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Spatial Terms: The Acquisition of Multiple Referential and Syntactic Mappings

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The current study used a naturalistic, longitudinal design to investigate how children and parents use a set of early-acquired spatial terms (*up, down, in, out, on, off*). Measures included the frequency, referential contexts, syntactic frames, and referent-syntax pairings of these words from 14 to 30 months. Results showed that children's earliest use of these terms related to parents' referential use, but not to parent frequency of use. During the multi-word period, parent frequency of spatial term use was reflected in children's frequency of use. Further, children's most frequent referent-syntax pairings were predicted by these pairings in parents' speech. The current results indicate that children may initially use referential cues in the acquisition of these terms, and later become sensitive to the relative frequencies of referent-syntax pairings for individual lexical items. This study demonstrates how children use regularities across multiple sources of information in the input during acquisition.

Keywords: language acquisition, spatial language, input, reference, syntax

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REFERENTIAL AND SYNTACTIC USES

The present study concerns toddlers' acquisition of a set of spatial terms *(down, off, out, in, on, up)*. These six terms are among the earliest and most frequent spatial terms in children's naturalistic speech (Sinha et al., 1994; Smiley and Huttenlocher, 1995). The study of these terms offers a unique opportunity to examine the nature of children's early word meanings, as these words are used referentially and syntactically in multiple ways. In terms of reference, these terms encode multiple relations, including movements and static relational states. In terms of syntax, they belong to more than one linguistic category (e.g., prepositions, adverbials). In this paper, we investigate children's usage of these early spatial terms (from 14 to 30 months). We also examine the relation of children's acquisition of these terms to parent input during this period.

While we focus on spatial terms in the current paper, the results of the present study may be used to inform our understanding of the acquisition of other classes of words which encode multiple referential relations and appear in multiple syntactic structures. Furthermore, the acquisition of spatial terms should be of general interest to cognitive development, since children's initial uses of these types of words may provide a window into how children integrate spatial and linguistic knowledge (Ferrara et al., 2011; Pruden and Levine, 2017).

In the current study, we begin by considering what sources of information about words are available during acquisition, specifically frequency, syntax, and referential context. Further, we examine how these sources are reflected in children's emerging use of spatial terms over the one- to two-word stage of language development. Finally, we use prior cross-linguistic research to situate the current study within a larger debate on how non-linguistic and linguistic sources may relate to children's development of spatial terms.

Linguistic Sources of Input: Frequency and Syntax

Previous research has demonstrated that the frequency of parent speech is positively correlated with children's vocabulary growth (e.g., Hoff and Naigles, 2002; Rowe and Goldin-Meadow, 2009). Further, the probability that a child will know a given word is correlated with that word's frequency in parent speech (Vermeer, 2001). In a study of spatial term development, Internicola and Weist (2003) found that the more frequently a term was in the input, the earlier it was acquired. Pruden et al. (2011) found that parents' frequency and variability of spatial language predicted the frequency of children's use of these terms.

In addition to frequency, statistical regularities in syntactic input help infants locate words and word-boundaries as early as the first year of life (e.g., Aslin et al., 1999; Saffran and Wilson, 2003). Further, distributional input aids older toddlers in producing the syntactic frames (i.e., abstract phrasal patterns) of individual words (e.g., Naigles and Hoff-Ginsberg, 1998). In the child language acquisition literature, the term *syntactic frame* has been used to refer to a lexically-bound frame (e.g., the words and phrases that co-occur with the word *up*) (c.f. Naigles and Hoff-Ginsberg, 1998) and to also refer to an abstract syntactic structure in which many different words can appear (e.g., a noun phrase) (cf. Huttenlocher et al., 2010). For the present study, we look at the use of a given spatial term in its larger abstract phrasal pattern (e.g., *down* as a preposition). Regularities of word-and-frame are robust (e.g., Cartwright and Brent, 1997; Mintz et al., 2010), and the presence of these syntactic frames has been shown to further aid in tasks which do not require children's verbal responses, such as in picture identification (e.g., Fernald and Hurtado, 2006; Kedar et al., 2006). Lexical classes may be acquired on the basis of their distribution in syntactic frames (e.g., Landau and Gleitman, 1985; Gleitman, 1990; Landau and Stecker, 1990; Lederer et al., 1995; Naigles and Hoff-Ginsberg, 1995). The diversity of syntactic frames in the input further predicts the diversity of frames used by children (e.g., Naigles and Hoff-Ginsberg, 1998; Huttenlocher et al., 2010).

There is a growing body of research demonstrating that children first acquire syntactic frames for individual words (e.g., *throw, eat*), and only later generalize this information to word classes (e.g., transitive verbs) (e.g., Pine and Lieven, 1993; Rowland and Pine, 2000; Tomasello, 2000). Thus, Lieven et al. (1997) and Braine (1976) suggest that children under 3 years of age initially use limited syntactic patterns that are grounded in specific lexical items, as seen in the fact that young children are reluctant to use a verb in a syntactic frame that has not been heard in conjunction with that particular verb in the input (Akhtar and Tomasello, 1997). While other researchers have proposed an alternative explanation (c.f., Fisher, 2002), the research above suggests that children may make use of the distributional information in syntactic input when acquiring novel words, and their production may reflect syntactic patterns characteristic of particular terms in the input.

Reference via Extralinguistic Context

Though word frequency and syntax are important linguistic cues, non-linguistic cues in the referential context may play a facilitative role in children's language learning. Children's development of spatial concepts may be rooted in their understanding of these cues. Some of these relations (e.g., containment) may be represented universally, be easily accessible perceptually (Clark, 1973; Göksun et al., 2017) or be simpler referentially (Johnston and Slobin, 1979). We see these relations reflected in children's earliest categorizations of these events across languages (e.g., Sinha et al., 1994; Casasola and Cohen, 2002). Further, the child's experience within their environment, in terms of personal and conventional object relations, may also shape relational concepts (Grieve et al., 1977; Coventry, 1999; Rohlfing, 2006, 2011). Thiel (1985) refers to *landmark objects* which are often paired with typical relations. Tables, for example, may be more likely to be used with *on* relations as opposed to cups or bowls which are used with *in* types of relations. Further, according to van Geert (1985), children's referential experiences with spatial terms (e.g., learning *on* with respect to clothing or *up* with respect to being picked up) will help form the early basis for the child's meaning of the terms (Huttenlocher et al., 1983). As spatial terms can occur in multiple extralinguistic contexts, comparing across these contexts can tell us whether certain types of these cues may facilitate acquisition over others (e.g., Smiley and Huttenlocher, 1995).

Integration of Referential and Linguistic Cues

In the current study, we examine referential and linguistic cues in the input for children's development of early spatial terms. We also examine patterns in which referential and linguistic cues co-occur. Since spatial terms have multiple referents and syntactic frames, it is likely that children will encounter these words used in multiple referent-syntax combinations over time. Insofar as children are responsive to both referential and syntactic contexts during language acquisition, individual words in child speech might initially reflect the specific patterns in which a word appears in the input. Below, we review the literature about these referent-syntax combinations.

Children's Acquisition of Spatial Terms: Referential and Linguistic Knowledge

Naturalistic, longitudinal case studies provide a foundation for understanding how children may use both referential and linguistic cues over time. Tomasello (1987) studied one child from 17 to 23 months, looking at referential and syntactic use of the six spatial terms of interest to the current study. He found that the child's spatial terms initially referred to motion. Further, three of the terms (*down*, *on*, and *off)* were used in one-word utterances, whereas three others (*up*, *in* and *out)* initially appeared in multi-word utterances. Choi and Bowerman (1991) investigated the development of these six spatial terms in the speech of two girls from 14 through 24 months. They found that *up* and *down* were among first relational words, emerging between 12 and 14 months. They too found that early uses

predominantly referred to motions, for example, centering on the child's own body. By 20 months, when multi-word utterances and static references appeared, spatial terms continued to refer to motions and were used as adverbials, but the motion referents were more varied in nature.

Sinha et al. (1994) examined the speech of two English-speaking children from 18 to 40 months. As in other studies of these terms, they found that *down, off, out,* and *up* were used primarily to describe motion events. Smiley and Huttenlocher (1995) also traced the longitudinal development of reference and syntax in 10 children during the first word stage, examining what they termed *event words*. Four of these overlap with the present study (*up, down, off,* and *out)*. These words predominantly referred to motion rather than static spatial relations. When multi-word speech emerged, three of them, *down, off,* and *out*, continued to be used for motion and were mostly adverbials (e.g., *get down*), although they were also occasionally used as prepositions (e.g., *down the slide*). The remaining word, *up,* was used equally often as an adverbial and as a preposition. Initial uses of *up* were for motion. The pairings of reference and syntax varied for individual words, suggesting that these words have different frequencies in different referent-syntax pairings, but the issue has not been systematically studied.

The case studies reviewed above indicate that spatial terms emerge early and seem to encode motion before they encode state. However, none of the studies yet provide enough information to determine whether the spatial terms were initially used exclusively for motion or also refer to spatial relational states. Nor do they systematically examine the relation between referential and syntactic uses of these words over the course of development and their relation to caregiver input.

Crosslinguistic Acquisition

Crosslinguistic work on children's acquisition of spatial terms further examines the extent to which more general perceptual non-linguistic properties compared to language-specific linguistic structures may shape children's learning. Spatial relations may be expressed differently across languages, in terms of syntax, semantics, and morphology of locative particles (Sinha et al., 1994). If there is a more universal tendency for certain types of spatial relations to be mapped onto language, we would expect children to learn these relations before others which differ by how their language encodes these relations (van Geert, 1985; Bavin, 1990; Göksun et al., 2011).

In a study comparing Danish, English, and Japanese, Sinha et al. (1994) found that while the specific linguistic structure of the child's language impacted their strategies, there was evidence of general cognitive mechanisms also driving these strategies (see also Halpern et al., 1983). These strategies may change over development. Göksun et al. (2011) found that at 14 months, English and Japanese-exposed infants perceived dynamic events similarly; however, by 19 months, differences emerged by linguistic exposure. This finding supports the idea that over the second year, language exposure decreases sensitivities to categorical differences not encoded by the child's language (Pulverman et al., 2006; Göksun et al., 2017).

Previous research has shown that the acquisition of these terms is related to properties of referential contexts and linguistic patterns. Longitudinal case studies have further revealed the patterns in which children use these terms referentially and linguistically change over time. Finally, cross-linguistic studies have shown that patterns in the acquisition of these words may reflect the relative importance of various cues during acquisition. These studies have demonstrated children's reliance on these different cues may change over time. We build on these previous studies and situate the current research with respect to the larger theoretical discussion of how children's early meanings emerge. Namely, the present paper asks the following question: Is children's acquisition of spatial terms driven primarily by non-linguistic event processing or linguistic factors, or a combination of the two, and how is this shaped further over time?

The studies reviewed in the current paper suggest that children's earliest acquisition of spatial terms may be shaped by general perceptual non-linguistic factors, causing early use to initially appear similar across languages. However, with experience, the child's earliest meaning of a particular word undergoes modification (Bavin, 1990; Gentner and Bowerman, 2009; Göksun et al., 2011). Meanings may be further shaped by specific linguistic exposure and further cognitive and social development. This process is named the *concept-to-language* hypothesis by Gentner and Bowerman (2009). The current research uses this hypothesis as a theoretical basis with which to examine how both non-linguistic and linguistic elements of spatial input may shape children's acquisition of spatial terms.

THE PRESENT STUDY

The current study investigates the relation between contextual reference and syntactic structures by examining children's and caregivers' use of a set of early spatial terms. We present findings from a naturalistic, longitudinal study of the acquisition of spatial terms in 46 mother-infant dyads. We track the emergence of spatial terms during early language development (14–30 months), a period in which children go from one-word utterances to speaking in simple sentences. This period is further divided into two sub-periods, one-word speech (14–18 months) and multi-word speech (22–30 months). We focus on six spatial words (*up, down, in, out, on, off*) because of their high frequency in the language and their diverse uses in reference and in syntax (e.g., Tomasello, 1987; Smiley and Huttenlocher, 1995). We examine both referential and syntactic uses in child speech to determine how and when spatial terms emerge. For parent speech, we examine these factors as well as overall frequency at the first and last time point to assess children's exposure to these words. Finally, to examine the use of multiple cues, we examine the relation between parent and child speech over time with respect to the referent-syntax pairings of these terms.

MATERIALS AND METHODS

Participants

We examined longitudinal data from 46 monolingual English-speaking parent-child dyads of diverse socioeconomic backgrounds from the Chicago area. The sample was drawn from a larger longitudinal study of 64 families. We selected our subset of 46 families using the following criteria: (1) the parent was a

native speaker of English and English was the dominant language in the home, and (2) the same parent was filmed at all of the visits. This resulted in 46 families. All data in the current study came from dyads, which all included a mother and a single target child. There were 24 boys, and 22 girls. Twenty-seven children were first-born children. Families were of diverse educational backgrounds (14 parents did not have a bachelor's degree; 15 parents had a bachelor's degree; 17 parents had an advanced degree (e.g., a master's degree); income levels (13 families earned less than $35,000; 14 families earned $35,000–$74,999; and 19 families earned more than $75,000) and self-reported racial or ethnic backgrounds (9 families were African-American, 4 were Hispanic, 3 were of two or more races and 30 were Caucasian). This study was approved by the institutional review board of the sponsoring university. Written and verbal informed consent was obtained by all participants in this study prior to the procedure. Parents gave written and verbal informed consent for their own participation as well as for the participation of their children.

Procedure and Apparatus

The procedure for this study is outlined in previously published research (e.g., Pruden et al., 2011). Dyads were filmed interacting naturally for 90 min in their homes with a handheld digital video camera by a trained experimenter who shadowed but did not interact with the participants. Visits took place when a given child was most likely to be alert and content, which varied across dyads as well as within dyads over time. The dyads' activities during the sessions naturally varied, but typically included events such as playing in the living room or child's room or the child assisting the parents with household tasks (e.g., folding laundry). Other family members were occasionally present, but their speech and speech directed to them were excluded from analysis.

Speech Data

The data for this study come from transcribed 90-min naturalistic dyadic interactions, occurring during the child's 14th, 18th, 22nd, 26th, and 30th months. Child speech was analyzed at all observations, to track language acquisition from its earliest stages to multi-word speech. All child speech was transcribed, with the exception of unproductive, non-referential speech (e.g., non-sense babbling: *ba ba ba*). Parent speech was analyzed at the first and final observations, as an index of input at the one-word and multi-word stage. All parent speech addressed to the target child was transcribed, with the exception of parent imitation of non-sense babbling. Coding of the data involved first coding for referential use and second, analyzing each spatial term's surrounding syntactic frame.

Referential Coding and Analysis

At each observation, we examined children's uses of each target spatial term. For each use of a spatial term, there are a number of different aspects that could be investigated (e.g., whether the use was accompanied by an action and who performed that action). In the current study, to evaluate the role of different sources of information, we restricted our analyses to whether the speaker (parent or child) used the word to encode a spatial state or a motion by analyzing the videotaped interaction. Our definition of states compared to motions was conceptually similar to Göksun et al. (2011), in that static depictions preserve the spatial but not temporal (movement) aspects of events.

We excluded data pertaining to one of the following exhaustive conditions: (1) non-spatial formulaic uses (e.g., *quiet down*); (2) if the camera's view was temporarily occluded; (3) non-spontaneous, recited speech (e.g., songs, poems, prayers, or books); (4) if we were unable to identify the referent; and (5) incorrect uses of a spatial term (e.g., a child said "getting on here" while putting a teddy bear in a bathtub). These data were excluded from all subsequent referential and syntactic analyses described below. We divided spatial word uses into the following categories.

Motion Encoding

A spatial term was used to describe or request an action. For example, the child said "up" while engaging in the process of standing up. We included those actions that were unfulfilled (e.g., requests for actions not met; children's failed attempts to carry out a labeled action). For example, a child said "in" while attempting to put a toy in a container but failing to do so.

Stative Spatial Relations

A spatial term described a static, or stative, spatial relation. For example, a child said, "blanket on" while pointing at a blanket covering a doll. This category included uses in which the referent was not present, yet the intention to describe a stative spatial relation was apparent (e.g., a child points to a doghouse saying "doggy in there?" while the dog was not visible).

Linguistic Coding and Analysis

Prior to 22 months, children largely produced one-word utterances. Once the children began using these terms in multi-word speech, we analyzed the surrounding syntactic structure. For our linguistic analysis, we excluded all data that were also excluded from referential analysis. For multi-word utterances, we characterized the syntactic structures as follows.

Adverbials

A spatial term was treated as an adverbial if it modified the verb and did not form part of an idiom or a prepositional phrase. Adverbials trace the path of motion or describe the end state and often appear in sentence final position: *toss the ball up, put the bunny down.* This category thus includes both traditional adverbs and what are sometimes referred to as verb particles. We also treated as adverbials those uses of a spatial term where it immediately followed an NP and there was no other word in the utterance (e.g., *shoe in; my puppy out)* because those forms would be adverbials if the copula *be* or another verb were present.

Prepositions

A spatial term was coded as a preposition when it had a noun phrase as its syntactic object: *on the carpet, in the box.*

Idioms

We have chosen to treat idioms as their own category. Idioms develop wordlike properties in lexical memory, unlike literal versions (Burbules et al., 1988; Schraw et al., 1988). Lexicalization

occurs as the idiomatic phrase is associated with a specific meaning until it may function as a single word (Lakoff and Johnson, 1980; Schraw et al., 1988). Lexicalization may affect processing (e.g., Schraw et al., 1988).

English has several frequent idiomatic combinations of verbs and prepositions that are not productive in the same way as other parts of the language and that have semi-metaphorical meanings. For example, while it is possible to *hang up the phone* by hanging it up on the wall (an increasingly rare occurrence), it is equally possible to *hang up the phone* by pushing a button (a much more common experience). By allowing for these structures to be included, we captured the rare instances where they did refer to spatial relations while acknowledging that their meaning is often metaphorical in a way that *put the shoe on the box* is not. Further examples of phrasal verbs include *pick up, break in, blow up, back up, clean up*. For our coding, we first constructed a list of idioms by consulting lists of and criteria for idioms made available by Purdue University (https://owl.purdue.edu/owl/general_writing/mechanics/two_part_phrasal_verbs_idioms/index.html). Next, we excluded those idioms that did not include one of our target spatial terms (e.g., *blow over*). Lastly, we excluded those idioms that had nothing to do with spatial relations (e.g., *calm down*). We excluded from our analyses uses of spatial terms that did not fall into one of the above categories. These uses were exclusively those that: (1) were ungrammatical based on adult syntax (e.g., *the up*), (2) occurred in a fixed phrase with its semantic opposite: (e.g., *up and down),* and (3) uses of a spatial term where it formed a complex preposition (e.g., *up on the shelf, out of the box*). Summing categories (1), (2), and (3), these uses totaled 4.1% of children's multi-word uses and 3.8% of adults' uses. Uses that co-occurred only with an interjection were treated as single word utterances (e.g., *no up, ok down*).

Analyses

Throughout this paper we use binomial tests. Using binomials, rather than correlations, allows us to capture parent-child relations in terms of categories such as "most frequent pattern of use." This is important for our data because children frequently produced a given spatial term in only one referent-syntax pairing, resulting in proportions of 100%. For example, many children produced *down* exclusively as a motion adverbial. Parent uses of *down*, however, ranged from 50 to 100% motion adverbial. To analyze parent-child similarity in use of these spatial terms, we calculate the exact binomial test, given the assumption (null hypothesis) that child and caregiver usage patterns for each measure would be equally likely to match or not. Given the observed values we recorded, we test the null hypothesis.

Reliability was based on previously established protocols for these types of naturalistic, longitudinal studies (Huttenlocher et al., 2010; Pruden and Levine, 2017). The transcripts were initially coded in two stages. First, referential coding was conducted by a group of coders, guided by a researcher focusing on language and environmental cues. Second, a separate group of coders, having been trained by a syntactician, coded the transcripts for the syntactic structures described. For each time point, 10 of these completed transcripts were selected at random to be coded by additional blinded coders for reliability. For referential reliability, a trained research assistant independently assessed each spatial term's reference using the original video. The first and second research assistant agreed on 94% of transcript decisions for referential codes. For syntactic reliability, agreement was 97%. A third-party judge resolved any disagreements between coders.

RESULTS

The aim of the current study was to examine how spatial terms emerge in child speech, including both reference and syntax, and to investigate the relation of child use to parent use. We divided children's results into the one-word period (14–18 months) and the multi-word period (22–30 months). We made this separation since over 80% of children's spatial terms were in one-word utterances at 14 and 18 months [14 mo.: $M = 99.2\%$, $SD = 2.2\%$; 18 mo.: $M = 84.2\%$, $SD = 32.0\%$]. Starting at 22 months, roughly half of children's spatial terms were in multi-word utterances starting [22 mo.: $M = 47.2\%$, $SD = 39.4\%$; 26 mo.: $M = 80.5\%$, $SD = 32.1\%$; 30 mo.: $M = 86.4\%$, $SD = 23.3\%$]. For parent speech, we measured input from two corresponding periods: 14 months (one-word) and 30 months (multi-word).

One-Word Period

First, we examine spatial term uses during the one-word period for children (14 and 18 months) and parents (14 months). We examine the overall frequency of use of each spatial term along with the frequency of use with particular referential contexts (motion vs. state). We then determine whether there is a relation between parent speech and child production in the one-word period.

Frequency

Table 1 shows the frequency of use of each spatial term, and the distribution of each term's referential use. *Up* and *down* were the most frequent spatial terms in child speech, comprising over 80% of spatial term uses during this period. The contextual uses of these terms predominately referred to motions, for example, a child saying "down" while throwing a toy ring onto the floor. The other spatial terms also referred more often to motions at this stage, with the exception of *on*, which referred roughly equally to both motions and states.

Table 1 also shows parent use of spatial terms during the one-word period (parents' 14-month data). For parents, *in* and *on* were the most commonly used spatial terms. Like children, parents used spatial terms at 14 months more often to refer to motions than states. For example, a parent might have stated: "Mom will take it off for you" while detaching a toy from a playpen, or "Up!" while lifting a child into her arms. If overall frequency were the main factor driving acquisition, we would expect that the most frequent spatial terms in the input would be reflected by children's most frequent spatial terms as well as appear earlier in children's speech. However, this was not the pattern in our data. The most frequent spatial terms in parent speech, *in* and *on,* did not appear in our children's transcripts until 18 months (*in* was used by just one child at 14 months).

TABLE 1 | Child and parent use of spatial terms during the one-word period ordered from most to least frequent in child speech.

Spatial term	Children		Child uses (14 mo.+ 18 mo.)			Caregivers uses (14 mo.)		
	14 mo.	18 mo.	One-word uses	Multi-word uses	Motion (one-word + multi word)	One-word uses	Multi-word uses	Motion (one-word + multi word)
Up	6	14	71	2	92%	88	290	81
Down	4	13	65	1	92%	48	201	87
On	0	5	5	12	47%	2	386	61
Out	2	5	15	0	86%	3	152	73
Off	1	3	8	0	100%	1	86	98
In	0	1	0	3	67%	6	820	56
Total	8	20	164	18	87%	148	1935	68

Some children produced more than one spatial term and thus, the total number of children producing spatial terms at each time point reflects this fact. The proportion of motion uses in based on the sum of one-word and multi-word uses.

Further, *up* and *down* were the most frequent words in child speech, but not in adult speech.

Referential Context

We next tested whether children's contextual use of spatial terms would reflect the frequency of referent type (motion vs. state) used by their parents. During this one-word period, we limited our analyses to dyads where both parent and child produced a given spatial term. Binomial tests revealed that the tendency for parents and children to use the same principal referent type was significant for *down*, and *up* [*down*: $n = 11/13$, $p = 0.01$; *up:* $n = 12/16$, $p = 0.038$]. This was also true for other spatial terms, although the numbers are too small to analyze at this one-word stage. For example, for *out*, three of four dyads used the term to refer primarily to motion. Only one dyad produced *off*, and it was used primarily for motion. For *on*, one of 2 dyads primarily referred to motion. For *in*, only one dyad produced *in*, and both parent and child used it to refer primarily to motion.

During this one-word period, parents' referential uses of spatial terms were related to children's frequency of use of these terms. Spatial terms that predominantly referred to motion in adult speech (e.g., *up* and *down*) were frequently used by children during this early period, whereas those with the largest proportion of stative uses in parent speech (e.g., *in*) were infrequently used by children.

Parent One-Word vs. Multiword Speech

In earlier studies, parent syntactic frames have been shown to relate to children's word learning. Specifically, one-word input was suggested to be strongly related to child production during the one-word period because of the word's phonological prominence (c.f. Bernstein-Ratner, 1987). In our data, we explored whether frequency of use of certain spatial terms in one-word parent speech during utterances at 14 months was related to child speech at 14-18 months. For example, if a parent said *down* in a one-word utterance, we determined whether her child also produced *down*. Seventeen parents produced spatial terms in one-word utterances, and five of their children produced the same spatial term during the one-word period. This relation was not significant.

Turning to parent multi-word spatial term utterances during the one-word stage (14 months), all parents produced spatial terms in multi-word speech, and 20 of their children (at 14 and 18 months) produced the same spatial term, demonstrating that during the one-word period, child speech is related to parents' multi-word speech, $p < 0.001$. Furthermore, more children produced spatial terms that occurred in their parents' multi-word utterances ($n = 20/46$) than in their parents' one-word utterances ($n = 5/46$), $t_{(45)} = -4.67$, $p < 0.001$). Thus, the vast majority of spatial terms that children hear occur in parents' multi-word speech. We therefore consider the role of syntactic frames used by parents, in addition to other factors (e.g., referential context) in children's use of spatial terms during this period.

These results suggest that children's earliest uses of spatial terms were not determined simply by overall frequency in parent speech. Rather, they were related to referential uses, specifically, for motion, in both one-word and multi-word utterances. We consider two main explanations for these results: First, motion events may be perceived differently than labeling of static events; second, restriction of labeling to a single category of referential use (rather than two) may make those words easier to acquire. We examine these and alternative possibilities in the section Discussion.

Multi-Word Period

During the multi-word period, we looked at the frequency of use of each spatial term and the patterns of referent-syntax pairings for children (22, 26, and 30 months) and parents (30 months). We then determined whether there is a relation between parent input and child speech during this multi-word period. Finally, we investigated whether parent early use of spatial terms at 14 months is predictive of later child production at 30 months.

Frequency

Table 2 shows the frequency of spatial terms in both child and parent speech during the multi-word period. During the multi-word period, children used *in* and *on* most frequently, as did parents during this stage. In order to determine whether the overall frequency of spatial terms in the input was related to child production during the multi-word period, we examined whether

TABLE 2 | Frequency of spatial terms in parent and child speech during the multi-word period ordered from most to least frequent in child speech.

	Child frequency				Caregiver frequency
Spatial term	**Total**	**22 mo.**	**26 mo.**	**30 mo.**	**30 mo.**
In	648	87	284	277	636
On	451	60	203	188	551
Up	308	91	136	81	131
Down	201	26	97	78	212
Out	111	23	55	33	125
Off	107	16	39	52	54
Total	1826	303	814	709	1709

the most frequent spatial term in a given child's speech was also the most frequent in their parent's speech at 30 months. Twenty-seven of 40 dyads showed this pattern, which was significant, $p < 0.001$. Six children produced no spatial terms. In sum, although overall frequency of spatial terms in the input did not predict the first appearance of a given word during the one-word period, it was strongly related to child frequency at 30 months.

Referential Uses and Syntax Pairings

At 22 and 26 months, 26% of child multi-word uses described stative spatial relations (22 mo.: 79/303 uses, 26 mo.: 212/814 uses). By 30 months, roughly 40% of child multi-word uses referred to stative relations (30 mo.: 286/709 uses).

For each spatial term, we next examined the proportion of children's uses with different referent-syntax pairings (**Table 3**). Children's uses of individual spatial terms varied in terms of the frequency of particular referent-syntax pairings. Children most commonly used *down, off,* and *out* as adverbials referring to motion (similar to the one-word period) while they commonly used *in* and *on* in two ways: as a motion preposition and as a stative preposition. Lastly, children had four common uses for *up:* as a motion adverbial, a motion preposition, a stative preposition, and a motion idiom. It should be noted that the children did use *off, out, in, on,* and *up* in all of the possible frames.

In order to refine our analysis of the referent-syntax pairings, we separated spatial terms into those terms with a single most frequent type of referent-syntax pairing, those with two frequent types of pairings, and those with more than two. Because there was a one in six chance (17%) that a spatial term could be used with a particular reference-syntax pairing, a spatial term was considered to have one most frequent pairing if the most frequent pairing was at least 17 percentage points greater than the second-most used pairing. For example, children used *down* as a motion adverbial in 76% of uses whereas the next most frequent use as a stative adverb was 12%. Thus, *down* was considered to have one frequent form. A spatial term was considered to have two frequent pairings if the first and second most frequent uses were within 17 percentage points of each other but the second most frequent was at least 17 percentage points greater than the third most frequent. For example, children used *in* as a motion preposition 41% of the time and as a stative preposition 38% of the time. The third most frequent use of *in* is as a motion adverbial at 14%. Thus, *in* was considered to have two most frequent pairings. Lastly, a spatial term was considered to have many frequent pairings if the second and third most frequent pairings were within 17% of each other. For example, children used *up* as a motion adverbial in 36% of uses, as a motion preposition in 19% of uses, and as a stative preposition for 14% of uses. Any categories of referent-syntax pairings that were <10% of uses were considered infrequent.

In turning to caregiver speech, at 30 months, parents' most frequent referent-syntax pairings were highly similar to children's (**Table 3**). Parents used *down* and *out* as motion adverbials for over 60% of their uses. Parents also used *on* at 30 months roughly evenly as motion prepositions and stative prepositions much like their children, whereas *in* was used more frequently as a stative preposition. Lastly, at 30 months parents produced *up* most frequently as a motion adverbial, motion idiom and stative preposition. Caregivers produced *off, out, in,* and *up* in all possible referent-syntax pairings. Caregivers never used *down* or *in* as stative idioms.

Comparing parent speech at 14 and 30 months, we note that parent use of spatial terms was largely consistent with one notable exception: *off*. At 14 months, ∼71% of parent uses of *off* were motion adverbials, but by 30 months, this figure decreased to only 37%. There was also a slight shift in parents' use of *out, on, in,* and *up*. Parents' use of *out* as a stative adverb increased from 11 to 25% of all uses from 14 to 30 months. Caregivers produced fewer instances of *on* as a motion adverb at 30 months. Caregivers at 30 months used *in* slightly more as a stative preposition and slightly less as a motion preposition. At 14 months, parents used *up* frequently as a motion adverbial, a motion preposition, a motion idiom, or as a stative preposition. At 30 months, *up* was no longer used as frequently as a motion preposition.

In sum, for the multi-word period, we found that parents and children used certain spatial terms with certain referent-syntax pairings more frequently than others. *Down, off,* and *out* were typically used as motion adverbials; *in* and *on* were frequently used as motion prepositions and stative prepositions; lastly, *up* was used frequently as a motion adverbial, motion preposition, stative preposition, and motion idiom. There was a similarity between parent and child referent-syntax use, suggesting that children may be sensitive to these distributions in parent speech.

Caregiver-Child Speech During the Multi-Word Period: Referent-Syntax Pairings

We next determined whether children's acquisition of a given spatial term was related to the most frequent referent-syntax pairings in parent speech. Our six spatial terms differed in terms of frequent referent-syntax pairings: *down*, *off,* and *out* had one most frequent pairing (e.g., motion-adverbial); *in* had two primary referent-syntax pairings involving two referents but a single syntactic form (e.g., motion-preposition and stative-preposition); and *on* and *up* had several frequent pairings (e.g., motion-adverbial, stative-preposition, motion-preposition, and motion idiom).

The different distributions of referent-syntax pairings also allow us to address the hypothesis posed by previous research: is it more difficult for children to acquire words with stative referents

TABLE 3 | Caregiver and child spatial terms by referent-syntax pairing.

Spatial Term	Total uses	Referent-syntax pairing					
		Motion			State		
		Adverb	Preposition	Idiom	Adverb	Preposition	Idiom
ONE FREQUENT PAIRING							
Down							
Children (22–30 m)	308	76%	7%	0%	11%	6%	0%
Caregivers (14 m)	201	75%	9%	0%	7%	9%	0%
Caregivers (30 m)	131	71%	5%	1%	11%	13%	0%
Off							
Children (22–30 m)	107	61%	10%	17%	9%	2%	1%
Caregivers (14 m)	86	71%	12%	15%	1%	1%	0%
Caregivers (30 m)	54	37%	26%	24%	4%	7%	2%
Out							
Children (22–30m)	111	76%	5%	2%	14%	3%	1%
Caregivers (14 m)	152	64%	6%	2%	11%	16%	1%
Caregivers (30 m)	125	58%	6%	3%	25%	8%	1%
TWO FREQUENT PAIRINGS							
In							
Children (22–30m)	648	14%	41%	1%	6%	38%	0%
Caregivers (14 m)	820	14%	42%	0%	1%	43%	0%
Caregivers (30 m)	636	11%	33%	1%	2%	53%	0%
On							
Children (22–30m)	451	11%	44%	11%	6%	26%	2%
Caregivers (14 m)	386	20%	40%	2%	5%	32%	1%
Caregivers (30 m)	551	4%	42%	4%	2%	45%	4%
MORE THAN TWO FREQUENT PAIRINGS							
Up							
Children (22–30m)	201	36%	21%	19%	6%	14%	4%
Caregivers (14 m)	290	31%	12%	32%	5%	18%	2%
Caregivers (30 m)	212	32%	6%	37%	7%	14%	4%

or is it more difficult for children to acquire words with multiple frequent referent-syntax pairings? If stative referents are more difficult, then the relation to input should be weaker for words like *in* and *on* which are used often for states than for *down*, *off*, *out*, and *up* which are usually used for motion. However, if many frequent referent-syntax pairings were difficult to acquire, there would be a stronger relation for *down*, *off,* and *out* (with one frequent pairing) than for *in* and *on* (with two pairings), and even less of a relation for *up* (with four frequent pairings).

In order to test these hypotheses, we examined the speech of dyads where both parent and child produced a given word. In other words, we excluded those dyads in which parents produced a given spatial term while their children did not. For each spatial term, we investigated whether the child's distribution of use across the various possible pairings matched the distribution of use in parent speech. For *down*, *off,* and *out*, there was only one frequent pairing, thus we determined whether or not the child's most frequent use of a given spatial term was also the most frequent in parent speech. For *in*, *on,* and *up*, we ranked children's uses across the various referent-syntax pairings, from most to least frequent. We then ranked adults' uses. Next, we examined whether the pattern of distribution of use in child speech matched the pattern found in parent speech. That is, if a child used a spatial term with two most frequent pairings, we determined whether those pairings were also the parent's two most frequent forms. Lastly, we performed a less restrictive analysis to determine whether just one of child's frequent pairings was also one of the parent's.

Table 4 shows the results comparing parent and child referent-syntax pairings at 30 months. Dyads matched significantly in their most frequent referent-syntax pairings for *down* and *out* but not for *off*. Interestingly, there was a shift in the use of *off* in parent speech; their production of *off* as a motion adverbial decreased by almost half from 14 to 30 months. This decrease was significant [$t_{(45)} = 3.52$, $p < 0.001$]. At the same time, parent use of "*take off* [article of clothing]" increased to ∼23% of all uses [$t_{(45)} = -1.80$, $p < 0.10$]. These changes in parent speech may explain why so few dyads shared the same most frequent referent-syntax pairing at 30 months.

For both *in* and *on* (**Table 4**), children's two most frequent referent-syntax pairings were also their parents' two most frequent pairings, and this was highly significant: for *in* ($p < 0.001$) and for *on* ($p < 0.001$). For *in*, dyads also shared one of the most frequent referent-syntax pairings ($p < 0.001$). For *on*,

TABLE 4 | Most frequent referent-syntax pairings in parent and child speech.

		Child (30 m)—Caregiver (30 m)	Child (30 m)—Caregiver (14 m)
Spatial Term		**Same time point**	**Caregiver as predictor**
		# dyads	**# dyads**
One frequent pairing			
Down	Referent-syntax matches	15/22***	13/18***
Off	Referent-syntax matches	1/9	3/9
Out	Referent-syntax matches	9/15**	9/16**
Two frequent pairings			
In	2 of 2 matches	12/35***	10/34***
	1 of 2 matches	18/35***	20/34***
On	2 of 2 matches	13/35***	6/33+
	1 of 2 matches	13/35***	15/33***
More than two frequent pairings			
Up	4 of 4 matches	0/30	0/30
	3 of 4 matches	0/30	3/30
	2 of 4 matches	3/30	1/30
	1 of 4 matches	13/30	15/30

*$^{+}p < 0.10$; **$p < 0.01$; ***$p < 0.001$. "Matches" indicates dyads for which the most frequent referent-syntax pairing in caregiver speech was also the most frequent in child speech.*

the number of dyads sharing one of their most frequent forms was also significant ($p < 0.001$).

Lastly, for *up* (**Table 4**), no dyad had the same three or four categories ranked for frequency in the same order. Thirteen dyads shared one of the most frequent referent syntax pairings, yet this relation was not significant. Three dyads shared two frequent referent-syntax pairings, yet this relation was also not significant. This pattern of results suggests that the number of frequent referent-syntax pairings in parent speech may play a role in acquisition.

Predictive Relation of Parent Input to Child Production: Overall Frequency

To determine the relation of spatial term frequency in parent speech at 14 months to later child use, we investigated whether the most frequent spatial term in parent speech at 14 months predicted the most frequent spatial term in child speech at 30 months. That is, if a parent produced *up* more than the other spatial terms, we also determined whether or not his or her child produced *up* most frequently. This was true for 22 of 40 dyads, and this relation was significant, $p < 0.001$. Six children produced no spatial terms. This suggests that overall frequency in input predicted later child production.

Predictive Relation of Parent Input to Child Production: Referent-Syntax Pairings

We examined whether parent's use of spatial terms with different referent-syntax pairings at 14 months predicted children's referent-syntax pairings at 30 months (**Table 4**). For spatial terms with one frequent pairing, parents' earlier most frequent syntax-referent pairing was significantly related to later child production for *down* ($p < 0.001$) and *out* ($p < 0.05$), but not significantly related for *off*. For *in* and *on,* which have at least two frequent pairings, parents' two most frequent uses at 14 months predicted their children's two most frequent uses at 30 months (i.e., motion preposition and stative preposition) for *in* ($p < 0.001$) [for *on* ($p < 0.061$)]. Also for *in* and *on*, the number of dyads sharing one of the two most frequent referent-syntax pairing was significant for both terms ($p < 0.001$). Lastly for *up*, once again, no dyad had the same ranking across all four common uses (i.e., motion-adverbial, motion-preposition, motion-idiom, and stative preposition). Fifteen of thirty dyads shared one of the most frequent referent syntax pairings, one shared two pairings, and two shared three pairings. None of these relations were significant. Again, the relations between parent input and child speech were weakest for the term with the most pairings.

We hypothesized that if stative referents were more difficult to acquire than motion referents, one would expect only a weak parent/child relation for *in* and *on*, and a stronger relation for *up*. This was not the case: children and parents matched significantly in their use of *in* and *on* at 30 months. Moreover, parent use of *in* and *on* at 14 months was related to child production at 30 months. Uses with a stative referent did not seem to hinder children's acquisition of the most common uses. However, if child production were related to the number of frequent referent-syntax pairings in the input, then more pairings would be more difficult to acquire. Caregivers commonly produced *up* in four different referent-syntax pairings and no dyad shared all four rankings. Thus, even though *up* typically refers to motion, children and their parents did not match completely in their usage patterns. Hence, it may be the case that the number of pairings has an effect on child language.

To summarize our parent-child relation results, frequency in child speech at 30 months was generally related to overall frequency in parent speech at 30 months and 14 months. The most frequent referent-syntax pairings in child speech at 30 months were related to the most frequent referent-syntax pairings in parent speech at 30 months and at 14 months. There were no significant relations for *up*, which had many frequent referent-syntax pairings.

DISCUSSION

There were two main goals for the current study. First, we aimed to investigate the emergence of six spatial terms (*up, down, off, on, in, out*) and their referential and syntactic nature in children's productive vocabulary from 14 to 30 months of age. The second goal was to investigate whether parents' use of spatial terms was related to their child's acquisition of these terms. For referential use, the spatial terms were coded as referring to motions or states. For syntax, we coded the terms as being used as adverbs, prepositions, or idioms. We found that children acquired terms primarily in reference to motion earlier than states. However, once children began using these words in syntactic structures, their uses closely mirrored the most frequent referent-syntax

pairing used by their caregivers. These findings suggest a number of ways in which children's acquisition of spatial terms relates to caregiver use of these terms.

Of interest to the current study was whether overall frequency of spatial terms in parent input would relate to children's acquisition. Our results indicate that frequency is not the primary factor predicting children's initial acquisition of these terms. While overall frequency did not predict age of emergence, it did predict the frequency with which children later produced spatial terms. This is in line with previous research demonstrating that parent frequency may predict children's later acquisition of these terms (Smiley and Huttenlocher, 1995; Pruden et al., 2011).

The current data indicate that non-linguistic information may be more critical to early acquisition, aligning with previous research on the primary role of the referential context in children's acquisition of these types of terms (Clark, 1973; van Geert, 1985; Rohlfing, 2006; Göksun et al., 2017).

Previous research suggested that children's earliest one-word uses of spatial terms typically refer to motion rather than states (Choi and Bowerman, 1991; Sinha et al., 1994; Smiley and Huttenlocher, 1995). Stative uses may then emerge as the child comes to understand the relation between motion and state, notably that particular motions lead to particular outcome states (e.g., *down* as a motion that leads to a state of being *down*). Our data indicate that *down, off, out,* and *up* emerge at 14 months and are used primarily to describe motion. However, *in* and *on* emerge at 18 months and are used roughly equally as motions and states. Together, the current evidence suggests that reference to state may be acquired differently from reference to motion, a finding which reflects previous research by Göksun et al. (2011) that infants perceive static and movement events differently, and these differences are reflected in their use of spatial terms.

Further, we examined whether children's use of spatial terms in multiword speech would reflect distributional information in the syntactic input. Our results revealed a positive relation between parents' and children's syntactic usage patterns for individual words. This finding is compatible with approaches to language acquisition which suggest that words are tightly bound to their particular syntactic frames (e.g., Pine and Lieven, 1993; Rowland and Pine, 2000; Tomasello, 2000). In this view, syntax may emerge as particular to individual words and later extend to other lexical items and syntactic structures. Following this idea, we suggest that the acquisition of spatial terms may be similar to other lexical classes with multiple referential and syntactic uses: Initially, these words may emerge according to the most robust patterns in the input and later expand to encompass less frequent patterns. Consistent with our findings, many researchers have argued that children are able to use syntactic frames and the distribution of word types across frames to distinguish lexical classes (e.g., Landau and Gleitman, 1985; Gleitman, 1990; Lederer et al., 1995; Naigles and Hoff-Ginsberg, 1995). Other researchers have found that the diversity of syntactic frames is positively related to children's use of those frames (e.g., Naigles and Hoff-Ginsberg, 1998).

Our results support the idea that children, at least by the multi-word period, associate particular words with particular syntactic structures. While this interpretation is compatible with a constructivist learning perspective (e.g., Tomasello, 2000), it is also compatible with the Universal Grammar (UG) proposed under current syntactic theories such as *Minimalism* (Chomsky, 1995). Under *Minimalism*, syntactic features and syntactic structures are innately available to the child (Adger, 2003). However, each word in each language behaves slightly differently and hence, children's input determines how their UG associates a particular word with its proper syntactic structure (Adger, 2003). The current study reveals the importance to both perspectives in understanding how diverse sources of information in children's environment can trigger the association of words, meaning and syntax.

Finally, the current study was able to investigate how syntactic and referential cues may co-occur in the input. We examined whether individual spatial terms were used with certain referential and syntactic patterns in the input, and if so, whether children's acquisition would reflect these patterns over time. We found that these terms did occur with different frequencies in referent-syntax pairings. The data further suggest that during the early stages of acquisition, children's development of spatial terms is largely driven by the non-linguistic referential context, and after children first acquire these terms, their pattern of use then reflects adult linguistic patterns.

These current findings extend previous research and contribute to the larger theoretical discussion of how children learn spatial terms over time (van Geert, 1985; Bavin, 1990; Rohlfing, 2006, 2011; Gentner and Bowerman, 2009; Göksun et al., 2017). For example, the *concept-to-language* hypothesis (e.g., Gentner and Bowerman, 2009; Göksun et al., 2011) describes how spatial terms are initially used to encode motion, reflect concepts universal across languages and then later reflect linguistic distinctions of a particular language (Göksun et al., 2011). The current data support this hypothesis, suggesting that children's understanding is honed by exposure to different referential and linguistic contexts. This honing may occur as children experience mappings across multiple exemplars and revise their semantic categories to eventually develop full adult knowledge of these terms (Gentner and Loewenstein, 2002).

Though our data suggest that extralinguistic context may be more important in early acquisition, it is also possible that frequency of spatial terms may not be completely independent of the frequency of referential context. Our data show that how often a child is exposed to reference-syntax pairings is critical to learning, so frequency is indeed important. Children's usage may, however, reflect a more nuanced appreciation for how these words are used in context, both syntactically and referentially. Concurrent exposure to these types of different cues (e.g., syntax + referential context) may further enhance learning (Goldstein et al., 2010).

The *emergentist coalition model* of word learning (Hollich et al., 2000) extends the *concept-to-language* hypothesis to account for children's use of multiple sources of information at a given time as well as over development. In this model, multiple types of cues (e.g., social-pragmatic, linguistic, attentional) may be differently weighted and may interact dynamically over development, based on the child's linguistic, cognitive, and social abilities. Linguistic factors, for example, may initially be

more important very early in development (when infants attend to statistical distributional data), but less so while children develop social cognitive strategies to work out referential intent, then again more heavily weighted later as children begin to demonstrate syntactic development in multiword speech. However, at each stage of development, multiple cues are available and may be used. Future research based on the *emergentist coalition model* could examine the diversity of co-available linguistic and extralinguistic cues over a broader developmental timeline to further explain how children acquire these types of terms.

Limitations and Future Directions

The current results support growing evidence that the development of spatial terms as a class is more complex than previously understood (e.g., Pruden and Levine, 2017). As such, our present examination of spatial terms generates several lines of future inquiry. While the fully naturalistic nature of the current study allows access to parents' and children's spontaneous spatial term use, there are limitations. First, the age range of the present study ends before many other spatial terms are acquired. Thus, it is unknown how the syntactic and referential cues in the acquisition of these six spatial terms may relate to those acquired later (e.g., *above, between, beneath*). It may be the case that these words with their distinct referent-syntax pairings form the basis of the entire class, and later words' first uses are based on these pairings. Alternatively, later words may exhibit additional patterns of referent-syntax pairings that were not present in the current study. The age range of the current study may be expanded in future research to examine how these early words connect to spatial terms acquired later.

Further, parent speech was examined at 14 and 30 months. We did not predict that parent speech concerning our set of spatial terms would change significantly during this time. This was supported by our data, which revealed no significant differences in caregivers' speech between these time points with the exception of *off*. Previous research (e.g., Huttenlocher et al., 2010), however, has shown that while some aspects of input remain constant (e.g., word order and phrase structure), other aspects may change over time (e.g., richer, more abstract vocabulary, longer, more complex syntax). Though our current study did not motivate a further examination of parent speech, our findings may serve as groundwork for future research to more fully examine how parent-child speech aligns over an extended period of time.

The child's role in the acquisition process is another area for future research. Rather than the parent input shaping children's acquisition, children's use of spatial terms may have also influenced subsequent parent input referring to these terms. Supporting evidence comes from Rohlfing (2011) who found that parents' use of gesture with spatial terms was based on children's linguistic competence, suggesting a mutually directional relation between the extralinguistic cues children receive and the child's development. Children's motivational factors may also help explain early spatial term use (Huttenlocher et al., 1983). For example, requests for actions (e.g., up) may drive children's use of some of these terms. Finally, in the current study, we excluded children's errors from our analyses, yet these errors can offer clues to whether children rely on preexisting concepts or are actively constructing semantic categories early on (e.g., Bowerman and Choi, 2003). Exploring these possibilities may help us more fully understand the child's active role in the acquisition process.

While our variables of interest involved referential and syntactic cues, we did not conduct an exhaustive examination within these categories. There are several possible sources of input to examine in future research. For example, our findings reflect previous research highlighting the importance of referential context and social cues in early word learning (e.g., Carpenter et al., 1998; Marcus et al., 2000; Goldstein and Schwade, 2008). Infants are attuned to referential cues, such as gesture, and use them in word learning situations (e.g., Tomasello and Farrar, 1986; Baldwin, 1991; Shimpi and Huttenlocher, 2007). These cues help children attend to and categorize events or relations (Casasola, 2005; Göksun et al., 2017). Parent gesture has specifically been found to predict vocabulary (Rowe and Goldin-Meadow, 2009) as well as acquisition within word classes. Cartmill et al. (2010) found that parents' earlier use of gesture alongside spatial utterances (dimensional adjectives) predicted the number of spatial types their children produced, from 14 to 42 months. It is also possible that linguistic factors such as phonological salience may relate to a word's typical syntactic frame (e.g., adverbs occurring in utterance-final position), thus making it easier to parse out certain words from the speech stream. From the earliest stages of language development, children may be able to use information from multiple sources in acquisition, and future studies could expand our understanding of how children weight and use these various sources.

CONCLUSION

To examine the acquisition of a set of spatial terms with multiple contextual referents and syntactic structures, we tracked both the emergence of use in children's production as well as the patterns of use in parent input using a naturalistic, longitudinal design from 14 to 30 months. At the one-word stage, children's acquisition reflected the contextual referents (*motion* vs. *state*) used by parents. Parent frequency of use of these terms did not predict children's initial acquisition yet matched the frequency in children's multi-word speech. Further, in parent speech, certain spatial terms occurred more frequently in some contextual referent-syntax pairings and less in others, and children's use of spatial terms reflected parents' distribution of use of referent-syntax pairings. These results illustrate how combinations spanning multiple input sources, in this case syntactic and extralinguistic, may shape spatial term acquisition during early one-word and multiword speech.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Institutional Review Board at the University of Chicago 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 Institutional Review Board at the University of Chicago.

AUTHOR CONTRIBUTIONS

PS and HW contributed conception and design of the study, organized the databases for contextual and linguistic information, performed the statistical analysis, and wrote all drafts of the manuscript. Special thank you to Janellen Huttenlocher.

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