated by discussing theoretical assumptions with FL and with RC.

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Salutogenic Affordances and Sustainability: Multiple Benefits With Edible Forest Gardens in Urban Green Spaces

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With increased urbanization, ecological challenges such as climate change and loss of biodiversity, and stress-related disorders globally posing a major threat to public health and wellbeing, the development of efficient multiple-use strategies for urban green spaces and infrastructures is of great importance. In addition to benefits such as climate and water regulation, food production, and biodiversity conservation, green spaces and features have been associated with various health and wellbeing outcomes from a psychological perspective. Research suggests links between exposure to green environmental qualities and restoration from psycho-physiological stress and attention fatigue, promotion of physical activity, increased neighborhood satisfaction and even reduced mortality. Especially strong associations have been observed in urban and socio-economically challenged areas. Usually such salutogenic, i.e., health-promoting, effects are explained through theories related to the notion of *biophilia*, i.e., the idea that humans share innate tendencies to attend to natural environments and features that have been beneficial during evolution. This paper assumes an ecological approach to perception and behavior to be fruitful in order to analyze the salutogenic potential of environments such as urban green spaces and to step beyond the "green vs. gray" dichotomy that has been prevalent through much of the research on health-promoting environments. Through an analysis of environmental affordances for certain perceived qualities such an approach is explored through a proposed concept for urban green space use and management, *the edible forest garden*. Such gardens, based on agroecological principles, have emerged as one of the most promising models regarding ecologically sustainable food production. In addition to potential contributions of importance for urban sustainability and biodiversity, we argue that the inclusion of edible forest gardens in urban green spaces – today globally dominated by lawns – also potentially could reinforce several affordances of salutogenic importance, both in terms of, e.g., social cohesion but also in regard to restoration from psycho-physiological stress and attention fatigue. Increased opportunities for contact with nature and processes of food production may also reinforce pro-environmental behaviors in the population and thus also affect long-term sustainability.

Keywords: salutogenic affordances, multiple-use, urban green spaces, green densification, sustainability, agroforestry, edible forest gardens

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INTRODUCTION

More than half of the human population resides in urban settings, and urbanization is an ongoing trend (WHO, 2014). By 2050 66% of the world's population is expected to be urban, as compared to 30% a hundred years before, in 1950 (ibid). Urbanization thus poses a major current and future challenge that affect how people interact with their close living environment, including potentially diminished contact with the natural world in terms of both quality and quantity (Markevych et al., 2017). Robert Pyle remarked that "local and tacit knowledge related to agriculture is disappearing from metropolitan landscapes, creating an 'extinction of experience' of human–nature interaction and a collective 'forgetting' of how to grow food" (Pyle, 1978). Such an experiential lack may lead to a degradation of public health and wellbeing, a loss of emotional affinity to nature and a decline in pro-environmental attitudes (Soga and Gaston, 2016). It has also been shown that various mental disorders, such as depression and even schizophrenia, are more common in urban than in rural areas (Peen et al., 2010). This has been attributed to higher stress levels in urban settings, and brain imaging studies have suggested that residents of urban areas often have a lesser capacity to cope with stress than rural dwellers (Lederbogen et al., 2011).

Meanwhile, non-communicable diseases such as cardiovascular disease, stroke, diabetes type 2, obesity, stress-related mental disorders, depression, and anxiety dominate the global disease burden and both insufficient physical activity and chronic stress are recognized as risk factors for such disorders (WHO, 2010). In Sweden the trend of sick leave due to mental health problems is increasing and according to a Swedish Social Insurance Agency (2013) report, the most common cause of sickness absence from work was stress-related mental illness. Globally, mental health problems are estimated to be among the major contributors to ill health and work disabilities (Salomon et al., 2012; Vos et al., 2013). A lack of green space access in urban areas have been linked to more self-reported mental distress and greater rates of anxiety and depression (Maas et al., 2009; van den Berg et al., 2010; Nutsford et al., 2013), as well as premature death (van den Bosch and Bird, 2018). The latter link applies to all-cause mortality but in particular to increased mortality in cardiovascular diseases (van den Berg et al., 2015; Egorov et al., 2016). Such findings could partly be explained by reduced green space access leading to decreased opportunities for physical activity (e.g., Konijnendijk et al., 2013) and restoration from high stress levels (Hartig et al., 2014; Braubach et al., 2017). Especially pronounced effects have been observed for people with lower incomes (Mitchell and Popham, 2008), highlighting the potential of using urban green spaces as a means to mitigate health inequalities in socioeconomically challenged areas, as discussed by e.g., Skärbäck et al. (2014). In addition, Hanski et al. (2012) have suggested that the reduced biodiversity in urban settings also may lead to decreased diversity of gut and skin microbiota. This in turn has been associated with inflammatory conditions, including asthma, allergic and inflammatory bowel diseases (IBD), type1 diabetes, and obesity (Haahtela et al., 2013).

POTENTIAL BENEFITS OF URBAN GREEN SPACES

Urban green spaces and infrastructures may contribute to the reduction of noise, filtering of air, and to the adaptation of climate change effects such as regulation of temperature, water run off, function as carbon sinks, while simultaneously serve various aesthetic and social purposes (e.g., Bolund and Hunhammar, 1999; Berghöfer et al., 2011; Gómez-Baggethun et al., 2013). Such functions is part of the Nature Based Solutions approach suggested by the European Commissions, and is often less expensive than technical solutions (Bauduceau et al., 2015). Regarding adaption benefits it seems that a heterogeneous vegetation structure is preferable and that trees with large and dense canopies are the most effective for both cooling and rainfall interception (see Brink et al., 2016). In addition to climate change, recent research also reveals an exceptionally rapid decline of plant and animal populations over the last century due to human actions (Millennium Ecosystem Assessment, 2005; Ceballos et al., 2015, 2017). Habitat loss is considered a main driver of this development, and although urbanization has had a negative impact on many species urban areas can support native biodiversity and even threatened species (Hall et al., 2016; Ives et al., 2016). Due to the possibilities of rapid development and change, urban green spaces may provide opportunities for instant and continuous creation of new habitats (Beninde et al., 2015).

Meanwhile, lawns dominate urban green spaces (**Figure 1**) and occupy around 70–75% of such areas globally (Ignatieva, 2010; Ignatieva et al., 2015). In Sweden, close to 25% of the cities are covered by lawns according to Hedblom et al. (2017) and it has been suggested that lawns contribute to increasingly uniform urban environments around the world (Ignatieva, 2010). In addition, traditional lawns are expensive and resource demanding to manage and rather poor in terms of biodiversity (ibid). They are green, but may in spite of this be rather weak regarding support for some important human needs, such as restoration from attention fatigue and psycho-physiological stress. There is a need for development of strategies that allow for urban environments and green spaces to be efficiently used in order to simultaneously meet the current ecological and social challenges. The development and employment of such multiple-use strategies for urban green spaces and infrastructures

FIGURE 1 | Lawns dominate urban green spaces globally.

may be seen as a process of "green densification", aimed to optimize the design and planning of such features in order to provide multiple benefits addressing the various current challenges.

MOVING BEYOND THE "GREEN VS. GRAY" DICHOTOMY WITH A SALUTOGENIC PERSPECTIVE

The term "salutogenesis" describes an approach focusing on factors that support human health and wellbeing, rather than on "pathogenesis," i.e., factors that cause disease (Antonovsky, 1996). The relationship between health and disease is seen as a continuum rather than as a dichotomy. Individual or environmental factors that push an individual toward the disease end of this continuum are termed *stressors* and factors that work in the opposite direction, toward optimal health and wellbeing, are called *salutogens*. According to Antonovsky, human health and wellbeing ultimately depend on the individual's ability to create and maintain a "sense of coherence" and meaning, thus strengthening the capacity to cope with life's various stressors (ibid). Salutogenic strategies, aimed at supporting such processes, may then complement pathogenic strategies that primarily strive to mitigate or eliminate stressors (Antonovsky, 1996; Becker et al., 2010).

Markevych et al. (2017) suggest that beneficial effects on human health and wellbeing from natural environments and green spaces work through three main complementary pathways; (1) *mitigation* ("reduction of harm," e.g., reducing exposure to air pollution, noise and heat, etc.), (2) *restoration* ("restoring capacities," e.g., attention restoration, physiological stress recovery, etc.), and (3) *instoration* ("building capacities," e.g., encouraging physical activity, facilitating social cohesion, etc.). In the light of salutogenic theory, mitigating strategies could be considered as primarily pathogenic, i.e., focused on harm-reduction, whereas support of restorative and instorative pathways could be considered as fundamentally salutogenic, i.e., focused on restoring and strengthening the capacities needed to cope with life's various stressors and ultimately facilitating a sense of coherence and meaning in life. Salutogenic pathways could arguably be seen as distinguished in comparison to most mitigating services in that they primarily depend on environmental support for certain experiences and behaviors, i.e., rely on a level of analysis that takes human psycho-physiological needs and preferences into account in order to be properly understood.

Although existing reviews and meta-analyses (e.g., Egorov et al., 2016) seem to confirm causal relations at population level between various beneficial health outcomes and access to natural environments and green spaces, Markevych et al. (2017) also highlight the fact that some epidemiological studies have failed to support such connections. Such findings might indicate that green spaces can support salutogenic pathways to different degrees. Furthermore, salutogenesis can also include more subtle effects of, e.g., aesthetic appreciation that may or may not be visible in epidemiological studies, arguably often focused on less subtle health and wellbeing outcomes. The same is arguably also true for various urban/built environments and psychologically relevant qualitative differences may exist here as well, as highlighted by, e.g., Stigsdotter et al. (2017a). Sallis et al. (2016) report that, in addition to the number of parks, the population density, intersection density, and public transport density all were positively related to physical activity in urban contexts in several cities across multiple countries and continents. It thus seems clear that both "green" and "gray" environments and features may function as salutogens in various ways and that research in health-promoting environments need to move beyond this dichotomy, arguably until recently prevalent in the field. There is thus a need to identify in more detail the specific qualities important in order for different environments to support salutogenic processes efficiently. This paper focuses specifically on urban green spaces and qualities within these that may contribute to their potential as salutogens in people's lives. This is done without thereby dismissing the importance of other urban qualities.

AFFORDANCE THEORY TO ANALYZE THE SALUTOGENIC POTENTIAL OF URBAN GREEN SPACES

We believe that much of the salutogenic potential of environments could be understood through an ecological approach to perception and behavior, by analyzing the environmental support for certain *affordances* in people's living environment. Introduced by Gibson (1979), an affordance is regarded as a perceivable and utilizable possibility for a certain behavior or experience, provided to individuals by environments. We here consider affordances primarily as relations between the individual and the environment, in accordance with the affordance theory developed by Chemero (2003, 2009). As such they are situation-dependent and are shaped between the abilities and needs of the individual and the present socio-material environmental conditions. Previous studies have applied the affordance concept to investigate how outdoor environments can afford, e.g., physical activity levels (e.g., Cosco, 2006; Björk et al., 2008) and independent mobility (Kyttä, 2003), socialization (Clark and Uzzell, 2002), self-regulation, (Korpela et al., 2002) and play behaviors (e.g., Heft, 1988; Zamani and Moore, 2013) among children. Kyttä (2002) revealed rural environments to have higher potential in providing affordances for play and social behaviors among children than urban environments. Other studies have used an affordance approach to investigate the potential of different environmental settings to aid in the restoration of stress and stress-related illness, such as rehabilitation gardens (e.g., Stigsdotter et al., 2017b) and forest environments (Stoltz et al., 2016).

Understood as dynamic human-environment relations, the affordances perceived are affected by various aspects regarding individual needs and characteristics, social factors, and physical environmental conditions. For instance, the perceived neighborhood safety may be regarded as one important factor that may shape the perception and utilization of green space

affordances, as shown through epidemiological research by, e.g., Weimann et al. (2017). Such results indicate the importance of accounting for the broader socio-material context to understand how green space affordances are shaped and utilized. In general, salutogenic effects from urban green spaces have been related primarily to the amount of time spent there (Grahn and Stigsdotter, 2003) and research has shown both the use rate and time spent in urban green spaces to decrease markedly already in the interval of 100–300 m away from the dwelling (Grahn and Stigsdotter, 2003; Nielsen and Hansen, 2006). It is thus important to identify factors that make urban green spaces afford actual use and it seems clear that accessibility, not the least through physical proximity, is key in this regard. The perceived biodiversity of urban green spaces has been identified as another important factor for visit rates (Gyllin and Grahn, 2015; Sandifer et al., 2015; World Health Organization [WHO], 2015), thus also indicating a general importance for the qualities perceived within green spaces. In order to analyze the salutogenic potential of urban green spaces in more detail, however, and possibly come up with evidence-based design and management suggestions, we would need a deeper understanding for the qualities of such environments that are important in shaping affordances of salutogenic significance. Also from a planning perspective this would be important to be able to identify which needs that are well catered for in a given environment and those that might require improved environmental support.

NATURAL ENVIRONMENTS AS A SALUTOGENIC FACTOR

Human connections and interactions with green and natural environments have been the focus of much research from various perspectives. Physical, mental, and spiritual perspectives have been highlighted and associated with various health and wellbeing outcomes. Research has described how perceptions of natural environments and features may impact various aspects of human health and wellbeing (e.g., Ulrich, 1984; Nilsson et al., 2011; Haluza et al., 2014), cognitive functions (e.g., Kaplan, 1995; Ottosson and Grahn, 2005; Berman et al., 2008) and stress-related aspects such as parasympathetic nervous system activity (Annerstedt et al., 2013), cortisol levels (Ward Thompson et al., 2012; Roe et al., 2013) and blood pressure and heart rate (e.g., Ottosson and Grahn, 2005). Such environmental influence has also been studied in various kinds of rehabilitation contexts (e.g., Ottosson, 2001; Pálsdóttir, 2014) and nature-based rehabilitation for individuals with stress-related disorders has been performed in various settings (e.g., Sonntag-Öström et al., 2014, 2015; Pálsdóttir et al., 2017; Stigsdotter et al., 2017b). Sahlin (2014) describes how such environments could promote and facilitate high-order cognitive behaviors such as existential reflections that aid in shaping experiences of meaning, coherence, and acceptance. Influence of natural and green environments has also been studied from a children's perspective. Mårtensson et al. (2013) for instance investigated relations to physical activity among school children. Carrus et al. (2015) showed how contact with nature could positively influence both cognitive capacities and social behavior among preschool children.

The Psycho-Evolutionary Theory; Restoration From Stress

Commonly, such effects from natural environments and features are explained with theories related to the *Biophilia*-hypothesis (Wilson, 1984; Ulrich, 1993), i.e., the idea that humans tend to respond in favor to natural characteristics that have been beneficial to survival and wellbeing during human evolution. The often-cited *psycho-evolutionary* theory (PET; Ulrich, 1986; Ulrich et al., 1991) focuses mainly on restoration from psycho-physiological stress. It holds that immediate affective responses, to a large degree dependent on common evolutionary traits, are important for how we respond to different environments. Responses of approach or avoidance depend on how environmental perceptions are interpreted and valuated in regard to survival and wellbeing, much in line with the evolutionary approach to motivation and valuation suggested by Mercado-Doménech et al. (2017). In accordance with Orians (1986); Ulrich (1986) suggests that our genetic configuration explains a preference for "savannah-like" environments consisting of layered vegetation with a mix of trees, grasses, and shrubs, preferably with visible water features, as well as support for the "prospect/refuge" dimension, i.e., opportunities for sheltered overviews and outlooks, as previously proposed by Appleton (1975). Empirical evidence in support of these theoretical claims has been reported by, e.g., Falk and Balling (2010). Such environmental characteristics are suggested to trigger stress-reducing responses whereas threatening or adverse conditions may induce stress (Ulrich et al., 1991). In general, PET suggests urban environments and stimuli to be significantly more stressful and less restorative than natural settings and features (ibid).

The Attention Restoration Theory; Restoration From Attention Fatigue

Another influential model in the field is the *attention restoration* theory (ART; Kaplan and Kaplan, 1989; Kaplan, 1995). It shares with PET the basic idea that evolutionary traits play an important role in how humans perceive and react to environments. Instead of psycho-physiological stress, however, ART instead focuses on our capacities for attention where it distinguishes between two basic kinds; "directed attention" and "soft fascination." ART suggests that our directed attention has a limited capacity and gets exhausted if overused. Typically the use of executive functions, such as planning and problem solving, require the activation of directed attention (Kaplan and Berman, 2010), as do many urban environments with an abundance of signals, information, and noise that the brain needs to sort through and handle. Circumstances that instead trigger our soft fascination, or "spontaneous" attention, e.g., certain natural environments and features according to ART, allow our directed attention to rest and its capacities to restore (Kaplan, 1995). In order for such restoration to occur, ART suggest that the environment should: (1) offer a sense of *being away* from the everyday

environment, (2) give a sense of *extent*, of an uninterrupted world in itself, (3) offer opportunities for *fascination*, through, e.g., natural features, and (4) be *compatible* with individual needs and abilities (Kaplan and Kaplan, 1989). ART, however, does not go into further detail in explaining how environments need to be physically structured in order to support these factors at the level of planning and design of public environments and urban green spaces.

THE SUPPORTIVE ENVIRONMENT THEORY; AN ECOLOGICAL APPROACH

The *supportive environment theory* (*SET*; Grahn et al., 2010) represents an approach to account for restorative and instorative processes (Stigsdotter and Grahn, 2003) that acknowledges the basic mechanisms and pathways suggested by both PET and ART, but emphasizes human's embodied relations with the environment and its affordances for certain experiential qualities termed *perceived sensory dimensions*. The theory suggests eight such qualities to be of particular importance to account for salutogenic effects. These have been revealed through factorial analysis of several different survey studies regarding people's green space preferences and use. They are based on people's reported needs regarding environmental support in their daily lives and do not rely on, e.g., image studies which has otherwise been common in the field. They may thus be regarded as ecologically valid categories in terms of green space qualities of potential salutogenic importance. Grahn and Stigsdotter (2010) term these qualities as (1) *Serene*, (2) *Nature*, (3) *Rich in species,* (4) *Space,* (5) *Prospect,* (6) *Refuge,* (7) *Culture,* and (8) *Social*. **Table 1** presents brief descriptions of each perceived sensory dimension.

TABLE 1 | Eight perceived sensory dimensions associated with affordances supporting different needs.

Perceived sensory dimension	The environment affords behaviors/experiences associated with. . .
(1) Serene	Peace, silence and care. Sounds of nature. Freedom from disturbances.
(2) Nature	Fascination with the natural world; the "self-made" as opposed to the man-made. Seemingly self-sown plants, a sense of untouched nature.
(3) Rich in species	A sense of abundance and variation, a large diversity of different species of plants and animals.
(4) Space	An experience of entering a world in itself, a coherent whole.
(5) Prospect	Views of the landscape, a sense of openness, prospects, vistas and stays.
(6) Refuge	Shelter and safety. Possibilities to relax and, e.g., let children play freely.
(7) Culture	A sense of fascination with human culture and history, the course of time and human efforts.
(8) Social	Social activities and interactions.

After Grahn and Stigsdotter (2010).

Each dimension indicates a generally perceived need that requires support in the environment (Grahn and Stigsdotter, 2010; Grahn et al., 2010) and people tend to agree as to which level an environment support a quality or not, making them suitable for objective environmental evaluations (see e.g., de Jong et al., 2011, 2012; Stoltz et al., 2016). Such general agreement may be important in the context of design and planning of public environments such as urban green spaces where individual tailoring is not applicable. It may also be considered as in line with the notion that humans share certain tendencies regarding environmental preferences due to common evolutionary traits, as held by PET and ART. A key assertion of SET, however, is that preferences and valuations (Mercado-Doménech et al., 2017) of each quality vary with changing needs, depending on, e.g., stress levels (Grahn et al., 2010). This has also been clear when studied in various rehabilitation contexts. For instance, Pálsdóttir et al. (2017) investigated which qualities that were considered the most restorative in a rehabilitation forest environment. The results showed the perceived sensory dimensions Serene, Space, Refuge, and Nature to be rated highest in this regard and the Social quality to generally be seen as the least restorative, all in line with previous studies (e.g., Grahn and Stigsdotter, 2010). This indicates that salutogenic design and planning of urban green spaces should take into account the need for variation in terms of perceived environmental qualities in order to satisfy different needs in the population.

The perceived sensory dimensions may thus be considered as quite stable in the environment regarding their general presence/support, while their actualization as perceived affordances will vary depending on individual needs. This makes them interesting as a framework through which affordances of salutogenic importance, although always realized as unique human-environment relations, may be considered in a more general and objective sense for purposes of design, planning and evaluation of public environments. Following these assertions, public health and wellbeing outcomes may to some degree depend on the affordances for the different perceived sensory dimensions in people's close living environment. Such relations have been investigated in epidemiological studies. Björk et al. (2008) found an association with the number of dimensions perceived as supported in the neighborhood green spaces and reported neighborhood satisfaction. The opposite association was found regarding body mass index (BMI; ibid). These effects were, perhaps not surprisingly, most pronounced among tenants as compared to house-owners. de Jong et al. (2012) found an association with increased physical activity and the number of supported dimensions in the neighborhood green spaces. These results were all adjusted for in regard to individual characteristics such as age, sex, educational level, and income, suggesting that the observed effects indeed share a common driver in the structure of the physical neighborhood environment. In line with such findings, Stigsdotter et al. (2017b) suggest that the perceived sensory dimensions framework is valid for use as a guideline in the design and evaluation of salutogenic environments.

THE EDIBLE FOREST GARDEN

The edible forest is one of several agroforestry practices based on *agroecological* principles (Gliessman, 2007). Agroecology is a scientific discipline derived from agronomy and ecology that studies productive lands through an understanding of the workings of natural ecosystems (ibid). The edible forest garden describes a low maintenance, productive and species rich cultivation system with its origins in the tropics (Hart, 1996; Crawford, 2010). It is modeled after the structure of young natural woodland and consists of edible perennials such as fruit and nut trees, shrubs with berries, herbs, vegetables, flowers and fungi that are intercropped in layers in a so-called *multi strata* system (**Figure 2**). The edible forest garden thus resembles a forest more than a conventional horizontal garden and the management methods used mimics the cycles in natural ecosystems (Crawford, 2010). No external inputs of resources such as irrigation, pesticides, or fertilizers are used and digging/tilling techniques are avoided. Instead recycling of organic matters on the ground makes the soil fertility self-generative, the moist is kept and green house gas emissions are low or even negative (ibid). Natural pest control is accomplished through the high species richness – usually about 100–200 species per garden – and the forest garden is also resilient of weather extremes as well as demanding lesser labor for maintenance and weeding than annual crops (ibid). Edible forest gardens exist as home gardens in the tropics (Bardhan et al., 2012) and in temperate areas such as in the United Kingdom since a few decades (Hart, 1996; Crawford, 2010). In Sweden, their ecological benefits have been highlighted through an applied pilot project on 13 smallholdings (Björklund et al., 2018).

Edible Forest Gardens and Urban Sustainability

From the literature on food production the edible forest garden is considered as promising regarding ecological sustainability (Crawford, 2010). Russo et al. (2017) include edible forest gardens in their concept of "edible green infrastructures" and the city of Seattle, United States, has an ambitious tree-planting program in order to create edible urban landscapes supporting urban sustainability (McLain et al., 2012). Clark and Nicholas (2013) have investigated 37 existing urban "fruit forests" in the United States and address their multiple benefits regarding sustainability. Furthermore, edible forest gardens can increase urban biodiversity; even a small bed could consist of +100 species and this high biodiversity could contribute to ecological values, especially when compared to traditional lawns (cf. e.g., Ignatieva, 2010; Ignatieva et al., 2015). Since it consists of trees and shrubs the overall structure resembles a forest/orchard with shelters, providing habitats for organisms such as birds and insects (Björklund et al., 2018). Even smaller forest gardens (≈60 m^2) can exhibit these qualities (ibid) and thus contribute to increased urban biodiversity. On the landscape level edible forest gardens could strengthen the green infrastructure through contributing to ecological connectivity (Russo et al., 2017). Bohn and Viljoen (2011), under the concept of the Continuous Productive Urban Landscape (CPUL), have suggested cities to have continuous productive stretches with room for green areas, mobility without vehicles, and urban agriculture. Edible forest gardens could be part of such a strategy.

To our knowledge there are not yet any published literature on temperate zone urban edible forest gardens. We suggest, however, that they have great potential in these areas as well. They are more robust than annual cropped gardens and therefor allow other activities such as room for play or for people that do not want to garden themselves. Edible forest gardens could be integrated in the ordinary maintenance of outdoor-areas performed by public (e.g., municipalities) or private (e.g., housing companies) actors. They demand less labor, resources, and land area than annual cropped gardens (Hemenway, 2009; Crawford, 2010; Björklund et al., 2018) and could therefor also be less expensive. Edible forest garden could thus be an alternative for municipalities with constrained budgets. Stockholm for instance is a segregated city (Bremberg et al., 2015) and since the municipality owns 70% of the land forest gardens could contribute to urban sustainability in underprivileged districts by urban agriculture in the forms of edible forest gardens and community gardens. In a small-scale study on edible forest gardens in residential areas in Stockholm, Schaffer (2016) highlighted the multiple user-groups that visited the gardens, thus indicating a potential for broad social benefits. If space is limited, forest gardens can be kept small and fit in well in existing urban environments, e.g., in between apartment blocks (**Figure 3**).

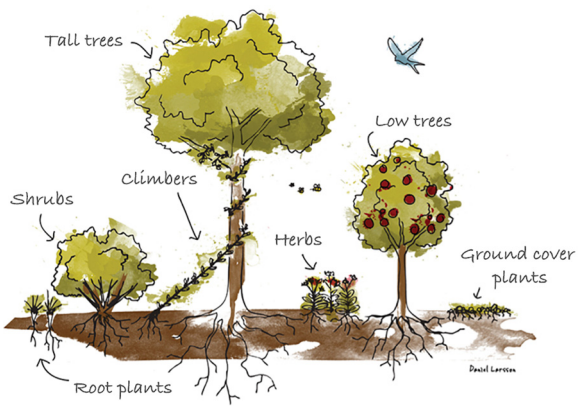

FIGURE 2 | The multi-strata (layered) system of an edible forest garden (illustration by Daniel Larsson).

COMMUNITY GARDENING IN URBAN AREAS

Social factors such as neighborhood interaction patterns, social cohesion (Wilkinson, 1996), social capital (Giordano et al., 2012), and a shared sense of coherence and safety (Taylor et al., 1997) have important influences on health and wellbeing. Urban agriculture in general is suggested to contribute to multiple dimensions of sustainability depending on organizational form, location, size, and gardening methods (Guitart et al., 2012; Mok et al., 2014; Eigenbrod and Gruda, 2015). As an organizational form the *community garden* have been highlighted

FIGURE 3 | View from a young edible forest garden in Bagarmossen, south of Stockholm, Sweden. It is located close to the metro station and a shopping mall in an area with apartment blocks without own gardens.

in the literature. Hale et al. (2011) argues that the relational qualities from community gardening contributes to social health, since it nurtures relations such as those between gardener-plant, gardener-gardener and the garden/gardener-the local community. Community gardening could increase the social capital (Firth et al., 2011) and contribute to learning and a sense of place (Bendt et al., 2013). Gardening as an activity also contributes to health for gardeners from a physical activity perspective, and for others as well since the garden could be the attraction for a trip or a walk (Hale et al., 2011). Various forms of urban gardens, such as edible forest gardens, allotment gardens, etc., organized as community gardens may contribute to social capital (Firth et al., 2011) and a sense of place (Bendt et al., 2013). In a recent study by Bonow and Normark (2018) on community gardens in Stockholm, the many social qualities generated are highlighted versus the rather small amount of food produced.

Clavin (2011) identified features of sustainable design in community gardens in the United Kingdom that had impact on wellbeing. Factors that affected wellbeing were related to agency (both individual and collectively) from experiential learning (learning by doing) and having choice (freedom) to work in one's own manner (to be both slow or busy, to be both alone or work with others), and having choice of a variety of tasks suitable for different people different days. Community gardens as a form of do-it-your-self urbanism (Finn, 2014) enable people to participate in the design of their own neighborhood. Such gardens might thus afford an arena where urban citizens can be more than voters/consumers, but also actively engage as co-creators of the city. In allotment areas ecological knowledge is shared among gardeners and over generations (Barthel et al., 2010) and this could also be true for community-based forest gardens. Edible forest garden may also afford learning opportunities, as described by, e.g., Askerlund and Almers (2016) who studied how edible gardens could support children's learning on ecology. When located in urban areas edible forest gardens may provide increased possibilities of interaction with the natural world, thus aiding an increased sense of connectedness to nature (Hale et al., 2011), support environmental awareness and pro-environmental behaviors (cf. e.g., Annerstedt van den Bosch and Depledge, 2015). Arguably, forest gardens could thus somewhat remedy the "extinction of experience" mentioned by Pyle (1978).

PERCEIVED SENSORY DIMENSIONS OF EDIBLE FOREST GARDENS

We argue that edible forest gardens in urban green spaces is an interesting concept to explore, both in regard to such dimensions of ecological and social sustainability as has been outlined above, and in terms of affording perceived qualities of salutogenic importance, which could be highlighted using the perceived sensory dimensions framework described above. Compared with lawns, edible forest gardens seems particularly promising in supporting perceived sensory dimensions such as Nature, Rich in species, and Refuge; dimensions that have been described in the literature as important to support restorative processes (e.g., Grahn et al., 2010; Pálsdóttir et al., 2017; Stigsdotter et al., 2017b). **Table 2** relates typical features of the edible forest garden with each perceived sensory dimension of the SET theory.

The use of trees and other perennials, a core principle of agroforestry, could be an efficient means to reinforce affordances for the perceived sensory dimension of Nature; especially so when given an impression of being "self-sown" (Grahn and Stigsdotter, 2010). The general salutogenic potential of urban trees in particular have been highlighted in previous research (e.g., Kardan et al., 2015), as have the salutogenic potential of forest environments (e.g., Sonntag-Öström et al., 2014, 2015). In addition, trees can often be made visible from the windows of houses that in dense urban areas often reach several floors above ground and thus increase the need for vertical green structures in order to be visible from inside the dwellings. The salutogenic potential of having access to trees outside the window has not the least been highlighted by Ulrich (1984) in a well-known study. Support for the perceived sensory dimension of Nature would possibly increase over time as the forest garden grows and matures; a sense of nature's "untouched" development over time is indicated as important to strengthen this perceived quality (Grahn and Stigsdotter, 2010). Compared to, e.g., lawns – that arguably will look almost the same even after 50 years of cultivation – a forest garden with 50-year-old fruit and nut trees would give quite another impression in such terms. Experiences of the passage of time in nature could further be reinforced through the high biodiversity of the forest garden with a large variety of plants that may mature at different times during the season, thus changing the environmental impressions as time passes.

The high biodiversity could also strengthen the affordance for the Rich in species dimension and the perceived biodiversity, as already mentioned linked with use rates of urban green spaces (e.g., Sandifer et al., 2015). Again, when compared to traditional lawns, the potential difference here seems obvious (**Figure 4**). The emphasis on edibles in the forest garden does not exclude plants that are just there for aesthetic or other reasons (e.g., pest control or other functions), however, the edibility factor arguably offer even more ways to interact and relate to nature in meaningful ways using the whole body and all its senses. Forest garden environments may also support affordances important for

TABLE 2 | Typical features of edible forest gardens in relation to eight perceived sensory dimensions (after Grahn and Stigsdotter, 2010).

Perceived sensory dimension	The environment affords behaviors and experiences associated with. . .	In relation to features of the typical edible forest garden
(1) Serene	Peace, silence and care. Sounds of nature. No disturbances.	Edible forest gardens, especially when mature, could provide habitats that attract singing birds and humming insects. Sounds of wind blowing through the trees etc. could also reinforce affordances associated with this dimension.
(2) Nature	Fascination with the natural world; the "self-made" as opposed to the man-made. Plants seem self-sown, a sense of untouched nature.	Mimicking the natural ecosystems of young woodlands, the mature edible forest garden could provide plenty of affordances associated with this dimension, e.g., trees and plants with interesting shapes, a sense of nature's power to grow and create through the passing of time.
(3) Rich in species	A sense of abundance and variation. A large diversity of different species of plants and animals.	Edible forest gardens typically exhibit a very high biodiversity. Usually +100 plant species, most of them edibles. The forest garden environment could also attract various animals through the different habitats created by the various plants and the young woodland, *multi-strata* structure.
(4) Space	An experience of entering a world in itself, a coherent whole.	May be reinforced through the *multi-strata* structure the forest garden, adding to a sense of 3-dimensional "spaciousness" and of entering into "another world, a coherent whole." An entrance gate may further strengthen such affordances. It would, however, be important for the forest garden to be large enough in order to fully support associated experiences and behaviors (e.g., "wandering around").
(5) Prospect	Views of the landscape, a sense of openness, prospects, vistas and stays.	Affordances associated with this dimension are generally better reinforced by, e.g., lawns rather than by edible forest gardens in themselves. However, from a distance the forest garden might provide for a pleasant "view" or "scenery" that are important aspects of this dimension.
(6) Refuge	Shelter and safety. Possibilities to relax and, e.g., let children play freely.	Could be reinforced through the *multi-strata* structure of the forest garden with trees and shrubs of various heights mixed with more open parts. A gate to the garden may further strengthen affordances that allow for a sense of shelter and privacy and to "see without being seen."
(7) Culture	A sense of fascination with human culture and history, the course of time and human efforts.	An edible forest garden represents a highly cultivated environment. Crops could be chosen that relate to cultural heritage. With time a growing sense of appreciation for the history of the place and the human labor put into the garden might grow, thus further strengthen associated affordances.
(8) Social	Social activities and interactions.	Especially true when realized as community gardens in public green spaces close to dwellings. Opportunities for learning, workshops, gardening activities, etc. have been highlighted in the literature.

FIGURE 4 | In front of the public sports hall in relatively low-income and culturally diverse suburb of Fisksätra, southeast of Stockholm. A lawn has been planted with around 130 different plant species to form an edible forest garden. On regular basis children from a nearby kindergarten visit the garden to learn about ecology and explore the affordances of the garden.

species other than humans, such as singing birds, insects, and other animals that further may strengthen the Rich in species quality. Many times forest gardens also include the presence of an "insect hotel" – a structure made to provide shelter for insects – that in addition may contribute with, e.g., pollination functions.

Singing birds, sounds of wind blowing through the trees, etc. could also reinforce the affordances for the Serene dimension through the presence of various "sounds of nature" (Grahn and Stigsdotter, 2010). In addition, the potential to use trees and other vegetation to reduce, e.g., traffic noise levels have been highlighted in the literature (e.g., Bolund and Hunhammar, 1999; Gómez-Baggethun et al., 2013). Evidence also suggests that green features might mitigate annoyance associated with such noise in urban environments, and that the type and structure of the greenery matters in this regards. Li et al. (2010) for instance investigated Hong Kong residents and found "garden parks" visible from home to reduce noise annoyance to a greater degree than "grassy hills". Renterghem and Botteldooren (2016) reached a similar result and concluded that visible outdoor vegetation was essential for the reducing effect on noise annoyance at home.

Trees and other perennials in the semi-open *multi-strata* structure (**Figure 2**) of the edible forest garden could furthermore support affordances for Refuge through the creation of shelters and hideaways. Such affordances have been described as particularly important from the perspective of stress restoration (Grahn et al., 2010; Pálsdóttir et al., 2017; Stigsdotter et al., 2017b). This has also been indicated in forest rehabilitation

contexts (Sonntag-Öström et al., 2015). A sign and a gate that marks the entrance of the garden could further enhance such affordances (Pálsdóttir et al., 2017). If large enough to provide a sense of "coherent whole," and of "entering a world in itself" (Grahn and Stigsdotter, 2010; Pálsdóttir et al., 2017), an edible forest garden may also afford of the perceived sensory dimension of Space to some extent.

Over time, an edible forest garden could also support opportunities to experience and appreciate the work and efforts of "previous generations," thus affording the perceived sensory dimension of Culture (Grahn and Stigsdotter, 2010). Artifacts such as "sculptures" or "ornaments" (ibid), made with a sensibility for the qualities of the place could be used to further strengthen this dimension. A lawn would generally better afford the Prospect dimension than a forest garden in itself. However, from a distance a forest gardens could potentially aid in providing a pleasant "view" or "vista" that also are important aspects of this dimension (ibid). The potential of edible forest gardens to support various social affordances in urban areas, especially when implemented as community gardens, have already been pointed out above and will not be further discussed here. What may be important to highlight here though is the conflict that has been observed in empirical studies between highly restorative qualities such as Serene and the Social dimension (see e.g., Pálsdóttir et al., 2017). This implies that a balance is needed between the support of social affordances and the potential for restorative qualities in the forest garden if the environment is to support such opposing needs. For instance, this could be done by making sure that social activities in the garden is not overly promoted and that time slots are reserved where the garden can be available for those in need of a more solitary experience.

How the Perceived Qualities of Edible Forest Gardens May Support Restorative Processes

Pálsdóttir et al. (2017) investigated the potential of a forest garden environment to support the rehabilitation process of individuals with stress-related mental disorders. Participants described how the "natural appearance" of the forest garden environment appealed to them and was perceived as "calming and safe." Participants described how they felt that "nature was strongly present" in the forest garden, that "they could think without effort" and find a "way back to peace and quiet" (ibid). Other participants in this study mentioned the restfulness of the "overgrown and wild-like nature." The forest garden environment was described as embedded in "lush vegetation" and participants mentioned how the wild attributes of the forest garden provided opportunities for "undemanding and restful" experiences. Some participants also mentioned regaining a feeling of "natural origin" and a strong "belonging to a greater whole" (ibid.). Participants in the study shared how they, in the forest garden environment, could "closely interact with nature" and "dared to expose their deepest feelings and thoughts." The "smell of grass," "the taste of berries," the "sounds of the wind" and "bird twitter and songs" were other experiences mentioned. In the winter participants reported seeing tracks from animals in the snow, giving an indication that restorative processes may be supported during all seasons. The forest garden environment also allowed participants to "hide and find a nice, sheltered place" and "move around without being heard or seen." Some participants "walked slowly or strolled around" in the forest garden, while others "just sat somewhere and enjoyed the surroundings" (ibid). Stigsdotter et al. (2017b) conclude that spatial aspects are important in order for environments to support restorative processes. Environments with a "natural and wild appearance," "diverse vegetation," and a "balance between enclosed, dense growth and open views" were found to be generally preferred in this regard. The dense growth should have "the appearance of a den and offer experiences of privacy" (ibid.). These are all descriptions that would suit the typical, mature forest garden well.

SUMMARY AND CONCLUSION

We have highlighted several factors that present edible forest gardens based on agroecological principles as an interesting model to explore in order to achieve efficient multiple-use of urban green spaces. We have pointed to the potential of several ecological benefits from such a design and management strategy, not the least in terms of increased urban biodiversity, which could be achieved while simultaneously increasing affordances and perceived qualities important for human health and wellbeing. The global prevalence for diseases highly linked with lifestyle and living environment, in turn affected by increasing urbanization, stresses the importance of supporting such affordances in people's close living environment. Not the least opportunities to restore from stress and attention fatigue seems important, but also possibilities to shape an increased sense of connectedness to nature and to processes of food production. This could also encourage pro-environmental behaviors that could further benefit long-term public health and wellbeing and mitigate ecological challenges. The importance of accessibility, not the least expressed in terms of physical proximity, for the perception and utilization of such green space affordances highlights the need to place edible forest gardens in public green spaces, at street level, close to dwellings and accessible for all. The general potential of green space affordances to mitigate socioeconomic differences in health and wellbeing can make edible forest gardens extra interesting to implement in socioeconomically challenged areas. Further research is encouraged in order to establish a deeper understanding for how affordances and qualities of salutogenic importance may be supported through urban green spaces and infrastructures. The potential of edible forest gardens in urban areas to contribute to biodiversity through the creation of new habitats, i.e., to also support affordances of importance for species other than humans may also be interesting to further investigate.

AUTHOR CONTRIBUTIONS

JS conceived to original idea for the paper and took responsibility for the overall structure and writing of the final manuscript. CS provided expertise and knowledge about urban sustainability, gardening, and edible forest gardens.

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Social-Cultural Processes and Urban Affordances for Healthy and Sustainable Food Consumption

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In this paper, we provide an overview of research highlighting the relation between cultural processes, social norms, and food choices, discussing the implication of these findings for the promotion of more sustainable lifestyles. Our aim is to outline how environmental psychological research on urban affordances, through the specific concepts of restorative environments and walkability, could complement these findings to better understand human health, wellbeing and quality of life. We highlight how social norms and cultural processes are linked to food choices, and we discuss the possible health-related outcomes of cultural differences in food practices as well as their relation to acculturation and globalization processes. We also discuss the concepts of restorative environments and walkability as positive urban affordances, their relation to human wellbeing, and the possible link with cultural processes and sustainable lifestyles. Finally, we outline issues for future research and areas for policy-making and interventions on the links between cultural processes, healthy and sustainable food consumption and urban affordances, for the pursuit of public health, wellbeing and environmental sustainability.

Keywords: social norms, food consumption, cultural processes, sustainability, wellbeing, restorative environments, walkability, urban affordances

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INTRODUCTION

The multi-cultural reality created by the worldwide phenomena of globalization, immigration, mass media communication and global social networking points to the need of deeply understanding the cultural and sub-cultural realities to comprehend individual behavioral change within any given country (Shweder and Sullivan, 1993; Stokols, 2018). The growing importance of the migratory phenomenon on the global level (for statistical facts on this issue see United Nations, 2017) over the last decades and the related social, political, economic and educational implications (see for example Pirchio et al., 2015, 2017a,b, 2018; Passiatore et al., 2017 for a discussion of these issues in the field of multicultural education and language learning) suggests also the relevance of ethnic identities in modern societies for understanding sustainable lifestyle change. Among the cultural dimensions connected to ethnicity, food preferences, preparation methods, and consumption choices have a central role, with relevant implications in terms of social and environmental sustainability. Research in anthropology has shown that food is a key expression of human cultures and subcultures. Far from being only a means of survival, the relation between human beings and food in modern societies has rather to be considered for its symbolic value, connected to the development of the individual, social and collective self (Cleveland et al., 2009).

In this paper, we discuss the issue of cultural processes in food consumption, its implication for human wellbeing and environmental sustainability, and its relations to two distinct features of urban affordances, namely restorative environments and walkability. The cultural dimension of urban affordances, walkability and restorative environments could be an interesting concept for bridging together different theoretical approaches and historic roots in environmental psychology. While the notion of affordances can be traced back to Gibson's (2014) ecological approach to perception (see also Heft, 2010), restorative environments have typically been studied in relation to cognitive processes and human health (e.g., Ulrich, 1983; Kaplan and Kaplan, 1989; Hartig, 2004) or social psychology (e.g., Staats and Hartig, 2004). Interestingly, the links between cultural processes and affordances have been previously investigated in studies on child development (e.g., Kyttä, 2002, 2004), and place-based pedagogies has also been used to engage refugee students re-settling in Australia (e.g., Comber and Nixon, 2013).

SOCIAL INFLUENCE AND CULTURAL NORMS IN FOOD CONSUMPTION AND DIETARY CHOICES

Food choices and dietary patterns (e.g., food preferences, preparation methods, consumption) represent a central aspect at the basis of human social and cultural diversity (Fischler, 1988). These ideas have long been in the focus of classical anthropological research on food habits and eating preferences (e.g., Harris, 1998). Many other scholars have highlighted in a similar way the role of food preparation and consumption for the development of social identity, among people with an immigrant background or other minority groups, and the implications of this for cultural adaptation processes (e.g., Oswald, 1999; Gvion, 2009). Indeed, for many human societies and groups in a condition of immigration, food preparation and consumption often constitute a way for complementing traditional elements inherited from the home country with new ones derived from the host society. A review of the literature in this field, which we discuss in this section, taking into account the social, health and economic implications, allowed us to outline the following main aspects:

- variations in intake patterns and food practices occur across different ethnic groups, and are subject to mutual influence (e.g., Rozin et al., 1999);
- (un)healthy and (un)sustainable intake patterns and food practices can be typical of different ethnic groups, but they also could be challenged through educational programs, cultural transitions, lifestyle change public policies, and urban planning interventions (e.g., Gittelsohn and Vastine, 2003).

An opportunity to observe the cultural categorization process as it applies to food emerges from looking at how eating and dieting patterns develop and change in multicultural environments. This aspect is relevant for health promotion, although traditionally the objective content of nutrients in food, rather than attitudes toward food and food-related lifestyles, has been prioritized for understanding health issues and longevity. The phenomenon known as the "French Paradox" offers a pertinent example of this issue (Renaud and de Lorgeril, 1992). The French paradox identifies the weak link between saturated fat intake and the incidence of heart disease recorded by epidemiological studies in the French population compared to other populations (American or Japanese, for instance). A cultural perspective may then shed light to better understand the clinical facts, as it allows one to identify differences across countries that are likely to account for the paradox (e.g., Ferrières, 2004). In fact, the answers to the paradox should be mostly searched for in objective and subjective protective factors such as cultural norms, values and lifestyles, stressful versus enjoyable experience of food intake, levels of physical activity in the population, rather than looking at possible causes in genetics (Rozin et al., 1999). Therefore, the consideration of the social resources and constraints in defining dietary choices leads to a definition of health that corresponds not only to the absence of illness, but as part of a process involving the social, economic and environmental systems. In this perspective, health cannot be conceived without social and environmental sustainability (Kjærgård et al., 2014).

But what happens when different sets of cultural norms and identities meet in the same individual? Studies focusing on the experience of migrant people describe the changes in dietary habits and lifestyle associated to migration, and how this affects health status. Generally, it has been shown that migrants adopt the dietary patterns of the host country as part of their acculturation process. Acculturation is usually defined as a socio-psychological process of adaptation to a new cultural milieu, which is mediated by social, demographic and economic factors (such as gender, education or income) and by the development of individual lifestyles (Berry and Sam, 1997). While acculturation theoretically implies changes either in the individuals belonging to the minority group and in the host culture, nevertheless most of the literature focuses on the migrants' changes due to the adaptation to their new country (Rogler et al., 1991).

Usually, members of specific ethnic groups in a given society experience complex patterns of adaptation, based on the interplay between the acquisition of specific skills to function within a host culture and the conservation of features related to the home-country cultures. Sometimes a change in dietary pattern toward the adoption of the host country habits may be detrimental for migrants' health when the home country's lifestyle is healthier than the new country's one (e.g., Cardoso et al., 1997; Anderson et al., 2005). Sometimes, on the contrary, the adoption of the new country's lifestyle is accompanied by the maintenance of traditional eating habits, especially at the beginning of the acculturation process, or in conditions where the exposure to the home country cultural norms is assured. The increase in processed and fat food consumption, and the consequent increase in body weight and related diseases as hypertension, diabetes and cardiovascular disorders, is also a common outcome of the societal transformation from a rural and traditional culture to the

contemporary urban industrialized culture. This is the case, for example, of many sub-Saharan African countries (e.g., Walker, 1964; Holdsworth et al., 2004).

Works reviewed so far thus suggest that in many situations of cultural change and migration, preserving and improving food traditions from the home country and supporting a lifestyle that includes sufficient physical activity should be considered as a fundamental goal for health promotion programs and education interventions (e.g., Méjean et al., 2009; Satia, 2010; Popovic-Lipovac and Strasser, 2015).

The aspect here discussed not only interact with health promotion in food consumption but may also play a role in sustainable lifestyles. Health and sustainability are with no doubt linked in the field of food production and consumption (Johnston et al., 2014), but this link often fails to be translated in a fully integrative perspective while developing local or global policies. This dual perspective would imply that both health and sustainability should be considered as important issues by policymakers and other relevant stakeholders. Prevention authorities might thus want to keep both of them in mind when planning and implementing policies and developing strategies in the public health domain: without such a perspective, the likelihood and risks of negative social, environmental or health consequences may increase (Kjærgård et al., 2014). In fact, environmental, social and economic features of life contexts (e.g., the unconditional availability of food, in particular in the form of fast, high-sugar, and high-fat and fast foods) may lead to individual behaviors, such as uncontrolled or impulsive consumption, which are, in turn, detrimental not only for the individual health (e.g., obesity and its many comorbidities) but also affect economic and environmental sustainability, as stated by major intergovernmental bodies (e.g., Gonzalez Fischer and Garnett, 2016; see also Drewnowski, 2014). The unnecessary overproduction or waste of food, to meet unnecessary overconsumption demands in affluent societies, contributes in fact to the depletion of the planet's resources, such as the soil, air and fossil fuels, and negatively impacts on the wellbeing of current and future generations (Reisch and Gwozdz, 2011).

CULTURE, DIETARY PATTERNS AND SUSTAINABILITY

A major trend in (un)healthy and (un)sustainable food consumption and production seems to be occurring at the global level, across different cultural contexts (see[1] for a more detailed discussion and global trends on this issue). The food production and consumption systems have serious and intertwined implications for both public health and environmental quality, worldwide. For example, livestock food production is a substantial source of greenhouse -gas emissions and a source of some essential nutrients, but at the same time meat provides large amounts of saturated fat, which is a known risk factor for cardiovascular disease (e.g., Garnett, 2009). In particular, issues that have been identified as crucial for understanding the relation among food choices, cultural processes and sustainability refer to factors such as the public health benefits of greenhouse gas reduction policies in the domain of food habits and consumption (e.g., Friel et al., 2009), to the adaption of food systems and food security in relation to global environmental changes (e.g., Ericksen, 2008), and to the links between globalization, dietary patterns and nutrition transitions in different areas of the world (particularly middle-income countries; e.g., Hawkes, 2006).

Higher intake of fruits and vegetables is usually associated with many health benefits, such as decreased risk of diabetes and metabolic syndromes, heart disease, and cancer, and is at the same time associated with a lower carbon footprint. Thus, dietary shifts away from meat and dairy products are recommendable for both public health and environmental reasons (e.g., Friel et al., 2009; Garnett, 2011). In this perspective, many studies analyzed the role of ethnicity in shaping food choices and consumption in western societies, by referring to the already mentioned process of acculturation. In fact, the analysis of the migrants' changes in food consumption may clarify the factors and variables fostering and limiting healthy and sustainable lifestyles. Studies that investigated the food intake patterns of groups with Hispanic origins, living in United States or Canada (e.g., Bermudez et al., 2000) seem to suggest for example that the acculturation process might be associated with lower fiber-rich food and higher added-sugar food intake. The transition to more North American dietary styles is often driven by the difficulty of finding food products from the original cultures, as well as fresh fruit and vegetables (Satia et al., 2000). Major barriers to healthy food choices among immigrant groups in North America seem thus to be related to the high cost of fruit and vegetables, to the lower energy supply and higher preparation time required for eating fruit and vegetables, and to the negative impact of mass media advertising; it is harder to see fruit and vegetables than unhealthy food in TV ads in TV (e.g., Klepp et al., 2007), but might also be linked to specific spatial features of everyday living environments.

Indeed, cultural or country differences might not fully account for the variations in diet styles, food intake and health outcomes that many studies outline. In fact, centrally to the purpose of this paper, we propose that affordances from the physical environment could also be a relevant factor deserving systematic investigation in order to understand food consumption and the related health outcomes across different cultures and subcultures in contemporary cities. We argue here that features and affordances of the physical context, such as for example the presence of opportunities for psychological restoration in natural settings in the city (e.g., Hartig, 2004), or the supportiveness of outdoor environments (e.g., Curl et al., 2016), could also play a relevant role in shaping our habits in relation to food consumption or other health-related habits. Likewise, it has been suggested that a specific feature like walkability could be related to human health and wellbeing in present-day urban settings, also through increased physical activity (e.g., Brown et al., 2013; Van Cauwenberg et al.,

[1] https://www.glopan.org/

2016). We argue that walkability and physical activity could also be influential, by working in synergy with restorative environments, and help the transition toward healthier and more sustainable lifestyles (e.g., Rioux et al., 2016). For example, we could speculate that urban planning solutions that afford walking and promote nature-based outdoor activities could also have a positive impact on promoting social inclusion and intergroup contact, thus reducing interpersonal distances across different cultural or ethnic groups (e.g., de Vries et al., 2013). Food lifestyle could also be beneficially impacted in this case, as healthier and more sustainable food purchases might also be more likely if adequately supported by positive urban affordances. Indeed, many quotidian settings, where individuals are actively present and intellectually engaged in evaluating their surroundings (e.g., Alves, 2014; see also Mercado-Doménech et al., 2017), could be assumed to have beneficial outcomes on human health and wellbeing, as shown in a recent study by Mastandrea et al. (2018) on the restorative effects after visions of figurative and abstract art paintings in art museums (see also Chirumbolo et al., 2014 and Mastandrea and Crano, 2018 for more detailed accounts on the social cognitive mechanisms of art preferences).

RESTORATIVE ENVIRONMENTS AND WALKABILITY AS URBAN AFFORDANCES FOR HEALTH PROMOTION AND MORE SUSTAINABLE FOOD CONSUMPTION

Restorative environments are usually referred to as those settings that promote, and not simply permit, the experience of the recovery of a general psychological condition of wellbeing, the reduction of stress, the recovery of direct attention, and the increase of positive emotions (Ulrich, 1983; Kaplan and Kaplan, 1989; Hartig, 2004; Berman et al., 2008). More recent works also suggests that experiencing restoration opportunities may also positively affect social relationships in adults, families, and children (e.g., Taylor et al., 2002; Guéguen and Stefan, 2014; Carrus et al., 2015a, 2017; Hipp et al., 2016; see also Korpela et al., 2018). The literature on this subject has shown how natural environments, such as for example urban parks, peri-urban green areas, or extra urban nature preserves generally possess a high restorative potential (e.g., Hartig et al., 2011; Carrus et al., 2015b).

But how can urban restorative environments, in particular green spaces in compact cities, be related to the issue of a more sustainable and healthier food choices and lifestyles? Speaking about affordances, a link between these two aspects can be established through the issue of walkability. The concept of walkability has been recenly proposed to identify those physical and social characteristics of life contexts that promote pedestrian mobility and thus induce greater exercise and physical activity (e.g., Saelens et al., 2003; Brown et al., 2007). Walkability seems to be a function of several environmental factors, both at a "macro" level (e.g., density and connectivity of the roads, proximity of services) and at a "micro" level (e.g., aesthetic pleasure of places, perceived security, presence of green areas and sidewalks). In general, different authors have suggested a clear link between the walkability of residential environments and public health and wellbeing (e.g., Saelens et al., 2003; Brown et al., 2007; Brown and Werner, 2012). Likewise, access to outdoor green space and the possibility of being physically active in the residentials setting are important predictors of quality of life in urban settings (see Pol et al., 2017). According to Brown and Werner (2012), walking is a specific kind of daily life everyday physical activity and an important component for the promotion of public health. These authors refer to walkability also as a tool for contrasting the so-called obesity epidemic of affluent industrialized human societies. A decreasing trend in the physical activity level is in fact characterizing the present unsustainable lifestyle of large strata of the western population, also because individualized dieting and exercise programs implemented within public health interventions have not always succeeded in reaching their targets (see for example Catenacci et al., 2009). Density, street connectivity and proximity to stores were identified by meta-analytical studies as macro-level predictors of walkability (e.g., Saelens and Handy, 2008; Ewing and Cervero, 2010), while neighborhood green spaces, neighborhood aesthetics, perceived safety and social support have been associated with walkability at a micro-level (Brown and Werner, 2012). Thus, we could assume that more walkable urban settings should also be more restorative, with positive consequences for human wellbeing (e.g., Sugiyama et al., 2009), although more research is needed around this issue. Most importantly, providing walking- friendly structures in contemporary urban settings can be a relatively easy and cost-effective way to promote physical activity and pedestrian mobility, and more in general to initiate processes of lifestyle change and stimulate transitions toward sustainability at an individual and community level. What can be the connections between urban affordances such as restorative environments and walkable paths, on the one hand, and a more healthier and more sustainable lifestyle in the domain of food consumption, on the other hand? An argument for such a link is offered by recent studies that have explored the possible associations between the availability of healthy food stores, neighborhood walkability and general health indexes at the population level. A work by Rundle et al. (2008), showed, for example, how access to BMI-healthy food stores is associated with lower BMI and a lower prevalence of obesity among adult residents of New York City, also controlling for neighborhood walkability. At the same time, other works have explored the link between walkability and restorative environments, showing how the presence of green spaces can increase walkability (e.g., Rioux et al., 2016), and suggesting how public open space with affordances for physical activity could be an important source for health promotion at the community level (e.g., Giles-Corti et al., 2005). Stimulating people to spend more time outside as well as being physically active and walking, could then be a tools for shifting toward more balanced, healthier, and more sustainable food consumption patterns. A systematic review on green space and obesity suggested indeed that green space could be a positive factor to tackle weight-related health problems, although evidence in this

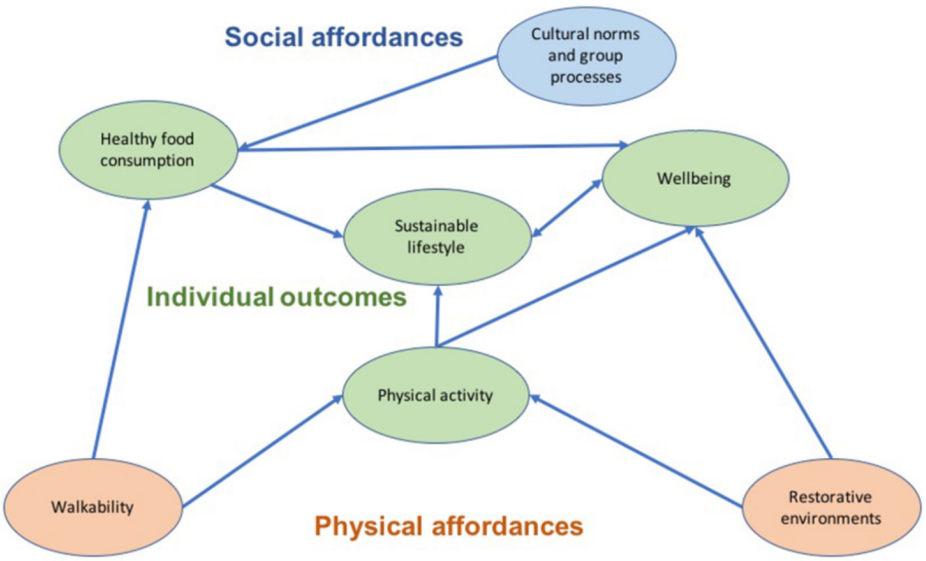

FIGURE 1 | A conceptual model.

field is not yet robust and abundant (Lachowycz and Jones, 2011). The presence of urban affordances, such as urban green spaces and walkable streets that increase the likelihood of exposure to healthy food stores, might be crucial in this sense (e.g., Paquet et al., 2017). A key mechanism could also be the possibility of experiencing psychological restoration in urban natural settings and a deeper sense of connectedness to nature, which seems to be associated with a better higher capacity of for self-regulation (e.g., Panno et al., 2017). We argue that this, in turn, could be associated with a more self-aware, healthier, more sustainable and environmentally aware food lifestyle (see also Fischer et al., 2017). This idea is consistent also with studies showing a more general association between mindfulness, relations to nature, environmental concern and sustainable lifestyles (e.g., Brown and Kasser, 2005; Fabjański and Brymer, 2017; Panno et al., 2018). The findings from a recent multi-national EU-funded research project (the GLAMURS project[2]), exploring the role of different sustainable initiatives (such as, for example, urban organic agricultural cooperatives), are also supporting this assumption (e.g., Frantzeskaki et al., 2016; Fischer et al., 2018).

CONCLUDING REMARKS

According to the literature we have briefly reviewed, the development of evidence-based policies in the domain of more sustainable food choices could be based on a combination of cultural and education interventions with urban planning management and transformation. Health and environmental issues connected to food consumption and lifestyle are a relevant phenomenon in the western industrialized Western world and a worrying trend in many developing countries. Furthermore, beside genetics, socioeconomic status and differential exposure to environmental features are key factors in overweight and cardiovascular disease risks. This makes it relevant to consider the cultural aspects of an individual life in order to design prevention programs and education interventions. The cultural values and representations attached to food and health should be the target of community interventions, aiming to improve people's healthy food choices and lifestyles, also through the provision of more restorative and walkable urban settings, to promote physical activity for individuals and communities. Different cultures might differ not only in the way food is produced, prepared and consumed, but also in the attitudes toward the relationship between food, health and pleasure, and in the ways through which food is acquired, prepared, processed and consumed in everyday physical spaces. People's choice to buy or not, and to eat or not a certain food, is necessarily implicating identity processes and signaling one's own stance in the social, political and ideological arenas, but it might also be related to features of the physical environment, such as those that afford more sustainable, mindful and self-aware consumption patterns. Within this context, social relationships in the symbolic and physical correlates of food consumption are also relevant. The individual access to the values, habits and places of her/his culture is allowed by the socialization processes that occur via the interpersonal relationships beginning at infancy. We learn what, when, how and where to eat by participating in the eating practices of our family, our community, and other social groups to which we belong, from which we acquire cultural norms and which teach us how to cope with the changes of norms and values. Positive social relationships could have a key role in the food production process too, as an important factor involved in the building of social capital, trust and social support, in order to facilitate small scale agricultural production and equitable markets in the contemporary industrialized metropolis as well as in poorer

[2]www.glamurs.eu

areas of the world (e.g., Lyon, 2000). In his brilliant and much widely cited psychological account of urban experience, Milgram (1970) identified cognitive and social overloads, accelerated pace of life and diminished social responsibility as distinctive and negative features of urban life. More recently, other authors have provided robust arguments suggesting how urban growth and size is associated with both higher socioeconomic productivity and wealth but also stronger inequalities (Bettencourt et al., 2007; Brelsford et al., 2017). Walkability and restoration opportunities might help to buffer the impact of such negative features, without affecting the positive aspects of increased urbanism. Therefore, one could expect that providing city dwellers with more walkable settings and better restoration opportunities, by positively impacting on citizen's wellbeing and social relations, could, in turn, promote the diffusion of healthier and more sustainable food consumption patterns, as they contribute to buffering the negative psychological outcomes of urban life.

Education programs and community interventions on food choices can thus be improved by acting on a multiplicity of factors, ranging from the individual level, to group processes and collective factors, to environmental affordances. Issues of culture, identity and relationships should thus be at the base of targeted communication and intervention programs to achieve desired future scenarios in food choices among the larger public in their everyday settings. Likewise, future research could better investigate the links between people's health and wellbeing in urban contexts and sustainable lifestyle change. It is indeed commonly assumed, as we have highlighted through the literature reviewed in this paper, that changing lifestyle in a more sustainable direction could have a positive impact on peoples' wellbeing, for example by eating healthier and more sustainable food. Likewise, empirical studies available to date suggest that promoting outdoor physical activity through more accessible urban green spaces or other nature-based solutions, or through designing more walkable cities and neighborhoods, could also help the promotion of sustainability and wellbeing. An overview of the conceptual relations among all these factors is provided in **Figure 1**.

In our model, we consider both walkability and restorative environments to be aspects of the physical environment that are likely to promote positive outcomes for the individual, such as more sustainable lifestyles and wellbeing. Based on existing empirical studies, physical activity could be a key mediating mechanism involved in these relations. In addition to that, we argue here that cultural norms and group processes could represent "social affordances" that might also drive an individual's pursuit of more sustainable lifestyles and wellbeing. A relevant mediating mechanism in this case could be identified in healthy food consumption. Some of the relations that we envisage in our conceptual model have been supported by previous empirical studies (e.g., the relation between restorative environments and wellbeing). However, empirical research is still needed to shed more light on all the relations depicted in **Figure 1**.

At the same time, future research could also aim to explore whether a reverse pattern is also likely to occur, i.e., increasing wellbeing in currently urbanized society might lead to more sustainable behavior and lifestyles. Some works on the concept of positive environmental psychology (e.g., Corral-Verdugo, 2012) suggest that this is indeed a plausible pattern, but more empirical research is needed on this issue.

In this paper we have provided arguments and reviewed previous empirical studies suggesting links between cultural norms and cultural processes such as migration and acculturation, healthy food consumption patterns, and sustainable lifestyles. Still, more research is needed on the links between cultural processes and positive urban environmental affordances. Since more studies on restorative environments have been conducted in western societies, it would be interesting to further investigate this issue through cross-cultural studies. In this domain, other interesting research questions could also be identified: for example, one might argue that walkable urban settings could be particularly restorative to migrants, as access to green space has been shown to be a powerful tool for tackling social inequalities (e.g., Mitchell and Popham, 2008). Cities can in fact promote sustainable development goals and economic growth but need to undertake the challenge of reducing social inequalities (e.g., Brelsford et al., 2017). Previous studies (e.g., Kyttä et al., 2016) suggest interesting differences in the relations between environmental features and wellbeing across central and peripheral urban settings. Therefore, a challenge for more inclusive urban planning would be to increase walkability, provide more restoration opportunities, and promote access to more healthy food in urban peripheries, where many migrant communities live.

AUTHOR CONTRIBUTIONS

GC and SP contributed equally to writing a first draft of the text and shared first authorship. SM revised and rewrote part of the text.

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