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Turning Eight Family Homes Into Interactive, Pervasive Playgrounds During the COVID-19 Pandemic Lockdown

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This paper presents an evaluation study of how eighth families adopted, played and experienced a movement-based game system of analog and digital technologies in their homes during a pandemic lockdown. The COVID-19 pandemic locked down many countries and grounded people in their homes with social and physical implications. A game system consisting of simple, tangible technologies with modular components was designed to meet these needs. The game system was developed for the players to set up in their homes easily and, therefore, should not depend on screens or extensive physical installations. The game system comprises simple, tangible technologies such as light and music cubes, a simple mobile robot, card game challenges, and a suite of mini-games combining the elements in a variety of playful experiences. Using the technology probes methodology, the game system was packed into a suitcase and evaluated by eight families that played the game in their homes, video-recorded their sessions, wrote a final report and were (informally) interviewed afterwards. The data set presents how the families turned their ordinary everyday spaces into interactive, pervasive playgrounds encouraging social and bodily exploration and play. Furthermore, the study shows how bodily movement and social play can be promoted through different technologies that stimulate various bodily senses and incorporate them through the different game and play structures into their everyday living environments. The findings resulted in four design implications to aid designers and researchers in future work on movement-based game systems and interactive, pervasive playground design. These design implications accommodate social and bodily activities in ordinary places otherwise not pre-allocated for play or game activities.

Keywords: bodily play, movement-based games, social play, game design, pervasive games, interactive playgrounds, COVID-19 pandemic

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INTRODUCTION

The design of movement-based games has increasingly attracted attention in the HCI community (Byrne, 2015; Isbister et al., 2016; Buruk and Özcan, 2018; Höök, 2018; Mueller et al., 2018; Matjeka, 2020; Tennent et al., 2020). Different motivations exist for designing such games: exercising purposes (Mueller and Young, 2017, 2018; Mueller et al., 2017; Matjeka and Svanas, 2018), to augment player engagement in computer games (Pasch et al., 2009; Bianchi-Berthouze, 2013) and to encourage joy and increase the amount of physical movement in our daily lives (Isbister et al., 2016; Segura et al., 2016). While movement-based games do not provide a solution to these problems, such games can provide a temporary frame for social and physical activities that permeate the boundaries of everyday life (Bateson, 1972; Caillois, 2001; Brown and Vaughan, 2009; Deterding, 2009; Stenros, 2012; DeKoven, 2013; Henricks, 2015; Huizinga, 2016) and thereby offer a different social and physical space in people's everyday lives (Eichberg, 2010, 2016; Møller, 2010; Deterding, 2017)[1].

During the COVID-19 lockdown in Copenhagen, people were isolated and bound to their homes. These circumstances posed an immediate threat to public health in the form of lessened physical activity, leading to many lifestyle diseases and less social activity with consequences for mental health, as stated by [World Health Organisation (WHO), 2020]. However, when the COVID-19 crisis hit the world, the development of a movement-based game provided a solution for promoting bodily movement while emphasizing social activities through bodily play and games designed to be played in people's homes. Furthermore, the qualities of promoting movement and social activities are also part of the inbodied interaction design area that focuses on these qualities in HCI design (Schraefel, 2019). As such, this study emphasizes a solution designed to make the players move (in little space), engage socially in new forms (play) and cogitate as the game challenges encourage not only physical movement but also the players' cognitive skills in solving unfamiliar challenges and the option to create their own games.

The ideal approach would be to intervene in people's own houses. However, due to the restrictions hindering researchers from entering homes and people leaving their homes, a technology probes approach was adopted (Hutchinson et al., 2003). Therefore, the game was boxed into a suitcase with manuals (see **Figure 1**) and a suite of five different minigames (**Appendix**) for people to play in their homes. The suitcases were delivered to eight families to play (in turn) in their homes during the lockdown.

This study focused on evaluating the game as a physical and social activity in people's everyday living environments (their homes), how the players adopted the system to their homes, and how the activities therein unfolded into bodily play experiences. There has been conducted (to our knowledge) few studies of adaptable interactive playgrounds and even fewer studies of how players play movement-based games in their homes. Thus, the results from this study can be valuable to designers and researchers interested in designing pervasive games systems for social and bodily play experiences.

Concretely, the following research questions were investigated:

RQ1: How did the players adopt the system to their homes?

RQ2: How do the activities unfold as bodily play activities—set out of the ordinary daily activities of the players' everyday living environment?

RQ3: What are the resulting game experiences as reported by the players?

RQ4: What can we learn about the design of the game system and its elements based on the answers to the above questions?

To answer these research questions, the families were asked to video-record their game sessions and, upon returning the game, to write a report answering a set of predefined questions. Furthermore, the informal conversations with the families when delivering and picking up the game provided additional data.

Methodologically, this study was conducted using a technology probes approach (Hutchinson et al., 2003) designed from the requirements mentioned above: adaptable to the players' homes while promoting bodily play and movement as a social activity, and then evaluated as such. For the design work, an experiential perspective to bodily movement, play and game activities (Merleau-Ponty and Lefort, 1968; Sheets-Johnstone, 1981, 2003, 2013, 2014; Gallagher and Zahavi, 2012; Zahavi, 2014) and a theoretical understanding of (interactive, pervasive) playgrounds as emerging spaces in which bodily and social play and game activities occur (Walther, 2011; Petersen, 2014; Sicart, 2014; Specht Petersen et al., 2018) was adopted. For the evaluation part of this study, the empirical data consisted of video recordings (Buur et al., 2000, 2010) with written reports and informal interviews (Holstein, 1995; Kvale, 2007; Lankoski and Bjork, 2015) and analyzed as qualitative data drawing on, e.g., ethnographic methods for (game) design (Rooksby et al., 2009), resulting in the discussion of four design implications leverageable for future designs.

The following section provides the theoretical background for the game design and previous research. The subsequent sections present the rationale behind the game system, the resulting game system, the research design, and findings, followed by a discussion of design implications, ending with a conclusion.

BACKGROUND

This section looks at related work on interactive playgrounds and pervasive games to learn from these experiences and inform our game design. Specifically, this section describes theories on bodily movement and social interaction and how they relate to bodily play and game experiences and theories on playgrounds.

As this study focus on both technical and theoretical issues as two intertwining aspects of digital game design, this understanding is reflected in the composition of the sections throughout the paper—including this section. Hence, this section starts by reviewing previous work in the field and moves on to explaining the theoretical grounding of this paper.

Pervasive Games and Interactive Playgrounds in HCI and Digital Game Design

As movement is naturally embedded in the gameplay of pervasive games and interactive playgrounds, they are often tied to digital solutions to health benefits promoting physical movement and exercise (Mattila and Väätänen, 2006; Sturm et al., 2008; Tetteroo et al., 2014; Valk et al., 2015; Delden et al., 2017). They

[1]Movement-based games (and interaction) are games designed to promote physical activity by emphasizing the players' physical movement in the design (Moen, 2005; Pasch et al., 2009; Mueller and Isbister, 2014).

FIGURE 1 | Elements; top left image: The moving robot, top middle: Restraint cards, top right: Laser lines, bottom left: Music Cubes, bottom right: Light cubes.

also utilized pervasive and ubiquitous computing, including smart toys (technology-enhanced toys) and augmented table-top games (Magerkurth et al., 2005) and smartphones (Bell et al., 2006; Benford et al., 2006; Drozd et al., 2006; Peitz et al., 2007) to accommodate play. While there are various definitions to pervasive games ranging from being explained by the technologies used (Björk et al., 2002; Magerkurth et al., 2005), to how these games differ from "traditional" computer games (Benford et al., 2005; Bell et al., 2006; Montola, 2009), there is less literature on interactive playgrounds. However, both terms are often described as bridging the digital and physical (Benford et al., 2005; Mattila and Väätänen, 2006; Tetteroo et al., 2014). The main difference between the two terms lies in that interactive playgrounds are often implemented by stationary technologies in large installations (Mattila and Väätänen, 2006; Delden et al., 2017; Specht Petersen et al., 2018), and thus define a specific space, while pervasive games utilize mobile and ubiquitous technologies and thus can be played anywhere, anytime (Benford et al., 2005, 2006; Magerkurth et al., 2005; Drozd et al., 2006; Peitz et al., 2007; Montola et al., 2009; Walther, 2011).

Montola et al. (2009) define pervasive games as the magic circle. Further, pervasive games expand the magic circle in up to three dimensions; spatial, temporal, and/or social. The magic circle, a much-debated term in game theory (Salen and Zimmerman, 2004; Rodriguez, 2006; Stenros, 2012), refers to the flexible boundary or invisible bubble emerging in play or game activities, allowing the players to make up the rules and define the activities as set out of the ordinary daily life.

Technology-supported games, coined by Waern, is a subcategory within pervasive games (Montola et al., 2009). Technology-supported games use technologies as part of the game world as a way to add "magic" and implement functions that "*superimpose the diegetic world on top of our everyday reality*" (Montola et al., 2009). In this regard, Delden et al. (2017) demonstrate how enticing—the use of non-functional rewards, e.g., aesthetic changes or additions, can promote physical movement and social interaction among children (Delden et al., 2017). Moreover, technology-supported games are not defined by the technology but are either supported or experientially enhanced by it, i.e., often technology-supported games can be adapted to a version without the technology (Montola et al., 2009). Both pervasive and technology-supported games are different from interactive playgrounds as interactive playgrounds are often situated in pre-allocated spaces. Moreover, such systems are often sustained (rather than supported) by the technology, i.e., dependent on calculations, state changes, and other measurements to function and progress.

Within the development of interactive playgrounds, Mattila and Väätänen (2006), designed the programmable playground Ubiplay, for which the players can design their own games to play in the digital environment. In the area of design, Tetteroo et al. (2014) investigate traditional children's play to create a design taxonomy as the basis for their (stationary) playground design, while Sturm et al. (2008) highlight a set of general key issues (social interaction, simplicity, challenge, goals and feedback) for the design of interactive playgrounds (Sturm et al., 2008). While these contributions bring valuable knowledge to the field of interactive playground design, they tend to focus on predetermined stationary installations requiring advanced equipment (that the players would not be able to handle on their own) and a pre-allocated physical space (Mattila and Väätänen, 2006; Sturm et al., 2008; Tetteroo et al., 2014; Delden et al., 2017). In contrast to these constraints, our game system emphasizes the quality of pervasiveness as the ability to adapt to different physical places and expand the magic circle in various ways, primarily spatial and social—instead of complex technology-sustained systems designed for a pre-allocated place.

Social and Emergent Play in HCI

Within studies of social play, Valk et al. (2015) demonstrate how social interaction is facilitated through three stages in open-ended environments—invitation, exploration, and immersion and how players transition between these stages throughout play (Valk et al., 2015). Mueller et al. (2017) present the idea of bodily interplay (the players' social interaction) as parallel and interdependent play. *Parallel play* is activities that could be played alone but are played as a shared session. In contrast, *interdependent play* is activities where the players rely on each other either by playing against each other or collaborating. In the context of pervasive games and interactive playgrounds, where interactive playgrounds tend to be bound to a physical location, the activities therein are naturally co-located and, thus, encourage social play in either parallel or interdependent form. However, as pervasive games have the inherent quality of expanding the magic circle, pervasive games "invite" any person (or animal) who accidentally appears physically within the magic circle into the activity. In other words, a pervasive game has the advantage of "accidentally" inviting outsiders into the activity because it expands spatially and socially, i.e., moves around, which the interactive playground does not—because of the pre-allocated space.

Furthermore, in this study of creating play spaces in spaces initially allocated for other purposes, the concept of emergent play is relevant. Emergent play refers to the kind of immediate play (Pichlmair et al., 2017) that emerges and develops from a situation—often in combination with the allocation or change in use of resources into the play activity that is initially intended for utility use—to use Suits (1978) understanding. Emergent play in HCI also refers to the appropriation or change of the technology to suit the play activity, as Desai et al. (2019) point out. Emergent play can be linked to coincident play (Wirman, 2021) that provides an analytical frame to distinguish play activities in urban spaces from non-play activities, as well as the concept of bodily play as bodily exploratory and experimenting without a set goal as described by Matjeka and Mueller (2020) in the following section.

Bodily Play Experiences

Bodily play experiences are rooted in bodily movement, and perception and our ability to navigate these. Sheets-Johnstone (1981, 2013, 2014) explains how play and bodily movement connect into kinetic joy rides, as the synergy of sequences of movements perceived as one experience. Furthermore, Sheets-Johnstone (1981, 2013, 2014) explains how the movement sequences are based on our movement repertoire as a repertoire of "I can's" [a term she borrows from Husserl (1982)] as our bodily abilities (Sheets-Johnstone, 1981, 2013, 2014). Bodily movement is our mother tongue, our first and universal language and primary way of understanding the world (Sheets-Johnstone, 2003; Sheets-Johnstone, 2007). Through our bodily understanding, we can understand and interact in the world, physically and socially, in what Merleau-Ponty (1968) introduced as inter-corporeality and further developed by other phenomenologists (Weiss, 1999; Moran, 2017).

Inter-corporeality seeks to explain how we, pre-reflectively, can bodily connect and behave with other people (Merleau-Ponty and Lefort, 1968; Whitehead, 2005, 2010; Gallagher and Zahavi, 2012). Recent phenomenological theories rely on the neuroscientific discovery of mirror neurons to explain this phenomenon (Gallagher and Zahavi, 2012; Moran, 2017). Mirror neurons are activated in the sensorimotor parts of the brain[2] when we experience action and emotions in ourselves and others and is in recent phenomenology linked to the human ability to feel empathy (Gallagher and Zahavi, 2012; Zahavi, 2014). Inter-corporeality is grounded in our corporeality (explained above as bodily movement and perception). Through a process with the mirror neurons, it enables us to bodily perceive and understand (pre-reflectively) the corporeality and bodily intentions of the 'other' (Gallagher and Zahavi, 2012; Zahavi, 2014) and thus move together, bodily relate to one another and also collaborate (pre-lingually) on a common bodily goal. Hence, the inbodied interaction's emphasis on *cogitate* as described by Schraefel (2019): "[pre-reflectively] *move from novel to familiar*."

In designing for bodily play experiences, Matjeka and Mueller (2020) unpack how playing a game, as conceived in the Danish language, entails two different attitudes with two corresponding game structures. The attitudes are (a) *lege* (being bodily playful), referring to play as an attitude dominated by exploration, experimentation and bodily perceptual stimulation without regard to a specific outcome, and (b) *spille* (being bodily "gameful"), which refers to the bodily stimulation caused by gaining results as either skill acquisition or tests of skills and bodily abilities. These two attitudes correspond to two different structures of a game, respectively: *en leg* (a "play")—which we know from open-ended play, and *et spil* (a game); a set structure with predefined rules and a clear and irreversible goal. Designing *en leg* is to design an open structure with no predetermined outcome for the players to continuously define and redefine by negotiating and collaborating throughout the activity. Designing *et spil* is to design a complete structure with a predefined outcome, not necessarily in the form of a winning condition, but as a determinant condition for the activity in either testing or developing bodily skills and achievements. To support this claim, Segura et al. (2013) concluded that the role of the chosen technology in a design for bodily play experiences (as co-located play) is a central design issue in how designers can use technology; as a "referee" of determining a winner, or as giving "broken" feedback, which the players can interpret more loosely. Having the technology as a "referee" will, in Matjeka and Mueller's (2020) view, be designing toward *et spil* (a goal-oriented activity), while emphasizing a design's "broken feedback" seems to be up for negotiation and interpretation by the players, hence designing toward *en leg* (exploration in an open structure). Matjeka and Mueller (2020) highlight how players have different foci for engaging in bodily play experiences and how designers

[2]Mirror neurons are also activated in other parts of the brain, i.e., Broca's area associated with language. For a fuller account, see, for example (Grèzes and Decety, 2001).

can facilitate such foci by incorporating both strategies (*et spil* and *en leg*) into the design. This division of and viewpoint on how play can unfold into different experiences is found similarly in work on playgrounds and pervasive games (Walther, 2011; Sicart, 2014).

Defining the Notion of an Interactive, Pervasive Playground

In his book, Play Matters, Sicart (2014) distinguishes between play spaces and game spaces in the chapter on playgrounds. He explains: "*A play space is a location specifically created to accommodate play but does not impose any particular type of play, set of activities, purpose or goal or reward structure*." He goes on to explain his take on game spaces: "*A game space is a space specifically designed for a game activity. The size, measure, props, and even location are all created with the purpose of staging games.*" Game scholar Walther (2011) provides a similar take on the differences between play spaces and game spaces. However, in particular regard to pervasive gaming in game spaces, the player moves according to fulfill a task to get a result, whereas, in a play space, the player moves to explore the space and discover new stories. Both descriptions of play and game spaces are comparable to the terms of bodily play vs. game proposed by Matjeka and Mueller (2020) above. Thus, we can say that the structure of *et spil* pertains to a game space as a designated space for an activity focused on achievements. In contrast, the structure of *en leg* pertains to a play space as an emergent space in which exploration and bodily stimulation are the dominating foci.

In line with these arguments, recent research investigating the design of playgrounds concerning play styles suggests that contrary to being one space, a (traditional) playground consists of several minor spaces. These minor spaces can be seen as an assembly of architectural elements, where each element constitutes its own space, e.g., a swing, a rollercoaster, climbing frame, etc. Like this, a playground can foster both play and game spaces, depending on whether the players *leger* (are being playful) or *spiller* (are being "gameful"). As such, we can say that a playground is a space constituted by minor play and/or game spaces fostering play and/or game activities fuelled by the elements present at the time. These elements can be designed for play (Petersen, 2014) as we know it from traditional playground designs, or players can allocate other available elements to fit the activities (Suits, 1978). Whether the elements are designed for play, like toys (Sicart, 2014), playground elements (Specht Petersen et al., 2018), or they are initially intended for other purposes, in play, elements shift roles and purposes as the activities progress (Suits, 1978). Therefore, we regard these as multi-stabilities (Ihde, 1999; Rosenberger and Verbeek, 2015).

Multi-stabilities is a theoretical concept from post-phenomenology referring to how the perception of technology can change depending on the context of use (Ihde, 1999; Rosenberger and Verbeek, 2015). In the area of play, Suits (1978) refers to how elements, which were initially intended for an instrumental activity, are allocated autotelic activities in playing (he uses the word resources, which also comprises, e.g., time). In this regard, anything can be allocated for play; an armchair can be perceived as a climbing frame or a brightness sensor in a sofa connected to a laser pointer on a bookshelf can be perceived as an alarm field to avoid while trying to move around it (see **Figure 2**).

To sum up: An interactive, pervasive playground is an assembly of allocated resources (i.e., multi-stabilities) that—alone or together—encourage and foster either game or play spaces—or both. While the choice of technology and design can support and enhance either type of space, these emerge from the players' attitudes of playing or gaming—as explained in the previous section.

DESIGNING A MOVEMENT-BASED GAME ADAPTABLE TO PEOPLE'S EVERYDAY LIVING ENVIRONMENTS

The final design originates in a Research through Design in HCI (RtD) process of exergames focusing on fall (Zimmerman and Forlizzi, 2014) prevention[3] for elderly people (65+). It emphasizes autonomous play-at-home interventions as part of the EXACT project. The game system initially targeted social play between elderly people and their grandchildren. However, as the circumstances of the COVID-19 crisis banned the assembly of elderly people and their grandchildren and evaluation of the system, the focus changed to target families and indoor social and physical playing. While there were no overall changes to the design and choice of technologies or the system, the adjustments were mainly in designing and formulating the minigames. These were the least developed part as they were deliberately kept as open structures to be adjusted and changed during a lab test. Furthermore, the focus was on packing a suitcase to contain all necessary equipment for the families to run the game sessions alone.

The design process went through a chain of considerations for the choice of technologies and to settle on a flexible structure in terms of size, range, and fitting to people's varying housing and furnishing. Furthermore, the technology had to be easily configurable for all ages to operate and set up the game. While movement-based games can have different foci, ranging from rehabilitation purposes (Skjaeret et al., 2015, 2016) to optimizing physical training (Endomondo LLC Under Armour, 2009), they are often not designed to be played at home by the entire family. This is either because they require assistance from a physician or physiotherapist (Tobaigy et al., 2018), or they are designed to be played outdoor (Benford et al., 2006; Endomondo LLC Under Armour, 2009; Alderman and Levene, 2012). However, the specific requirements for the design included that the game had to be autonomously playable by the players, adaptable to the various conditions of their homes, and at the same time promote physical and social activities.

One of the main requirements was for the game to promote physical activities that could be performed indoors and at the same time be sufficient to maintain physical health. For example,

[3]Falls due bad balance (decreased physical movement) have been determined as one of the main factors to elderly people's health decline (Sterk og Stodig, 2020).

FIGURE 2 | Two different set-ups: on the left; the light and music cubes involving the kitchen table, and to the right: the laser field involves the sofa in the living room.

keeping a light physical activity level for ~30 min (preferably) a day can be sufficient to maintain physical health [World Health Organisation (WHO), 2020]. Light physical activities are, e.g., going for a walk (not strolling), house cleaning, or bicycling to and from work (Sterk og Stodig, 2020). Moreover, the kind of movement in the activities should include movement diversity (Whitehead, 2005, 2010), e.g., stretching to the sides, moving up/down from the floor, and cross-coordination from one side to the other (Sterk og Stodig, 2020), basically doing movements that gently challenge our movement repertoire—our bodily abilities (Sheets-Johnstone, 2003). Besides training and maintaining the basic muscular and skeletal systems (Sterk og Stodig, 2020), these diverse movements[4] also stimulate the nervous system and, thus, essential brain training (Bushman, 2012). Thus, we chose to design for light physical activities and a significant degree of movement diversity.

As a family game (either of grandparents or parents and children), the final design facilitated multiplayer games from two or more players. Furthermore, to satisfy the different age groups and members in a family with children, the game had to facilitate play and game spaces by facilitating a wide variety of play forms (Matjeka and Mueller, 2020). The game had to encourage bodily exploration and experimentation and options for bodily achievements and improvements while also offering spatial flexibility and adaptation opportunities. Therefore, the choice was to design a technology-supported game system, taking advantage of such games' qualities. Furthermore, framing the design as a system of games and play qualities rather than one fixed game structure added options to accommodate the flexibility that the different indoor environments, age groups, and possible play and game preferences and situations required by facilitating different structures. This choice is further explained in the following section.

A PERVASIVE GAME SYSTEM IN A SUITCASE

The choice of designing a technology-supported game system and focusing on using pervasive, tangible technologies also helped to avoid the limitations of console games and interactive playgrounds (Mattila and Väätänen, 2006; Sturm et al., 2008; Delden et al., 2017). While these game forms promote physical and social activities in many instances, there are some limitations. For example, console games require accompanying controllers and a large screen with a designated physical space for movement in front of the screen. These requirements pose some immediate implications: The players are bound by the location and available space in front of the screen, implicating their physical movement possibilities; they have to face the screen to follow the game, a condition which limits physical movements like twisting and turning around, facing backwards, or moving up and down.

As indicated previously, designs of interactive playgrounds require advanced equipment like projectors and large screens (Mattila and Väätänen, 2006) and a physical place of a specific size for a stationary installation (Mattila and Väätänen, 2006; Tetteroo et al., 2014; Delden et al., 2017). On the other hand, pervasive games promote physical and social activities (Björk et al., 2002; Tobaigy et al., 2018) with renowned games like Pokémon Go (Wang, 2021) and Zombies, Run! (Alderman and Levene, 2012). While these games do not bind the players to a specific place in their homes, such games are based on GPS tracking not being suitable for indoor playing. Doing so was not possible nor recommended during a pandemic lockdown. Thus, the choice was to focus on technology-supported play with simple, pervasive, and tangible technologies with no screen, GPS, or demand for extensive physical installations. The aim was a game system accommodating an interactive, pervasive playground that the players would be able to set up and adapt to their homes, no matter their technical skill level, the furnishing or room size of their homes.

The Suitcase

To meet the requirements outlined above, the result was a modular game system consisting of different elements (Ihde, 1999; Rosenberger and Verbeek, 2015). The elements and technologies were chosen to add magic (Montola et al., 2009) and aesthetic rewards (Delden et al., 2017) by stimulating bodily senses. Furthermore, as bodily perceptual stimulation also encourages being playful (Matjeka and Mueller, 2020), the elements were chosen to stimulate a range of different senses. Furthermore, the elements work as multi-stabilities in the game, i.e., each element can have different roles, e.g., the laser lines can be used to mark off a space. At the same time, they can also constitute gameplay as a laser field to pass through.

[4]Basic balance training movements, including cross-coordination, are also neuromotor training, which is movements that stimulate the nervous system – and thus the functioning of the brain (Bushman, 2012).

The following sections explain how the elements function as standalone devices, while the minigames define the elements as part of a system. The game system was packed into a suitcase containing the following elements (see **Figure 1**): 10 light cubes, four laser lines (laser pointer + brightness sensor), two music cubes, a moving robot, three sets of restraint (Matjeka et al., 2021) cards and a camera.

Laser Lines, Light Cubes, and Music Cubes

The *laser lines* consist of four laser pointers and four brightness sensors, each with a speaker. They form lines by pointing the laser into the brightness sensor. When this line is broken, the speaker plays a beeping sound. The laser lines are included because they stimulate the kinaesthetic sense in that the players must avoid breaking the lines with implications for the hearing sense.

The *light cubes* (see **Figure 1**) change color according to which side is facing down. They have five different colors; red, blue, green, yellow, and purple. There are two sizes; 8 small cubes (diameter 7.5 cm) and two big cubes (diameter 15 cm). The light cubes stimulate the visual and tactile senses.

The two *music cubes* (see **Figure 1**) form a beat, with one playing the rhythmic part and the other a harmonic part. The harmonic part is designed to fit the beat part, ensuring that these two music parts always sound good together. The cubes are instantiated by a proximity sensor and play music for $\sim$5 s (equivalent to two bars of a 4/4 beat in 100 bpm)—then the players need to instantiate it again. The music cubes were developed to stimulate the hearing and kinaesthetic senses from the rhythmic pattern (Witek et al., 2017).

The Robot

A *robot* is included in the system as a moving entity as none of the other elements can move independently. Three individual proximity sensors connected to a motor/wheel unit control the moving robot (see **Figure 1**). Each pair of sensor and motor/wheel parts can only move forward. However, activating the left set will only move the left set as the sets are not connected. Because the other sensors are not activated, their corresponding wheels are not driving but instead "stopping" the forward movement—and consequentially twist the robot to the right. Activating only the right pair will twist the robot to the left while activating only the middle—or all—will move it forward at different speeds (see **Figure 1**). The robot does not move very fast and is included as the game's "plaything" like a ball in ball games (Matjeka, 2020).

Restraint Cards

The *restraint cards* are based on the restraints (Matjeka et al., 2021) mechanic inferring restrictions on the players' bodily preconditions for action as part of the game's obstacles to overcome (Suits, 1978; Caillois, 2001). There are three types of restraints: *exclusions* of body parts, *fixations* of body parts, and *deprivations/manipulation* of bodily senses. The cards are created from combining the three types of restraints with a body part; the two first types are combined with the body parts; legs, arms, feet, forefoot and heel, hands, elbows, shoulders, head, and the latter type is concerned with the bodily senses; vision and hearing. From these combinations, the cards formulate a restraint in combination with a body part for the players to adhere to while playing, e.g., "*Your right arm is glued to your back*" or "*Your right foot is not allowed to touch the ground*" (Matjeka et al., 2021). These cards help create the games' bodily challenges as bodily puzzles to solve, e.g., *move the robot when your feet cannot touch the ground*. The players draw cards upon beginning or during the activity, either by complementing or replacing a previous restraint. They can also choose to leave out the cards. The cards stimulate the kinetic and proprioceptive senses.

A Suite of Minigames—Rules

The suitcase also contained a *suite of minigames*. These were described in a booklet of rules. An example of a minigame: Collaborate to get the robot through the maze of light cubes. In this game, the players create a maze on the floor using the light cubes. Each player draws a restraint card. While adhering to the handicap, the players hold hands and collaborate to get the robot through the maze. When the robot reaches a light cube, the player turns the light cube red. For every cube the robot passes, the players exchange their restraint card with a new card. **Figures 3**, **4** illustrate instances of this game. For more games, see **Appendix**.

Combining Off-the-Shelf and Tailor-Made Devices

Most of the elements in the system are off-the-shelf products already available in existing products. Practically, these elements were more accessible and already thoroughly tested in terms of usability and durability. Only the music cubes are own production. The light cubes are sensory construction blocks from TTS Groupnormancs (2019), developed for sense stimulating play for pre-school children. The moving robot consists of a Modu (2020), element with a "motor" and sensors built from Cubelets (2020). Likewise, the laser lines are made from regular laser pointers in a mobile phone stand with a "receiving tower" assembled by a brightness sensor and speaker from Cubelets (2020). The cards are homemade cardboard cards.

RESEARCH DESIGN

Our study was inspired by studies using a cultural probe approach (Ståhl et al., 2009; Mols et al., 2014; Zijlema et al., 2019). However, our study design differs from Gaver and Dunne's (1999) original use of cultural probes in not only documenting people's everyday life and their use of technology they have but intervening by asking them to try out a game system in their home environment. While probes originally were intended to explore a design space and facilitate an open dialogue between the users and researchers (Gaver and Dunne, 1999; Boehner et al., 2007; Wallace et al., 2013), our design was already stable and needed evaluation of ideas instead of exploring potentials. Thus, the probes as a method were adopted for data collection while not fully adopting the original methodology—which is to explore a design space and enter in dialogue with the users as a co-designing practice (Boehner et al., 2007; Wallace et al.,

FIGURE 3 | Left image: Mom, daughter and cat playing together. Mom and daughter's hands are glued to each other, right image: Mom and daughter playing Keep the Music Going.

FIGURE 4 | Working together back to back, and ear to ear.

2013). The probes approach was used for information rather than inspiration (Boehner et al., 2007).

The Game System as a Technology Probe

Concretely, the Technology Probes (Hutchinson et al., 2003; Fitton et al., 2004) approach was adopted. As introduced by Hutchinson et al. (2003), technology probes "*combine the social science goal of collecting information about the use and the users of the technology in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring user and designers to think of new kinds of technology to support their needs and desires*." Our study fits this methodology in that we wanted to explore how movement-based play and games can lead to more joy and social togetherness to anticipate possible health-related complications in this regard. Similarly, Desai et al. (2020) applied off-the-shelf products as probes in their study of how people with dementia interacted with mixed reality technologies.

The "engineering goal" was to evaluate how the players adopted the system to their everyday living environments, i.e., their homes, and the design goal was to see how the system as a game system fostered different forms of play and game activities and to be inspired for "new games and play structures with the system." However, our design emphasis was on evaluation rather than generation. With this adaptation, the research questions considered these three aspects: RQ1 is concerned with the engineering goal of field-testing the system, RQ2 and RQ3 are concerned with the social science part of the study. In contrast, RQ4 is concerned with the design aspects described as design implications.

The Resulting Research Design

The resulting research design was thus a qualitative study where data collection consisted of using technology probes (Hutchinson et al., 2003), in combination with ethnographic methods and approaches such as observation and video-recording (Buur et al., 2010; Blomberg and Burrell, 2012), formal and informal interviews (Holstein, 1995; Kvale, 2007) (in the form of notes constructed afterwards)—inspired by ethnographic fieldwork methods (Nardi, 1997; Blomberg and Burrell, 2012) and written reports (Mason, 2017) as complementary methods. As such, this is a qualitative inquiry into how a specific game design was adopted, played, and experienced in a home setting.

Participants

Eight families were recruited *via* Facebook from personal and professional networks. All families lived in Copenhagen during the national lockdown due to the COVID-19 pandemic from April to June, 2020. Seven of the families had two adults, and one had one adult. The adults were all in their thirties and forties. The average number of children per family was two, with ages ranging from five to sixteen. Due to the recruitment method, the level of education for the participants (the parents) was significantly higher than the average for Denmark.

Equipment and Probe

A video camera was included in the suitcase for the participants to make recordings of their use of the system and a paper form to fill out as a written report besides the game system and user manuals. The equipment in the suitcase was sufficient to run the game, including chargers to charge the game elements. The questions in the form covered both game use and game experiences.

Informal Interviews During Delivery and Pick-Up

The game was brought to and picked up from the families' homes. As this study was interested in knowing about the families' adoption of the game system and the actual play activities with the system, the game system was brought to the families with no hard time limit. The families needed to have time to become familiar with the design and not only play the game once. Furthermore, we found this opportunity for the families to become familiar with the game to be one of the benefits of the probe's methodology compared to, e.g. lab tests where players most often play the game once. The agreement was that the game would be picked up when the families had tried it out, however, within 2–3 weeks as there was only one instance of the game system. However, one family requested to have the game for 4 weeks, which was accommodated. Although some families expressed a desire to keep the system for longer, it was assured that they all had had time to adopt the game, become familiar with the elements and try the system in various set-ups. One family had even misplaced one of the laser lines in the children's Lego box when they returned the suitcase.

Because there was only one instance of the game system (the suitcase), the evaluations were carried out in sequence. Although the pandemic put substantial restrictions on face-to-face contact, the national regulations allowed for short outdoor encounters as long as a two-meter social distance was kept. As we were not allowed to enter their homes, introductory information about the game and the content of the suitcase was given upon deliverance. Informative conversations with the families (both parents and children) about their game experiences took place upon pick-up. Furthermore, following the national pandemic recommendations, the game system and video camera were thoroughly disinfected between evaluations.

Gameplay Duration and Recorded Time

There was a significant difference in time spent playing the game and having the game at home between the families. While the average time with each family was 4 days, it spans 2–14 days. One family had the game for 2 days and provided more than 4 h of video. Another family had the game for 14 days and never got to play the game but only played with the elements (and no video recorded). This latter case was a single parent, and the time also spanned the time that the child was at the other parent's place.

The recorded gameplay time was ∼1.5 h for each family with a range of no recorded data (one family) to more than 4 h of data (two families). However, this does not include time to set up and to learn the game. The families reported the overall playing time (also the non-recorded playing time) to span between 2 h and 2 days—where the latter covers the time the game had been set up in their home and ready to play—but not played all the time.

Analysis Process and Methods

While we appreciated the benefits of a probes approach, such as getting an insight into the practices of people's homes (though not everyday practices because of the unusual situation) and seeing their (almost) uninterrupted interpretations and appropriations of the game system, the drawback of the approach is that the quality, type and amount of data is uncontrollable and return as inconsistent, unclear and at times omitted (Gaver and Dunne, 1999; Boehner et al., 2007). While this is a trade-off between the various study approaches, it also influences the analysis of the data, which will—eventually—also entail a degree of interpretation by the researchers. As Boehner et al. (2007) also states, probes is a relational methodology, comparable to ethnographic methods for design inquiries (Buur et al., 2010; Blomberg and Burrell, 2012), where the analysis and thus assessment of the results is partly based on the researcher's subjective interpretation and experience as well (Dourish, 2006).

When analyzing the videos as ethnographic data (Nardi, 1997), we also used ourselves as instruments to make assumptions about the quality of the interaction between the participants and the resulting user experiences. Svanæs and Barkhuus (2020) pointed out how second person analysis of past interactions give added value to video analysis, although it introduces some validity issues. Nevertheless, as probes studies draw on ethnographic methods and entail some subjectivity (Boehner et al., 2007), we found this method informative. Thus, to analyze the data, we drew on ethnographic methods (Nardi, 1997), a second person perspective to experiences (Svanæs and Barkhuus, 2020), as well as open coding to assess recurring patterns and themes for later comparison across data sources (Sharp, 2007).

Coding the Data

The data analysis process started with an open (inductive) coding looking for recurring patterns and themes (Sharp, 2007) found in the videos, the written questionaries and notes of the interviews (see **Table 1**). The results were divided into affinities and compared across corresponding sources, i.e., videos, questionaries, and interviews for each family. The data was

TABLE 1 | Themes, subthemes, and codes with corresponding heuristics.

Themes, subthemes, and codes	Heuristics
Appropriation of the game set-up	*Game and play places and spaces* (Walther, 2011; Sicart, 2014)
Places Location utilities	*Playgrounds as various spaces accommodating different kinds of play activities* (Petersen, 2014; Specht Petersen et al., 2018)
Space Type (play/game) Prior use Time Duration	*The magic circle as socially, spatially and temporally expanded* (Montola et al., 2009) *The magic circle as a particular social space* (Stenros, 2012)
Gameplay Collaboration Parallel Interdependent Type Play (leg) Game (spil)	*Being playful and "gameful"* (Matjeka and Mueller, 2020) *Collaborative and social play* (Valk et al., 2015) *Parallel and interdependent social play* (Mueller et al., 2017) *Play spaces and game spaces* (Walther, 2011; Sicart, 2014) *Play vs. game* (Eichberg, 2016)
The game system The use of game elements Which Preferences Game rules Their own rules Used the included game rules Creativity with the elements Use in the game set-up Individual use	*Toys as allocated resources for autotelic activities* (Suits, 1978) *Play and game as different activities* (Sicart, 2014) *Human-technology relations* (Ihde, 1990; Rosenberger and Verbeek, 2015) *Using technologies for design of social play* (Segura et al., 2013) *Game rules in play and game structures* (Matjeka and Mueller, 2020)
Subjective experience Use of the game system Practically As an activity The gameplay Play/game Development over time General bodily experience Movement Characteristics Applicability to their needs	*Kinetic joy rides as synergies of movement sequences* (Sheets-Johnstone, 2013, 2014) *Bodily perception* (Merleau-Ponty, 1968) *Magnification/reduction structures* (Ihde, 1990; Rosenberger and Verbeek, 2015) *In5: Move and engage* (Schraefel, 2019) *Play and game as different structures* (Matjeka and Mueller, 2020)

then compared across families to look for general themes—and individual instances as contrast and confirmation of general themes. However, the data was inconsistent and fragmented due to the trade-off in methods previously mentioned using technology probes. For instance, there were variations in the duration of gameplay and recording time for each family. In addition, the quality of the videos differed in terms of video recording angle not always covering the entire space of the activities, and the details provided in the written reports varied from family to family. However, this is a known disadvantage of the method and the corresponding complications for the analysis (Gaver and Dunne, 1999; Hutchinson et al., 2003; Boehner et al., 2007; Wallace et al., 2013). Hence the qualitative nature (and inspiration from ethnographic methods) of the inquiries and subsequent use of various analysis methods to derive the findings from the data.

FINDINGS

This section presents descriptions of the data structured according to the research questions; how the game was set up and adapted to the conditions of the players' homes (RQ1), the kinds of play that unfolded in the game sessions among the players as both bodily and social activities (RQ2), and the bodily play experiences (RQ3).

Concerning each research question, the results presented are those through the analysis to be the most critical emerging themes.

Setting Up the Game System

The analysis describes how the families allocated different everyday ordinary places in their homes to set up the system.

Space: Large Parts of the Homes Were Made Into Playgrounds

The most common way to set up the game among our players was to allocate space on the floor, often in the living room, either in an "already free" space with no furniture or sometimes by moving any large piece of furniture to the sides, e.g., sofa tables, armchairs, floor lamps. The places were not already allocated for play, such as the children's room or designated play spaces for example building Lego or Brio train railways. **Figure 5** shows an instance where the players involved their playroom in the setup. All the Lego builds are left untouched on the table to the right, while the piano and piano bench are included in the setup.

Furthermore, it was observed that as the game sessions progressed, gradually, the players allocated more places by involving different furniture, like putting the laser pointer on the corner of the sofa (see **Figure 2**) or music cubes on a bookshelf. In an instance where the living room was connected to the kitchen (open kitchen/living room environment), the kitchen table was involved as a stand for the music cube (see **Figure 2**). In this particular family's house, the children's room was not involved in any of the 11 game sessions that the players had recorded.

Time: The Game Setup Was Not Fixed, but Changed Over Time

A progression over time was observed in each family's game setups. Six families played with the game system for more than one session, and two families only played with it once. Several of the six families responded that they experienced increasing confidence with the game system. After some time, they felt confident enough to adjust and experiment with combinations and possibilities. The data analysis revealed that the players kept adapting the setup to their environment in different ways when they felt more confident with the game. Some liked to follow the rules and manual, while others did not like to follow a manual and instead "learn by doing." A family explained: "*Yes we changed it all the time when new challenges arose and made stable competition with music and colors! And obstacle course with handicaps!*" Two families explained that if they had been able to play the game more times (kept the game longer or owned one),

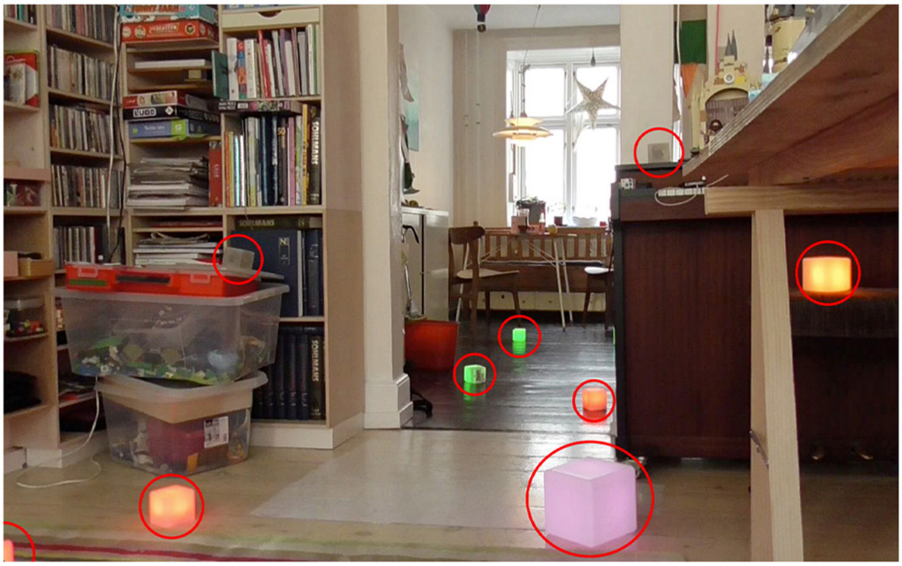

FIGURE 5 | A game set-up using both kitchen and living room including piano, piano bench and plastic boxes.

they would have evolved other ways of playing and made their own games. Instead, they felt that they had only "scratched the surface" of playing with the game system.

Shared Spaces: The Game Was Set Up to Foster Social Play

All game sessions were held in a shared room, e.g., living/dining room environment, involving different family members. It was, however, in general, a parent/child activity. One family had a pet (a cat) who also got involved in a game. Though it did not follow the same set of rules, it was included in the game—mainly because it had positioned itself in front of the robot (see **Figure 3**). Thus, the family included the cat in the game. Eventually, the cat bit the daughter and went away. One family had a visit from the grandparents. While the family was playing, the grandparents were having a debate in the background.

That the game sessions were held in shared rooms and could involve the people (and pets) who were present in the room either as participants—or watching the activity as bystanders indicates that the game system, in general, was perceived as a voluntary family activity for all members of the family to join and leave as wanted—even the pets.

The Game in Use

This section reports on the characteristics and variations in the activities as bodily play experiences. The most prominent game form was bodily collaboration—as anticipated by the minigames. Moreover, the game was presented as a family game when recruiting players. Although one of the minigames included competition between the participants, none of the families reported having played this minigame.

Emergent Play With the Game Elements Was Common

As mentioned earlier, the game system's elements were deliberately chosen because of their "commercial product"—quality as toys with different interactive behaviors, stimulating different bodily senses. The players also perceived this quality. However, it was discovered that outside the formal game sessions, the elements took on various functions as exploratory gadgets. The following quotes illustrate this phenomenon: "*Also because we decided just to explore the potential!*" "*It was a party to unpack the game, and we had to have some time to explore just this.*" Depending on the kind of activity, the elements were perceived differently. They took on different roles: In a gaming activity, i.e., *et spil* (Matjeka and Mueller, 2020), the light cubes were used as a treasure to protect or a building block. In contrast, in bodily playing, i.e., *en leg* (Matjeka and Mueller, 2020), the light cubes stimulated the bodily senses as either delightful (the light cubes and the music cubes) or alarming noise as the brightness sensors in the laser lines. One family reports such differences: *"It was pretty cool with all the gadgets that could do something when you did something with them and between them."* One family even reported using the light cubes as a night light. All families reported that the "free" play sessions also yielded bodily play like crawling around with the robot, jumping over and under the laser lines, and using the laser pointers as a game of catch or avoiding the laser. The players also reported spontaneous reactions like dancing to the music and being fascinated by the changing light of the light cubes.

These instances of play were not part of the formal game sessions, and therefore not video-recorded by the families at first. However, we asked the remaining families to video-record these instances when aware of these instances. Because these instances were spontaneous, our assumptions are based primarily on the written reports and the informal interviews. Nevertheless, it was an important quality and a finding that contributes to the players' perception of the game system as a whole.

Some Restraint Cards Led to Interdependence While Others Led to Parallel Play

Figure 3 shows two instances where the players collaborated while being glued together. To the left, two brothers work back-to-back, getting ready to move the robot around. On the right, their parents are working ear-to-ear, reading their next restraint card. Both couples were giggling and, at times, laughing out loud while they were steering the robot around the maze adhering to the different handicaps. In the written feedback, players reported these instances as: "*Fun when you are glued to each other and have to cooperate in that way*" and" *Being glued to each other was fun*."

The images in **Figure 6** illustrate siblings working together individually. To the left in **Figure 6**, the children work together to get the robot around the maze, each adhering to a restraint. Here, the boy's feet are not to touch the ground, and the girl's elbows are glued to her body. To the right in **Figure 6**, the child's (in the kitchen) right hand is not allowed to be used, and the other child's (in the playroom) elbows are glued to the body while playing the minigame *Keep the music playing*. Through these collaborative activities, the players explored their bodily capabilities—together: "*It was cool to move and invent together—the collaboration!*" Another family reported: "*[The mother] enjoyed that the pulse quickly rose on even a few square meters and that you suddenly experienced new angles and parts of your body and also the mutual dependence when we had to lean on each other's bodies and cooperate around it*."

The Players Chose to Solve the Game Challenges Through Close Cooperation

Some game challenges where bodily achievements were in focus were also present in the game sessions. These were activities such as passing the laser line with one foot not allowed to touch the ground as the mother is doing to the left in **Figure 7**. Another instance was succeeding in keeping the music playing while collaborating to turn all light cubes red, as the two players are doing in **Figure 7**. A quote from a family illustrates this kind of experience: "*It was incredibly challenging and fun with the collaborative game—discovering what the other was doing and making a common strategy was both problematic and fun when it succeeded*." Also, how to find a way together to be able to achieve an outcome or goal, e.g., moving the robot around the maze, was found in the videos. Furthermore, in the informal conversations, several families expressed a desire to set the time of the music cubes as this was perceived to be too short. As it was, they could not succeed in turning all light cubes and keeping the music playing simultaneously.

Social and Bodily Play Experiences

The spaces that the players created through their different setups and kinds of bodily play also yielded experiences of different movement potentials and social play forms than what the players were used to doing in those particular places. As was revised in section Background, a trait of bodily play is constituted in a reciprocal process of kinetic joy rides: Synergies of movement sequences that together form a whole and constitute its own meaning. Below, findings derived for meaningful kinetic joy rides are described, i.e., sequences of movements that formed a whole. These were, for instance, awkward movements (described below) that became meaningful in their own rights (and would not be outside the activity). The following sections describe findings regarding the players bodily as well as social play experiences.

The Players Experienced Physical Closeness

Section Time: The Game Setup Was Not Fixed, but Changed Over Time described how the players, at times, were exploring the potential of their bodies together. These experiences are illustrated in **Figure 4**, where two boys are working back-to-back, trying to move around to control the robot, and their parents had been moving around ear-to-ear. The mother of the family further expressed her bodily experience: "*[The father], and I had to put our ears together, and I (re)experienced a kind of closeness that we may lack in our everyday, hectic daily life*." She explains how bodily interplay can be more than just a fun and entertaining way to move around and explore our bodies. The social and playful nature of bodily interplay can create a space for bodily and social experiences that are not part of everyday ordinary family life. This experience was also viewed in the videos, though not expressed in the same way as the quote above.

The Game System Places the Generations at the Same Level

Making the bodily challenges unfamiliar and unpredictable through the constant changing in unknown restraints (the cards) anticipate equal premises for play across generations. The following quote exemplifies this point while also giving us an insight into the bodily movement potential of the game: "*[Restraints] give you an insight into other people's lives because you have your own room for maneuver—short or long arms, short and long legs, and it makes us more equal. Adults and children are equally good/bad at it. Adults also need to do something new*." The videos showed that the variety of the restraint cards—and that they are changed either between games or between rounds in a game forces a constant change in bodily challenges. While it was apparent in the videos that this design feature yielded much laughter, the subsequent bodily puzzle-like challenges were positively commented on in most reports. No one expressed any concern or dislike of this feature, only that they were difficult at times. As such, the continuous change in restraints *via* the implementation of the restraint cards force continuous bodily challenges as opposed to the non-changing restraints as in sports [e.g., football where the players are not restricted from touching the ball with their hands (Matjeka et al., 2021)] that force refinement in bodily skills and improvements. Thus, it was discovered that the unfamiliarity and shift in bodily challenges players experienced also made them experience each other in different ways and resolve gaps in (bodily) skill levels across generations.

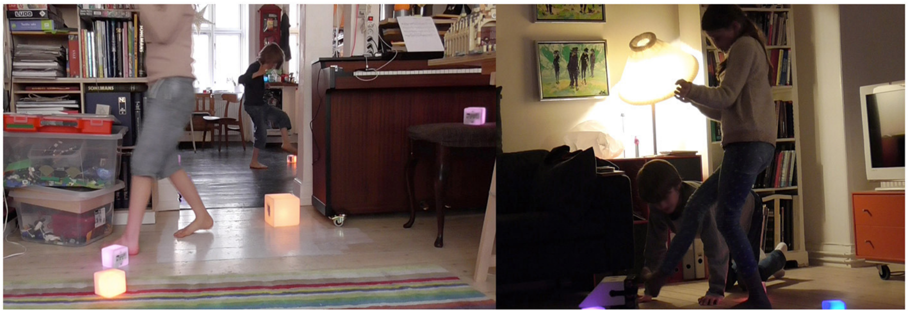

FIGURE 6 | Two examples of working together individually.

FIGURE 7 | Getting through the laser field; on the left; a mom is forcing the laser field with one foot off the floor, and the two children, in the picture on the right side, are getting under a laser line glued together (the laser pointer and sensor are not in the picture).

The Game Allowed for Awkward Movements and Silly Positions

Another recurrent theme found in the videos was doing awkward movements and standing in silly positions, like the ones illustrated in **Figures 3**, **6**. Though the design of the restraint cards anticipated this behavior, it was also a choice that the players took; to do more or less awkward movements. A family reported that the children found it fun to "*watch your parents in silly positions.*" The quote in the above section also touches on this finding of unfamiliar, i.e., silly positions resolved the gaps between generations. This finding corresponds to what game scholar Deterding (2017) explains in his article about adult play; how adults, as a way of escaping embarrassment, refrain from playing without a proper setting for doing so. As such, the players, when appropriating and playing the game in their everyday living environments, created temporary spaces in which it was allowed to be silly and bodily playing together in ways the specific places would not naturally encourage.

DISCUSSION

In the following discussion, the main findings are clustered into three overall themes and draw some design implications.

Configurable Interactive Playgrounds

Findings from the evaluation:

- Space: Large parts of the homes were made into playgrounds
- Time: The game setup was not fixed but changed over time
- Shared spaces: The game was set up to foster social play.

From the findings listed above, it could be observed how the emerging game and play spaces (Walther, 2011; Sicart, 2014) were facilitated by the modular structure of the game system with distributable elements that allowed, and even forced, the players to allocate places and use the furniture creatively to create a working setup. This approach in the design of letting the players define different parts of the physical setup and, thus, conditions for play and game is the opposite of both the traditional playground idea and the interactive playgrounds reviewed in section Background. Traditional and interactive playgrounds rely on pre-allocating specific places for specific activities (Mattila and Väätänen, 2006; Petersen, 2014; Tetteroo et al., 2014; Svanæs and Barkhuus, 2020). The analysis of our study revealed spaces that contracted and expanded as the activities unfolded—socially, like the cat that accidentally entered the game and—spatially, illustrated in **Figure 6** (left side image) and **Figure 2** (right side image). These images are from the same place, but the players' space with the elements is adjusted to the specific activity and time. While this phenomenon is known from children's play, e.g., creating train rails and landscapes, it is not a common way to think of interactive and traditional playground design.

When the players positioned the laser line in the sofa (see **Figure 2**), the light cube on the piano bench, or the music cubes on the kitchen table, the furniture became part of the emergent playground. Furthermore, when moving around while playing, the players had somehow to relate movement-wise to any physical object in the room, turning these into game elements. For instance, in the game *Get through the laser field* (**Figure 2**), the players were avoiding the laser lines and the rest of the "objects" (softa table and the other player) in the way. In a nutshell, all objects, game elements and furniture, in the allocated place became allocated resources for play (Suits, 1978), as technological multi-stabilities (Ihde, 1999; Rosenberger and Verbeek, 2015). Moreover, because the players were playing, the resources were allocated from instrumental activities (kitchen table, piano bench, etc.) to autotelic, playful activities as part of a game system. In doing so, the players transformed their homes into interactive, pervasive playgrounds:

As the players set up the game system in their everyday living environment (homes), they created a temporary, physical space in which social and physical activities and norms were redefined and renegotiated during the activities. As a pervasive game, those allocated spaces temporarily and physically expanded and contracted to suit the activities—as well as socially, when the family included the cat in the activity or the grandparents watched a game session as bystanders (Montola et al., 2009). We view the game system presented in this paper as an interactive, pervasive playground because the players transform parts of their homes into spaces of play and game activities (Walther, 2011; Sicart, 2014; Matjeka and Mueller, 2020). The game system is pervasive in that the game and play spaces expanded and contracted spatially and socially as the activities progressed (Montola et al., 2009). Sometimes it also expanded temporally, when the families kept the suitcase open for days and played with the elements as toys. As such, the game system is made up of many elements that are easy to configure and fit into any place, enabling the players to create temporary interactive pervasive playgrounds immediately.

Design implication: Movement-based game systems should be flexible and easily configurable by the players to allow them to transform their existing surroundings into an interactive playground. The game system should allow the players to change the setup during play and between play sessions dynamically.

Temporarily Redefine Social and Family Roles Through Playful Bodily Togetherness

Findings from the evaluation:

- Some restraint cards led to interdependence, while others led to parallel play
- The players chose to solve the game challenges through close cooperation
- The players experienced closeness
- The game system places the generations at the same level
- The game allowed for awkward movements and silly positions.

The most dominating and desired play experience that the players reported was the bodily collaboration encouraged by the unfamiliar bodily challenges caused by the restraints. Whether it was bodily collaborating in parallel or interdependent (Mueller et al., 2017), bodily playing in the form of intercorporeal exploring bodily possibilities and sensing the other player, or bodily gaming to find a common strategy to achieve a goal or reach an outcome (Matjeka and Mueller, 2020), the players expressed experiencing bodily closeness and temporarily turning ordinary everyday family life into play. For example, one of the families expressed the challenges: "*Adults and children are equally good/bad at it*" (see section The Game in Use). This way, the roles among the players were temporarily dissolved into a playful bodily togetherness in which they became equally skilled despite the age difference. Note that the players found this kind of play highly amusing, judging from the videos—and their quotes.

The restraint cards present bodily challenges that are not drawing on ordinary bodily skills from any sport or daily activity. Thereby, these challenges encourage a significant degree of bodily creativity in the form of awkward movements and silly positions that force the players to find bodily solutions outside their standard movement repertoire, resulting in immediate play (Pichlmair et al., 2017) —and a light physical activity level [World Health Organisation (WHO), 2020]. The cards were developed to challenge the players' basic movement repertoire by introducing unfamiliar and arbitrary restraints (e.g., "*close your right nasal with the pointing finger of your left hand*"—or "*your left knee is glued to the other player*"). Through their intercorporeality, the capacity to sense (bodily) empathy and work pre-reflectively together (Merleau-Ponty and Lefort, 1968; Gallagher and Zahavi, 2012; Zahavi, 2014; Moran, 2017), the players created a space for all players involved to be "*equally good at it*," where awkward movements and silly bodily positions were legitimate and anticipated. They even felt a "*closeness*" that they did not feel in ordinary everyday life, which the players explained as emerging in those spaces of legitimate awkward and silly movements being bodily equal and physically dependent on each other. We call this phenomenon the players' experience of a playful bodily togetherness caused by these intercorporeal experiences that temporarily transformed their ordinary space into spaces of bodily playing and gaming, constituting its own rules for bodily movement and togetherness (Walther, 2011; Sicart, 2014; Matjeka and Mueller, 2020).

As such, the game subverted the limits of bodily movement in the players' everyday life places by encouraging awkward movements, silly bodily positions and physical closeness as legitimate and even in some instances needed for the activity, i.e., they were bodily playing (Walther, 2011; Sicart, 2014; Matjeka and Mueller, 2020). Furthermore, the awkward movements and silly positions challenged the players' basic movement repertoire—and thereby indirectly basic motor skills as a light (though not structured) neuromotor training. This was one of the requirements in designing for a light physical activity, level as listed in section Designing a Movement-Based Game Adaptable to People's Everyday Living Environments.

It is worth noting that the players were already confident with each other and had a high level of trust among them. We cannot say whether such a finding would also be prevalent had the game been played among less familiar players—or less familiar places.

Design implication: Experiences of playful bodily togetherness can be achieved in movement-based game systems by adding game challenges that require players to bodily collaborate and move in odd and unfamiliar ways.

Emergent Play

Findings from the evaluation:

- Emergent play with the game elements was common.

The elements in themselves had a kind of toy quality to them, which fostered playful explorations. While the elements initially were selected to take on various functions and stimulate a range of different body senses, the elements were perceived by the players to have many other roles other than anticipated through the design. This can be explained by almost all the elements individually being commercial products aimed at bodily stimulation or emergent play as also Desai et al. (2019) found in their study. As such, they were already tested and developed for bodily exploratory interaction and, thus, worked very well in doing so (which was no surprise). However, this quality of individual elements part of a more extensive system is often not exploited as a feature in itself. Most existing games and interactive playgrounds use technologies depending on mutual interconnections, e.g., consoles, controllers, projectors, and screens, which do not embrace an individual function of their own. This quality was fundamental in our argument to include off-the-shelf elements in our prototype instead of reproducing these qualities in low-level prototypes.

This toy quality of physical game elements as part of a more extensive system is not a phenomenon emphasized in recent literature on designing movement-based games and bodily play experiences (see, e.g., Desai et al., 2019). However, our study revealed that when the players adopted the playful elements to their homes, they opened the possibility for bodily play and created an interactive, pervasive playground affording social and creative bodily possibilities and explorations. We argue that the toy quality of embedded elements as part of a more extensive game system can work as invitations for bodily play activities. Where Valk et al. (2015) focused on facilitating social play in open-ended play environments, we argue how such understanding—invitations for [social play] can lead to further [social] engagement—also pertains to bodily play. This means that the design of the individual elements can work as an invitation for further bodily play with the game system.

> **Design implication:** Movement-based game systems should consist of tangible interactive elements that by themselves inspire bodily playful without having to be part of a game setup. In this way, the individual elements can work as invitations for engaging in and developing bodily play activities.

The Sensibility of the Probe and Game System Design

Finding from the evaluation:

- Significant amount of time was spent with the elements as single elements—and not as part of the system.

While probes are supposed to be tentative "probings" and sensible to changes (Hutchinson et al., 2003; Boehner et al., 2007), as also anticipated in the game design, the game system proved an inconsistent sensibility across the elements in this regard. The data from the study showed how a significant part of the time playing was spent with the elements as single play elements and not the game system (based on the videos and informal interviews upon pick-up, see section Research Design). While such play can work as invitations to engage in bodily play, as discussed above, it was rarely working this way. The reason for this can be found in the differences in production stages. While the fully developed elements were easily accessed, the game system was only developed at the prototype stage was more complex to access and set up. This assumption is based on data that showed how playing with the system in all videos was mastered by a parent, who was also the creative part of developing and adjusting gameplay to the situation and setting up the system. Thus, the individual elements seemed to have had more substantial traction than the game system as a system. This tendency was further found in the case with the family of one parent and one child. Despite that this family had the game for 14 days, they never got to play the entire game or set it up. The parent reported that the child (11 years old), together with a friend, had played with the elements. However, because of the game's complexity (and prototypic nature), they never got to play the game themselves—and the parent did not have the time to help in the situation. While arguing that this is a design implication of the probe, it can be an issue to be aware of when developing such systems further (possibly into commercial products).

> **Design Implication:** When designing modular-based game systems, designers should be aware of the different levels of complexity in use between the individual elements, i.e., modules, their interrelations and how they affect the use complexity of the system as a whole.

LIMITATIONS

As is most often the case with studies based on probes, the data quality was inconsistent from family to family regarding the amount of gameplay time recorded, the quality of the recordings, the details provided in the diaries, what kind of games were played, and the game setup. These data provide different levels of insights. A proper lab test could have provided clearer and more consistent data for a clear and consistent analysis process with according results. However, the ecological nature of having people providing data from their everyday living environments with an insight into their use behavior in everyday life will is not possible under lab conditions. To the best of our knowledge, such a trade-off is unavoidable.

The number of respondents was limited to eight families due to two circumstances: (1) The lockdown entered a reopening after 2 months, and the families returned to more normal lives. While we could have conducted more studies with the new situation—and even compared the data from the two situations, this was not done because (2) the differences in the sensibility of the various elements of the game system skewed the gameplay experiences to be more about the elements (which were already off-the-shelf products) than the system itself—which was "only" a prototype. Because we were primarily interested in the game system and not the elements individually, more tests would need a more thoroughly developed prototype for independent use "in the field." Therefore, the differences in "quality" between the elements and the game system compromised the experience of the game system as being "less interesting" than the elements as standalone devices. Thus, the collected data would be in this light. Furthermore, because we did not have the resources to develop the game system to reach the level of an off-the-shelf product like the elements, the sample size was limited to eight families—28 players in total. Nevertheless, these findings provide valuable insights into researching pervasive and technology-supported games in people's homes during a pandemic.

Furthermore, the fact that the parents' educational level was higher than average (i.e., the majority of the parents have degrees from higher education) can have influenced their ability to understand and adopt the game system. However, because it is a qualitative study, the outcome serves as inspiration and knowledge for researchers and designers interested in designing movement-based games and does not, as such, make generalizations for the entire population.

Lastly, it was challenging to leverage the findings of people's behavior during a pandemic lockdown to a post-pandemic situation. While we do not have a valid answer to this question, we should not refrain from doing empirical HCI research under changed circumstances. However, it is an essential question to discuss for future advancements in this regard. One potential added value, though, is that when looking back at the COVID-19 crisis, this study will add to the documentation of life during a very unusual time.

CONCLUSION

The COVID-19 pandemic lockdowns of 2020 posed an additional threat to public health in lessened physical and social activity. To meet these challenges, a hybrid movement-based game system was packed in a suitcase and delivered to eight different families for test and evaluation as a social and physical activity at home—during 2 months of the lockdown in Copenhagen. Our study evaluated how this game system was adapted, played, and experienced by the families. This study has presented the design results meeting the specific requirements of a game being adaptable to people's homes and promoting bodily and social play, the evaluation thereof and subsequent design implications.

To do so—and to meet the lockdown restrictions—the game was packed as a technology probe into a suitcase, including a video recorder that the participants used to record their game sessions. The game suitcase was further prepared with manuals, instructions, chargers, etc. Furthermore, the families were asked to write a report answering questions regarding their experience.

The adapted research design sought to enable us to answer the following research question:

RQ1: How did the players adopt the system to their homes?

RQ2: How do the activities unfold as (bodily) play activities set out of the ordinary daily activities of the players' everyday living environment?

RQ3: What are the resulting game experiences as reported by the players?

RQ4: What can we learn about the design of the game system and its elements based on the answers to the above questions?

We found that the players adopted the game system to their homes by incorporating kitchen tables, pianos, sofas, plastic boxes, bookshelves, etc., as elements to play the game (RQ1). They created different game and play spaces where social and physical activities and norms were temporarily redefined and renegotiated. The different activities emerging therein left room for new and different movement potentials and explorations, providing light physical activity and bodily challenges, often as awkward movements and silly positions (RQ2). Both children and adults much appreciated this feature. We call such emerging spaces supported by the appropriation of various interactive technologies interactive, pervasive playgrounds as the spaces they occupy are expandable with the activities both spatially (varying parts of the home is allocated for play) and socially; anyone near gets involved—even the pet.

A recurrent theme throughout all gameplay was the awkward and silly movements that the players were employing—forced by the restraint card challenges. The players experienced 'being playful' as they reported how they were encouraged to explore their bodily possibilities in new ways. These explorations led to sensory stimulation and novel bodily positions that challenged their movement repertoire. An example was how two parents felt a closeness they were missing in their everyday lives when they were glued ear-to-ear. Furthermore, and because of the bodily puzzles emerging from the use of the restraint cards, the players experienced a different focus on skills, i.e., being "gameful." In these instances, the bodily skill levels between generations were altered so that the children were "just as good" bodily skill-wise as the adults (RQ3).

While interactive playgrounds tend to be designed for fixed spaces using complex technological setups, this study demonstrates how interactive playgrounds—as technology-supported game systems—can, when adopted by the players' to their everyday living environments, constitute emerging game or play spaces in any place using simple technologies. To accommodate such design, we have suggested four design implications, of which three were concerning the specific game design of the system as a playable interactive pervasive playground and the last concerning the design of the game as a technology probe (RQ4):

- Movement-based game systems should be flexible and easily configurable by the players to transform their existing surroundings into an interactive playground. Furthermore, the game system should allow players to dynamically change the setup during play and between play sessions.
- Experiences of playful bodily togetherness can be achieved in movement-based game systems by adding game challenges that require players to bodily collaborate and move in odd ways.
- Movement-based game systems should consist of tangible interactive elements that by themselves inspire playful interaction without having to be part of a game setup.
- Implications of using probes consisting of elements of mixed production levels:
    - Be aware of the level in the development of the products; prototype or commercial product—and how these are interrelated.

- Also, be aware of the complexity in use between the individual elements and the use complexity of the system as a whole.

This study aims at researchers and designers interested in bodily play experiences and the design of movement-based games. While this study gives the readers an insight into how an interactive movement-based game was incorporated to and changed the players' perception of their everyday living environment and the kinds of bodily play the game system yielded. The study also indicated that playing the game provided the players with physical and social activity as a legitimate space to explore awkward movements and bodily interplay that would typically not be allowed in the ordinary daily routines of everyday family life. Thus, evaluating the design as an inbodied interaction design shows how interactive, pervasive playgrounds demonstrate a potential to promote physical movement and social activities that challenges the players in unfamiliar ways to maintain or improve physical and mental health.

With this work, we hope to have inspired designers and researchers to advance their work in the field of designing interactive, pervasive playgrounds and the appropriation of technology-supported "play at home" systems.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available to protect the anonymity of participants. Requests to access the datasets should be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by NSD - Norwegian Center for research data, project ID 56322. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

LM has conceptualized, conducted, analyzed the empirical work, and led the writing of the study. DS reviewed and revisioned the second edition of the paper, contributions to the methodology, and conclusion sections. AW revisioned the last edition of the paper.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomp.2022.822337/full#supplementary-material

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