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Building spaces for play: Mothers design different environments for pre-walking and walking infants

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ABSTRACT

How do caregivers design environments for infants? Using a mixed methods approach, we examined how 52 mothers of 12-month-old pre-walking versus walking infants constructed a new play space. Mothers arranged large foam blocks in an empty lab playroom and discussed their design process during open-ended interviews. Mothers of pre-walkers created expansive layouts with multiple block groupings scattered across the room. In contrast, mothers of walkers built concentrated areas (half the size) surrounded by an abundance of open floor space. When reflecting on their designs, mothers' explanations echoed the spaces they created. Most mothers discussed their infants' postural and locomotor skills, unique personalities, everyday experiences at home or in childcare centers, and the characteristics of the blocks. But more mothers of pre-walkers emphasized exploration—promoting travel and discovery—than mothers of walkers. The characteristics of mothers' environments, however, did not shape the quantity of infant locomotor exploration: Walkers spent more time in motion and traveled greater distances than pre-walkers, regardless of differences in environmental layout. Findings highlight the importance of viewing infant development as a process embedded within the physical environment.

1. Introduction

The physical environment is the backdrop for human development. In most cases, physical environments are intentionally designed—urban planners map neighborhoods, architects construct buildings, teachers arrange classrooms, and parents organize homes. The characteristics of designed spaces likely reflect the characteristics of their inhabitants, resulting in different spaces for different people at different times. Consider environments for infants. Infants rapidly acquire new skills in physical contexts largely determined by their caregivers. Although researchers have investigated how adults structure environments for children in educational settings (e.g., classrooms, childcare centers; for review, see Schneider, 2025), little is known about how caregivers create and modify spaces for infants.

Developmental scientists have long recognized the importance of situating infant development within its physical context. Many influential theoretical perspectives position the developing infant at the center of increasingly complex levels of interaction with the surrounding environment. The idea that development is embedded and reciprocally affected by the organization of physical space is a fundamental assumption of ecological systems theory (Bronfenbrenner, 1979), the conceptualization of the 'developmental niche' (Super & Harkness, 1986), and the ecological approach to perception and action (Gibson, 1979). That is, the environment contains the physical materials for learning, is influenced by caregivers' decisions, and affords infants opportunities to discover different possibilities for action. Because infants' interactions within the physical environment set the stage for development, differences in the contents and layout of infants' spaces may shape how development unfolds (Heft, 1988; Wohlwill & Heft, 1987).

1.1. Caregivers make decisions about infants' environments

Caregivers are the primary architects of infants' spaces at home. They select the contents of the environment, arrange its layout, and make choices that create and constrain infant access to different areas. Caregivers' decisions about infants' environments are likely influenced by their views on infant development and childrearing, driven in part by family traditions, cultural expectations, and access to information (Super & Harkness, 1986). However, they may also be guided by everyday experiences. Caregivers witness striking changes in their infants on a daily basis—infants' developing locomotor skills, evolving personality characteristics, favorite ways to play, and propensity for

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risk-taking. Thus, caregivers may recruit knowledge about many facets of infants' experiences when arranging their spaces.

Infant locomotor development is likely a powerful cue that guides how caregivers structure the environment. Infants' repertoires for locomotion expand dramatically across the first year and may result in accompanying changes in caregivers' choices about physical space. For example, learning to walk changes patterns of locomotor exploration—how infants discover people, places, and things. Compared to pre-walking infants, walkers spend more time in motion (Adolph et al., 2012), see more of the environment while moving (Kretch et al., 2014), are more likely to travel to distal objects and locations (Karasik et al., 2011), and play at a distance from adults for longer stretches of time (Chen et al., 2023).

The transition to walking also leads to changes in caregiver behavior. Indeed, it spurs a reorganization in how caregivers interact with their infants (for reviews, see Iverson, 2022; Schneider & West, 2025). For example, caregivers are more likely to use language and gestures to comment on or direct infants' actions when infants walk compared to when they crawl (Schneider & Iverson, 2022; West et al., 2023). Caregivers mirror their infants' body position by maintaining an upright posture when infants walk and getting down on the floor when infants crawl (Franchak et al., 2018). And more generally, caregivers perceive their infants as more mature after they begin walking (Biringen et al., 1995; Walle, 2016).

Despite an abundance of evidence indicating that learning to walk changes how caregivers interact with infants, it is unknown whether this locomotor transition also changes how caregivers organize the physical environment. In one of the few studies in the literature, researchers provided a qualitative description of how caregivers spontaneously updated their homes across the first 18 months of infants' lives (Pierce, 2000). Caregivers provided objects for play, furnished the home with infant-designed equipment (e.g., locomotor toys, activity tables), and selected places for play by sectioning larger rooms with enclosures. Moreover, caregivers' practices around the construction of infants' spaces appeared to be malleable; that is, they changed in relation to infant age and skill acquisition (e.g., emergence of locomotor skills).

Malleability in how caregivers organize the environment may also be driven by safety concerns (e.g., preventing infant injury; see Murrugarra & Goldstein, 2025). For example, parents of toddlers identify more potential hazards in novel lab environments dressed as everyday spaces (e.g., mock living room or bedroom) than healthcare professionals or childcare center employees (Gaines & Schwebel, 2009). Moreover, when describing safety practices at home, caregivers report increased use of 'baby gates' only after infants become mobile (Bryant et al., 2023). These findings support the possibility that changes in locomotor development prompt changes in how caregivers arrange spaces for infants. Whether caregivers design different spaces for infants with different locomotor skills, however, remains unclear.

1.2. Environmental characteristics may shape infant behavior

The composition of the environment—its contents and structure—creates different possibilities for exploration. The literature on children's environments in educational settings provides compelling evidence for the impact of environment on behavior. Indeed, entire schools of thought are devoted to considering best practices for structuring educational spaces to improve learning and developmental outcomes (e.g., Montessori, 2013; Musatti & Mayer, 2011). For example, researchers documented that more 'openness' (i.e., amount of empty floor space) and 'definition' (i.e., presence of distinct areas) in classrooms results in more frequent peer interactions and encourages exploration (Burgess & Fordyce, 1989; Moore, 1986). Studies of environmental characteristics and exploration in childcare centers further suggest that open areas are most beneficial for social congregation and extended bouts of exploratory play (van Liempd et al., 2018; see also, van Liempd et al., 2020). Moreover, outdoor play environments brimming with various obstacles promote new forms of locomotor exploration and risk-taking (e.g., elevations for climbing and jumping; Heft, 1988; Morrissey et al., 2015).

Lab experiments with infants also indicate that the quantity and types of objects in an environment are related to how infants explore and play. For example, in studies of locomotor exploration, researchers discovered that infants walk just as much in an empty room as they do in a room filled with locomotor toys (e.g., a push toy designed to encourage movement; Hoch et al., 2019). However, infants spend more time walking during spontaneous play with locomotor toys than they do with stationary toys (e.g., a shape sorter; Hoch et al., 2024). Finally, total toy quantity matters: Infants engage in more sustained object exploration when playing in a room with just four toys compared to a room with sixteen (Dauch et al., 2018).

1.3. Current study: How do caregivers design play spaces?

This study used a mixed methods approach to examine how caregivers design the physical environment for infants with different locomotor skills. We invited 52 mother-infant dyads to our lab and engaged them in three tasks to address three questions.

(1) *Do mothers design different spaces for infants with different locomotor skills?* We developed a novel play space construction paradigm (inspired by research on children's environments; e.g., Jongeneel et al., 2015; Morrissey et al., 2015) that tasked mothers of pre-walking versus walking infants to build a new play space using large foam blocks in an empty lab playroom. Our experimental approach standardized the objects for building and the space within which to build, ensuring a consistent experience for all mothers and our ability to precisely characterize each mother's design. We quantified the dimensions (e.g., area covered by blocks) and complexity (e.g., number of block groupings) of each space. Given that walking infants move and explore more than pre-walkers (Adolph et al., 2012), we hypothesized that mothers of walkers would build larger and more complex spaces than mothers of pre-walkers.

(2) *What guides mothers' decisions about how to arrange a play space?* To enhance our understanding of mothers' design process, we asked mothers to reflect on the environments they created during an open-ended, qualitative interview. Because our goal was to gather information about what mothers considered while arranging their space, we allowed topics of conversation to arise naturally from the interviews rather than imposing a priori expectations about what mothers might say.

(3) *Do differences in the characteristics of mothers' spaces shape the quantity of infant locomotor exploration?* To test connections between environment and behavior, we observed infants and mothers during spontaneous play in the spaces mothers designed. We quantified how much infants moved (e.g., time in motion) and how far they traveled (e.g., total distance). We hypothesized that walking infants would move and travel more than pre-walking infants (Adolph et al., 2012). However, we also hypothesized that larger and more complex spaces would be related to increased locomotor exploration, regardless of infants' locomotor status (pre-walker versus walker; e.g., Burgess & Fordyce, 1989; van Liempd et al., 2018, 2020).

2. Method

2.1. Participants

Fifty-two mothers and their 12-month-old infants participated in this study. We focused on mothers given documented differences between mothers' and fathers' beliefs about infant motor development (Ishak et al., 2007). We chose 12-month-olds because infants in this age group vary reliably in their locomotor skills (e.g., some can walk and others cannot; Martorell et al., 2006). Families were recruited through a university-based recruitment service, advertisements placed in the community, word of mouth, and social media. The study was approved by the Institutional Review Board at the University of Pittsburgh (Study 22060184, "*Creating spaces for infant play*").

Fig. 1A–B provides a visual depiction of the sociodemographic characteristics of the sample—infants on the left and mothers on the right. Infants were typically developing, born at term, from multilingual households (58% English, 42% multiple languages), and lived in primarily single-family homes (89%) in suburban areas.

Based on a structured interview with mothers (Adolph et al., 2003), we classified 35 infants as *pre-walkers* (18 boys, 17 girls; $M = 12.15$ months, $SD = .19$; Fig. 1A, red symbols) and 17 infants as *walkers* (7 boys, 10 girls; $M = 12.37$ months, $SD = .34$; Fig. 1A, blue symbols). Pre-walkers could not take any independent walking steps but were experienced at crawling ($M = 3.01$ months, $SD = 1.26$) and cruising ($M = 1.72$ months, $SD = 1.14$). Walkers had more crawling and cruising experience than pre-walkers (Fig. 1A) but were novices at walking (onset criterion = 3 m across room without stopping or falling; $M = .71$ months, $SD = .60$). Mothers reported their infant's race as White (71%), Black (4%), Asian (4%), Multiracial (17%), or Middle Eastern/North African (4%), and ethnicity as non-Hispanic (90%) or Hispanic (10%).

Mothers of pre-walkers and mothers of walkers were similar in age ($M = 34.23$ years, $SD = 4.22$; Fig. 1B, red and blue symbols); and most mothers (83%) held a bachelor's degree or higher. Approximately half of mothers were first-time parents; half had childcare provided by another caregiver; and 12 had infants enrolled in a childcare center. Mothers identified their own race as White (81%), Black (4%), Asian (10%), Multiracial (2%), or Middle Eastern/North African (4%), and ethnicity as non-Hispanic (84%) or Hispanic (6%). Additional family characteristics are shown in Fig. 1B.

2.2. Procedure

The study took place in a large, empty lab playroom (4 m × 4.7 m) outfitted with a foam-tiled floor in alternating colors (.61 m × .61 m tiles). Two stationary cameras recorded activities from opposite corners of the playroom.

2.2.1. Play space construction task and mother-infant play

We provided mothers with a set of 16 large foam blocks (foamnasium.com) that could be arranged in any way to create a play space (e.g., slopes, stairs, tunnel, rectangles of varying size; see Fig. 2 for a photograph of the blocks and corresponding dimensions). The block set was selected to provide a wide range of options for construction. Twenty-four infants (46%) had played with similar blocks at least once (e.g., modular couch systems, large blocks at a museum), but only 10 mothers (19%) reported owning something similar at home. Thus, our set was largely novel for families.

The blocks were placed randomly in a row against one wall of the playroom so that mothers could see all of them. Mothers had 5 min (M building time = 2.82 min, $SD = 1.01$, *range* = 1.37–6.12) to construct a play space for their infant. We asked mothers to use at least eight blocks to ensure the space was sufficiently interesting for play but did not tell them how to choose blocks or where to place them. Infants were seated in a nearby highchair and occupied with toys and snacks as mothers built their space. After mothers confirmed they were finished building, we removed unused blocks and took two overhead photographs of their designs. Mothers and infants then played together in the space for 8 min ($M = 8.17$ min, $SD = .16$, *range* = 8.01–8.97).

2.2.2. Interviews with mothers

Mothers were then interviewed about their design process. We showed mothers the photographs of their spaces and asked them three open-ended questions: (1) "*Can you tell me a little bit about what you were thinking about when you were building the space?*"; (2) "*Can you tell me more about why you placed the blocks where you did in the room?*"; and (3) "*You used [#] of blocks. Can you tell me why you chose to use the number of blocks that you did?*". Mothers had unlimited time to provide their responses, but interviews were generally brief ($M = 1.79$ min, $SD = .60$, *range* = .79–3.72).

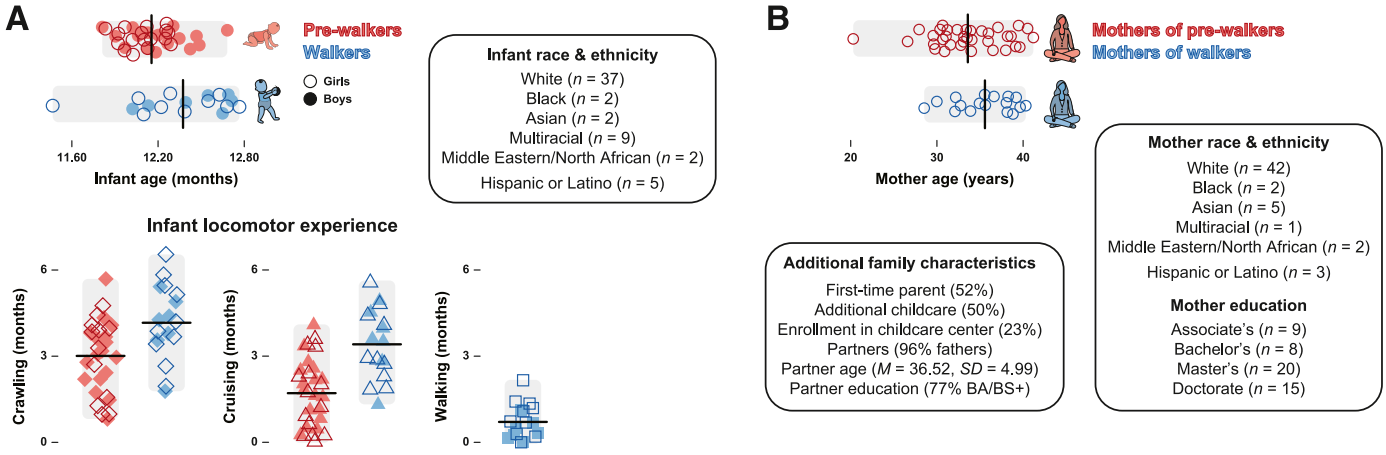


Fig. 1. Visual depiction of the sociodemographic characteristics of the sample. Panel A (left) provides information about infants. Top of panel: Infant age (distributions of circles), sex (open circles for girls, closed circles for boys), and locomotor status (pre-walkers in red, walkers in blue). Bottom of panel: Infant locomotor experience (diamonds for crawling, triangles for cruising, squares for walking). Inlayed box lists infant race and ethnicity. Panel B (right) provides information about mothers. Top of panel: Mother age (distributions of circles; mothers of pre-walkers in red, mothers of walkers in blue). Inlayed boxes list mother race and ethnicity, education, and additional family characteristics. Across the figure, symbols represent data from individual infants or mothers and black lines show group averages. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

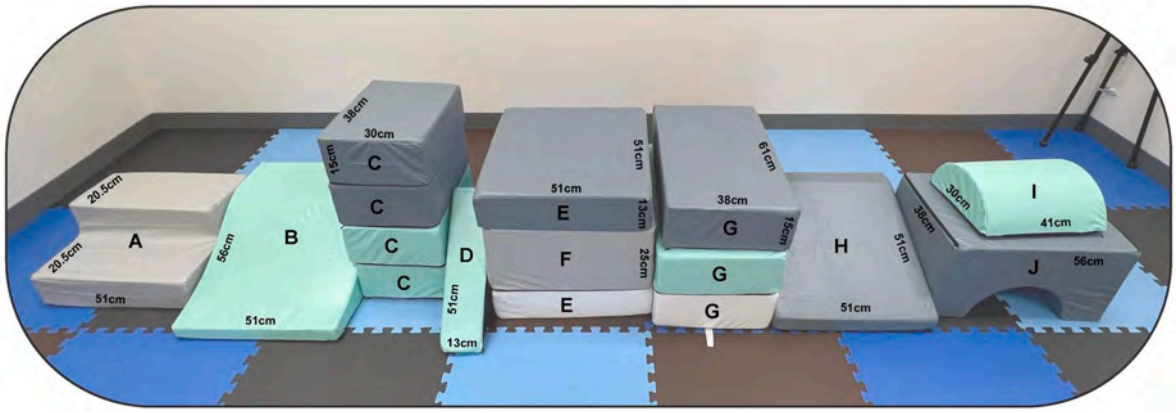


Fig. 2. Photograph of the blocks set with corresponding dimensions. The set contained 16 large blocks: (A) small staircase, (B) curved slope, (C) four small rectangles, (D) triangle, (E) two squares, (F) pedestal, (G) three large rectangles, (H) straight slope, (I) half cylinder, and (J) tunnel. Each block was made of high-density foam and covered with vinyl slipcovers (foamnasium.com).

2.3. Video annotation

To address our three research questions, a team of coders used Datavyu (datavyu.org) to annotate infant and mother behavior from video (camera views were synchronized). We characterized the design of each mother's play space, transcribed each interview, identified topics from interview responses, and quantified infant locomotor exploration. Coders also referred to the photographs of mothers' designs when making decisions about environmental characteristics.

2.3.1. *Characterizing mothers' play space designs*

Two coders independently quantified the dimensions and complexity of each mother's space using four measures. We counted the *number of blocks* mothers used (possible range = 8–16) and *number of block groupings* mothers arranged (i.e., distinct cluster of blocks with an empty one-tile border around its perimeter). We also calculated the *floor space* occupied by blocks (i.e., number of floor tiles at least half covered by blocks; length x width = total area) and percentage of blocks used for creating *elevations* (at least two blocks high, % of total blocks). Coders agreed on all measures for 42 spaces (81%). There were 2 disagreements for numbers of block groupings ($r = .95$, $p < .001$) and 8 disagreements for calculations of floor space ($r = .98$, $p < .001$). Disagreements were resolved through discussion.

2.3.2. *Deriving topics from interviews with mothers*

Interview coding was completed by two coders in two steps. First, a primary coder transcribed each interview verbatim, and a second coder checked each transcript for errors. After transcription, coders engaged in an iterative process to identify the topics of mothers' responses (following qualitative coding guidelines in Braun & Clarke, 2006). We began by creating an exhaustive list of all topics that arose in five interviews. We used this initial list to guide topic identification in five additional interviews with the goal of adding new topics that did not overlap with the original list. The updated list was then condensed (collapsed across similar topics) and used to code five more interviews. After 15 interviews were coded, we no longer found new topics. Coders then used the final list—containing eight topics—to identify topic prevalence in all interviews. Because mothers often referenced more than one topic in their responses (e.g., motor skills and exploration) and frequently wove together multiple topics as part of larger discussions of their construction goals, we identified whether mothers ever mentioned each topic (yes/no) during an interview. Inter-observer agreement was high for topic identification (percent agreement = 95–100%; Cohen's *k* coefficients ≥.95).

2.3.3. *Quantifying infant locomotor exploration*

Finally, four coders quantified how much infants explored the spaces their mothers designed. A primary coder annotated 100% of each video, and a second coder independently annotated 25% of each video (in randomly selected time blocks). We calculated *time in motion* by summing all bouts of locomotion—when infants crawled (on hands and knees), cruised (along blocks, walls, or mothers), or walked (independently). Bouts began at the video frame when infants' feet or knees displaced in any direction and ended at the frame when infants stopped moving for at least .5 s (e.g., Adolph et al., 2012; Schneider & Iverson, 2022). We also approximated *distance traveled* by leveraging the

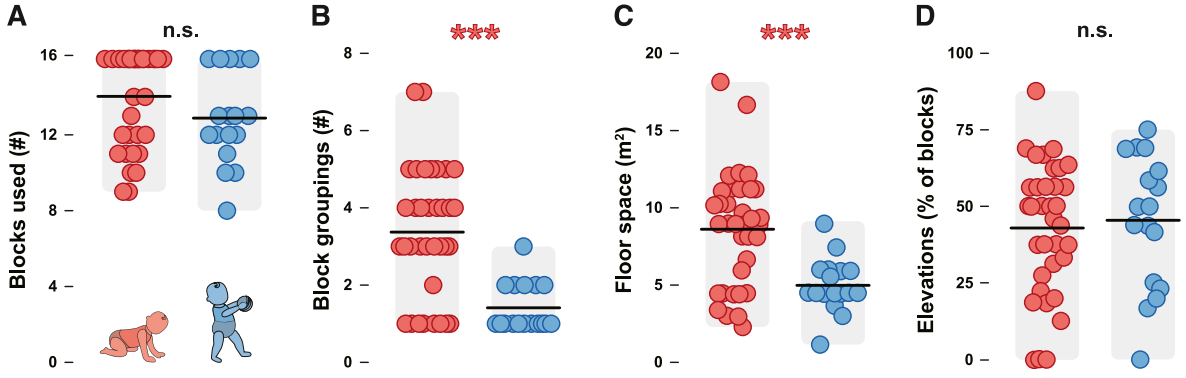


Fig. 3. Group differences in environmental characteristics of mothers' play spaces: (A) number of blocks, (B) number of block groupings, (C) floor space occupied by blocks, and (D) elevations. Symbols represent data from individual mothers (pre-walkers in red, walkers in blue) and black lines show group averages. (n.s. = not significant, ***$p < .001$). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

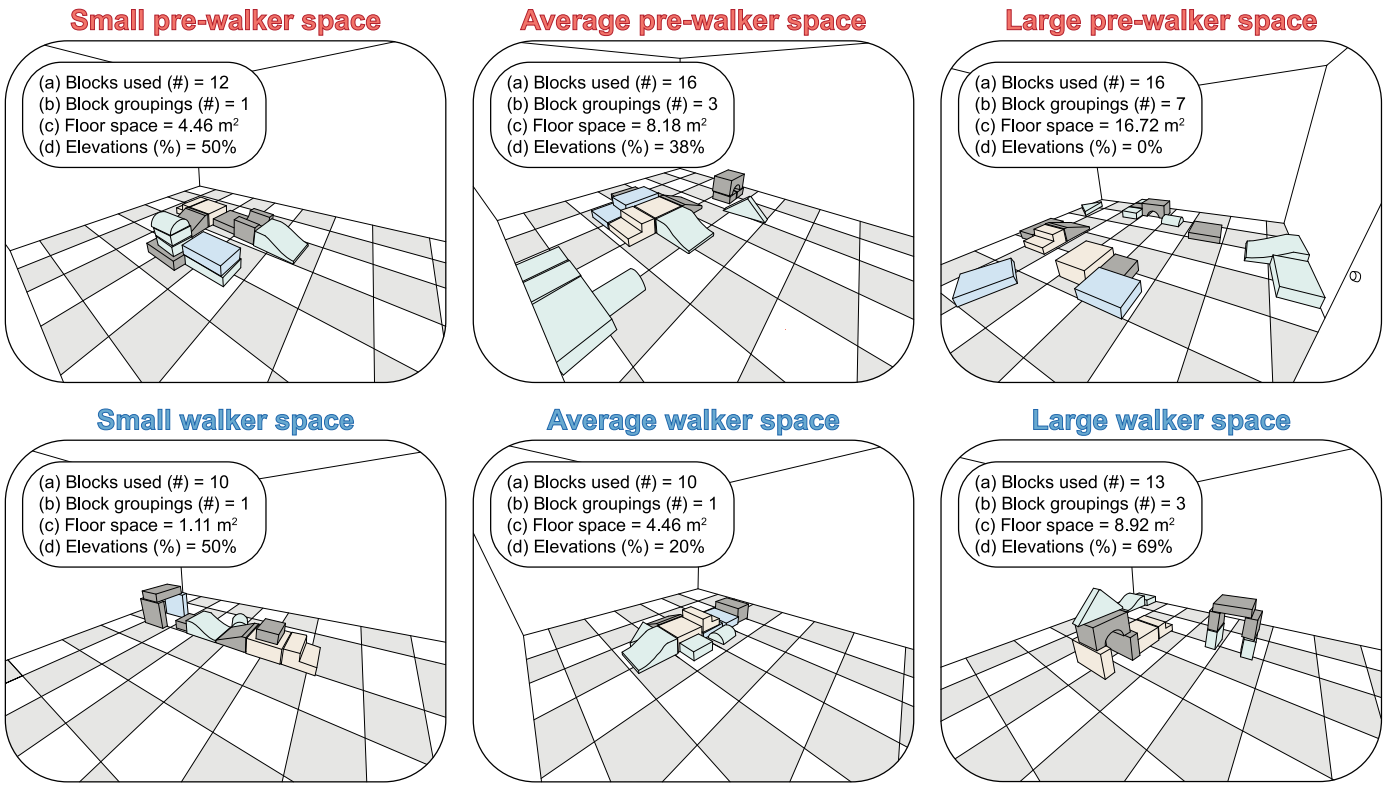


Fig. 4. Line drawings of representative environments for mothers in each locomotor group. Drawings show examples of small, average, and large play spaces built for pre-walkers (top row, red labels) and walkers (bottom row, blue labels). Inlayed boxes provide annotated values (from Fig. 3A–D) for each play space characteristic. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

consistency of the floor tiles. We summed the total number of floor tile crossings (i.e., infant's entire body moves from one tile to the next; Clearfield, 2011) across locomotion bouts and multiplied this value by tile dimensions. Correlations between coders for bout durations and number of tile crossings were .99 and .98, respectively (*ps* < .001); percent agreement for locomotion type was 99.4% (Cohen's *k* coefficient = .99).

3. Results

3.1. Preliminary analyses

In preliminary analyses, we explored whether several infant, mother, and/or household characteristics shaped our results. There were no effects of infant sex or birth order on any measure (all *ps* > .05). Moreover, although walking infants were slightly older than pre-walking infants, $t(50) = -2.46$, $p < .05$, infant age did not significantly adjust results, so it was not included as a covariate in final analyses. There were also no effects of mother age or education (*ps* > .05). Finally, we examined whether home size and household composition influenced the spaces mothers designed. Based on mothers' reports and publicly available property records from Allegheny County (https://realestate.alleghenycounty.us/), families' homes ranged from 83.6 m^2 to 325.6 m^2 (M = 165.5 m^2) in size and were occupied by 2 adults (*range* = 1–4) and 2 children (*range* = 1–6) on average. However, neither household variable was related to the characteristics of mothers' play spaces (*ps* > .05).

3.2. Characteristics of mothers' play space designs

The play space construction task revealed mothers' unique approaches to designing a new environment for pre-walking versus walking infants. Fig. 3A–D shows individual differences and group averages for each environmental characteristic; and Fig. 4 illustrates representative environments for mothers in each locomotor group. The drawings provide examples of small, average, and large play spaces built for pre-walkers (top row, red labels) versus walkers (bottom row, blue labels).

Contrary to our initial hypotheses, mothers of pre-walking infants built larger and more complex environments than mothers of walking infants. Mothers of pre-walkers and mothers of walkers used similar numbers of blocks from the set (*Ms* = 14.03 and 12.88, *SDs* = 2.51 and 2.45, respectively; $t(50) = 1.56$, $p = .063$, $d = .46$; Fig. 3A). However, mothers of pre-walkers created twice as many block groupings in their spaces as mothers of walkers (*Ms* = 3.37 and 1.41, *SDs* = 1.68 and .62, respectively; $t(50) = 4.64$, $p < .001$, $d = 1.37$; Fig. 3B). In fact, most mothers of walkers arranged just 1 or 2 groupings (16 mothers; 94%); only 9 mothers of pre-walkers (26%) did the same. Accordingly, the floor space occupied by blocks in pre-walkers' environments was nearly twice as large as in walkers' environments (*Ms* = 8.61 m^2 and 4.98 m^2, *SDs* = 3.70 and 1.73, respectively; $t(50) = 3.83$, $p < .001$, $d = 1.13$; Fig. 3C). The percentages of blocks used to create elevations did not differ between groups (M pre-walkers = 43%, SD = 22; M walkers = 45%, SD = 22; $t(50) = -.39$, $p = .348$, $d = -.12$; Fig. 3D).

Given that some features of mothers' spaces differed for pre-walkers and walkers, we also examined whether infants' locomotor experience (elapsed time since skill onset) shaped environmental characteristics. There were no significant relations between locomotor experience and mothers' designs—crawling and cruising experience for pre-walkers (*rs* ≤ −.078, *ps* ≥ .340) and crawling, cruising, and walking experience for walkers (*rs* ≤ .410, *ps* ≥ .102). For example, although walking experience ranged from 0 to 66 days (M = 22 days), nearly all mothers of walkers designed strikingly similar environments. Thus, differences in block groupings and floor space were related only to infants' locomotor status (pre-walker versus walker).

Table 1
Interviews with mothers: Topics, operational definitions, and representative quotations.

Topic	Operational definition	Representative quotations
Motor skills	Mentions infant's postural or locomotor skills—whether already acquired or newly emerging—with an action verb (e.g., sitting, crawling, climbing, standing, cruising, walking). Also includes talk about arranging blocks to create opportunities for infant to practice different motor skills (e.g., climbing up or down from a high place, pulling up on a block, cruising along a series of tall blocks).	Example #1: "I tried to have blocks with different heights [uh] in each of the different zones so he could practice [uh] climbing up on them [uhm], and theoretically climbing down, although we clearly have not mastered that." Example #2: "He's been standing a lot recently and like trying to walk so I wanted something that he would be able to pull himself up on and practice standing."
Infant characteristics	Mentions infant's individual characteristics (e.g., infant's personality, likes and dislikes, interests, attention span, temperament, favorite ways to play).	Example #1: "He likes novelty and playing with different things [uhm], and he likes crawling from place to place too so I figured I would just put them all out and see what he gravitated towards." Example #2: "She's big into peekaboo at the moment and so I was thinking if we had a space where I could go above and below the archway, that would work."
Block characteristics	Mentions characteristics of the blocks (e.g., shape, height, color, or other physical attribute) or using blocks to consider variety of options for play (e.g., maximizing variety by using many blocks, minimizing variety by reducing repetition).	Example #1: "They were like different shapes and sizes … just to give him more exposure to all of those." Example #2: "[Uhm], yeah … I mean some of them were just like repetitive I guess like same size and so I just didn't like use them."
Past experiences	Mentions a past experience with infant (e.g., infant's prior experiences at home, daycare, the playground, with siblings).	Example #1: "I did these two because I thought she might want to try the slide because she's been trying to do the slide at home and at her play school." Example #2: "We have stairs at home and she likes to go up and down so I thought I'll build something that she can go up and come down."
Encouraging exploration	Mentions promoting exploration in the play space. This includes reference to how mothers imagine their infants might move around the space, explore different locations, how the dyad might explore together, or about encouraging infants to explore.	Example #1: "I imagined her like getting out of the highchair and climbing on the gray one and then discovering the next one so I was like okay, and then she would like go on a path like I could imagine the path that she would crawl." Example #2: "I know I wanted to space them out … I wanted there to be enough space for us to move around each one so that she could move from one thing to another and I could move with her."
Different locations	Mentions creating one or many locations or areas in the play space (e.g., different stations, multiple zones, one central spot).	Example #1: "I was trying to think of a way that we could be a little more contained and have everything we wanted in one spot." Example #2: "I kinda did the circle arrangement cause I thought she'd kinda like go from playing here to playing there and play with like the different things in each area."
Ensuring safety	Mentions safety of infant in the play space.	Example #1: "I was trying to add a little more height but not like too much that he would be hurt if he fell … I wanted it to be okay if he fell off like without me." Example #2: "I wanted to give him things to climb on and then also not fall on his face."
Having fun	Mentions the idea of fun or creating the space for the sake of pure enjoyment.	Example #1: "They all looked fun!" Example #2: "[Uhm], I thought it would be fun to go underneath something and then also on top of something."

3.3. Mothers' reflections on their design process

The open-ended interviews provided insights into what mothers considered while building their space and allowed us to gather information on factors that may have guided mothers' decisions about how to arrange the environment. Our coding approach distilled mothers' detailed responses into 8 complementary topics. Table 1 provides the final topic list, operational definitions, and representative quotations; and Fig. 5 shows comparisons of topic prevalence between mothers of pre-walkers (red bars) versus mothers of walkers (blue bars).

All mothers (100%) talked about infants' postural and locomotor skills. Indeed, this was the most commonly raised topic during interviews. References to motor skills appeared throughout most responses, often woven into mothers' broader accounts of overarching construction goals. For example, mothers explained intentions to organize blocks in ways that provided new locomotor challenges (e.g., multilevel structures for climbing and jumping) or opportunities to practice emerging locomotor skills (e.g., tall, wall-like structures for pre-walkers to cruise along or an abundance of open floor space to "encourage [walkers] to walk around a little bit more").

Most mothers (84%) also talked about their infants' personalities, preferences, and idiosyncratic interests. This topic often arose when mothers described unique structures designed to engage infants in favorite play routines (e.g., towers to serve as "castles" for pretend play or archways to hide behind for peekaboo). Many mothers (72%) noted that the characteristics of each block (e.g., height, shape, color) influenced their choices. They emphasized the importance of considering variety in their designs—maximizing variety to capitalize on available options or minimizing variety to avoid redundancy. Some mothers (56%) also mentioned strategies for creating distinct locations that served as landmarks or "places to go" during play. These mothers piled blocks in one area of the room or distributed them in multiple "clumps" throughout the space (e.g., in "large circular arrangements").

Many mothers said that infants' past experiences (e.g., trips to museums and public libraries, activities in childcare centers, everyday play with toys at home) informed how they organized their space. Interestingly, more mothers of pre-walkers (77%) referenced infants' past experiences than mothers of walkers (35%; $X^2 = 8.64$, $p = .004$), potentially reflecting differences in infants' daily routines (10 of the 12 infants enrolled in childcare centers were pre-walkers). To our surprise, relatively few mothers (38%) discussed infant safety, and even fewer (12%) mentioned designing a space purely for fun.

Finally, many mothers described how they envisioned their space would encourage exploration. Mothers articulated goals of promoting infant discovery of different locations, shared hypothetical routes infants might travel (e.g., detailed pathways from one end of the room to the other), and suggested ways they planned to explore the environment alongside their infant. Talk about exploration differed by locomotor group: More mothers of pre-walkers (71%) mentioned exploration compared to mothers of walkers (35%; $X^2 = 6.21$, $p = .014$). Notably,

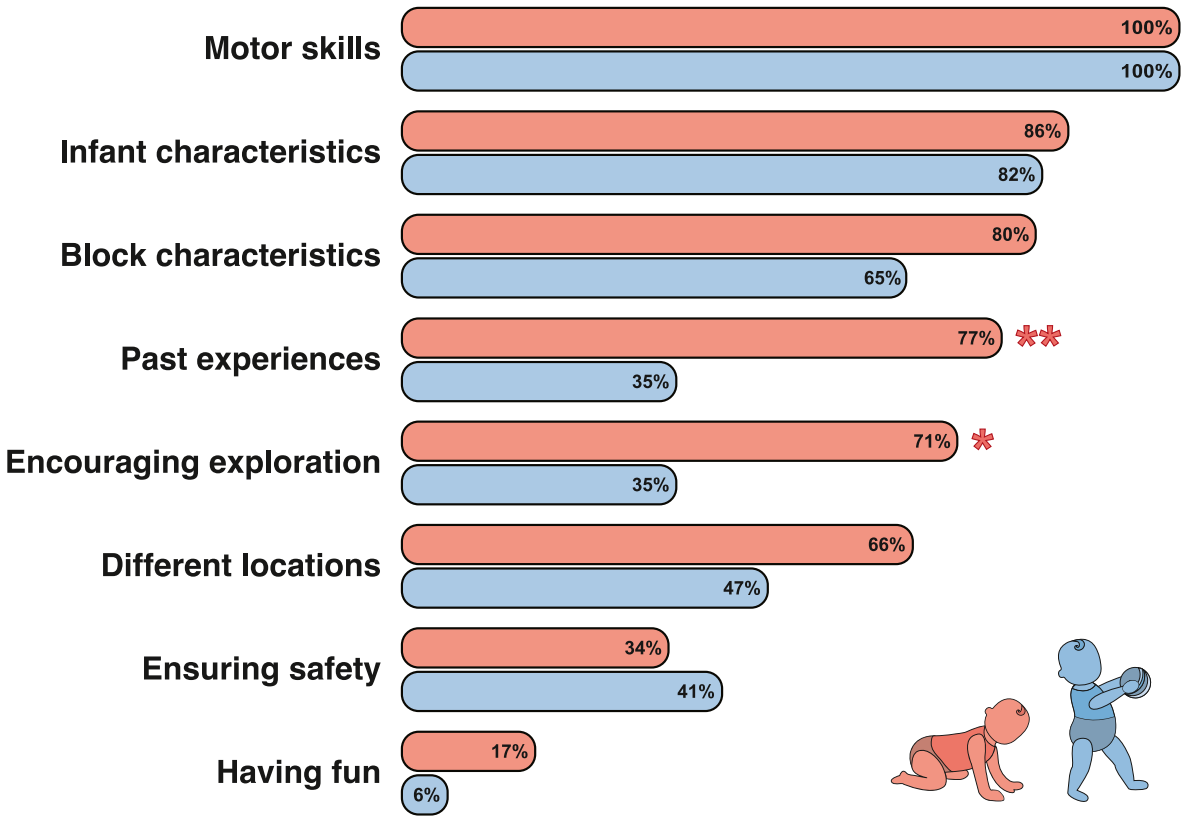


Fig. 5. Comparisons of topic prevalence between mothers of pre-walkers (red bars) and mothers of walkers (blue bars). Eight topics of conversation were identified from mothers' responses during open-ended, qualitative interviews. Topics are ordered from most to least prevalent across mothers. Bars show percentages of mothers in each locomotor group who ever mentioned each topic. (*$p < .05$, **$p < .01$). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

relative to mothers of walkers, more mothers of pre-walkers discussed exploration *and* arranged spaces that supported exploration (i.e., environments with more block groupings that covered a larger footprint). Thus, the significant group difference in prevalence of talk about exploration aligned with group differences in the dimensions and complexity of mothers' physical designs.

3.4. Quantity of infant locomotor exploration

In our final set of analyses, we examined how much infants explored the spaces their mothers built and whether differences in environmental characteristics were related to quantity of locomotor exploration. As hypothesized, walking infants spent more time in motion than pre-walking infants (Ms = 44% and 32%, SDs = 14 and 16, respectively; t (50) = −2.63, p = .006, d = .777; Fig. 6A, blue versus red symbols). Pre-walkers devoted a larger share of their locomotion time to crawling (M = 69%) than cruising (M = 31%); but walkers distributed their time between crawling (M = 48%) and walking (M = 52%) equally. This pattern was confirmed by a significant locomotor group x locomotion type interaction, F (1,50) = 6.74, p = .012, d = .119. Pairwise comparisons showed a significant difference between time crawling and cruising for pre-walkers ($p < .001$; Fig. 6B, red symbols), but no difference between time crawling and walking for walkers (p = .798; Fig. 6B, blue symbols). Walkers also traveled greater distances than pre-walkers (Ms = 15.06 m and 9.17 m, SDs = 8.47 and 7.39, respectively; t (50) = −2.57, p = .007, d = .760; Fig. 6C, blue versus red symbols).

However, contrary to our initial hypotheses, there were no significant relations between the characteristics of mothers' environments and infant locomotor exploration. Differences in numbers of block groupings and floor space occupied by blocks did not shape how much infants moved or how far they traveled—for pre-walkers (rs ≤ −.052, ps ≥ .722) or walkers (rs ≤ −.021, ps ≥ .253). For example, although floor space ranged from 2.2 m^2 to 18.1 m^2 for pre-walkers, distributions of pre-walker locomotion time were similar, regardless of the dimensions of the environment. Thus, differences in locomotor exploration were shaped only by infants' locomotor status (pre-walker versus walker).

4. Discussion

Infant development is embedded in the physical environment. Although this assertion represents a foundational concept in developmental science, little is known about how infants' environments come to be. To address this gap in the literature, we used a mixed-methods approach to examine how mothers designed a new play space for their pre-walking or walking infant. We quantified the contents and layout of each mother's constructed 'microenvironment' (e.g., Bronfenbrenner, 1979), identified factors that guided each mother's decisions about how to arrange the environment (e.g., Super & Harkness, 1986), and tested whether differences in environmental characteristics shaped infant locomotor exploration (e.g., Gibson, 1979). Three key findings emerged: (1) mothers created different spaces for infants with different locomotor skills; (2) mothers considered many facets of infants' experiences during the design process, but more mothers of pre-walkers emphasized exploration than mothers of walkers; and (3) infants' locomotor status shaped their locomotor exploration, regardless of differences in environmental characteristics.

4.1. Different spaces for different locomotor skills

We introduced a novel play space construction paradigm to examine how mothers arranged the environment for infants. Mothers of pre-walkers tended to create sprawling layouts with multiple block

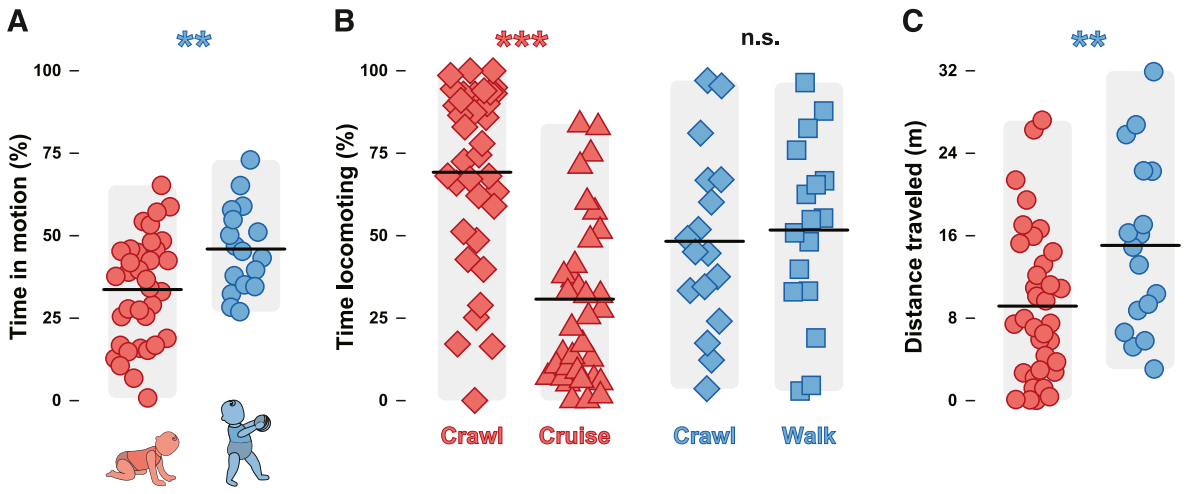


Fig. 6. Group differences in infant locomotor exploration: (A) time in motion, (B) time locomoting per locomotion type (diamonds for crawling, triangles for cruising, squares for walking), and (C) distance traveled. Symbols represent data from individual infants (pre-walkers in red, walkers in blue) and black lines show group averages. (**$p < .01$, ***$p < .001$). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

groupings scattered across the room. But mothers of walkers did the opposite: They clustered blocks into one or two concentrated groupings surrounded by an abundance of open floor space. We initially hypothesized the opposite relation—larger and more complex environments for walkers than pre-walkers—but this was not the case. Why did mothers of pre-walkers build larger spaces than mothers of walkers?

Our open-ended interviews offer some clues about this surprising result. All mothers discussed their infants' postural and locomotor skills, suggesting a shared belief about the importance of supporting motor development. However, more mothers of pre-walkers emphasized the importance of exploration (i.e., how the layout of a space can promote travel and discovery) than mothers of walkers. Critically, the alignment between pre-walker mothers' verbal explanations and physical design choices suggests that they actively considered exploration as a goal for infant play and built their spaces to support it. Mothers of walkers, instead, prioritized creating large open areas (perhaps, to encourage infants to practice walking), regardless of whether infants had been walking for two days or two months.

These findings raise questions about how caregivers arrange infants' environments at home—the primary setting where development unfolds (Bronfenbrenner, 1979). Our results are based on a controlled lab experiment that standardized both building materials and location. This methodological decision enabled precise characterization of each mother's design and minimized potential confounds (e.g., variability in home size or available objects). However, it also limited ecological validity as the curated experience mothers had in the lab may not directly translate to the everyday decisions caregivers make when managing infants' spaces at home (e.g., where to place objects, when to install baby gates, how to organize a nursery; Pierce, 2000).

Nonetheless, it is likely that our findings captured some meaningful aspects of caregivers' real-world practices. For example, mothers' designs in the lab may resemble how they arrange home spaces dedicated for infant play (e.g., infant bedrooms or playrooms) or how they improvise play spaces within shared common areas (e.g., clustering toys and infant furniture on large play mats in the living room). Future research can directly measure features of infants' home environments and ask caregivers about the circumstances that led to their organization. Moreover, because our findings are based on the behaviors and perspectives of a single sample of mothers, extending this research to fathers and other caregivers will enrich our understanding of how infants' environments are constructed.

4.2. Multiple factors informed mothers' design process

The range of topics mothers discussed during interviews suggests that they drew on multiple areas of knowledge about their infants when assembling the environment. This aligns with longstanding evidence that caregiver behavior may be shaped by their 'theories' about infant development and evolving perceptions of infants' skills (e.g., Super & Harkness, 1986; Tamis-LeMonda et al., 1998). For example, caregivers adapt verbal input based on infant age and perceived comprehension (e.g., change the prosody of their utterances; Thiessen et al., 2005), attune responsiveness to infants' developmental status (e.g., respond more readily to infants later diagnosed with autism compared to neurotypical peers; Calabretta et al., 2022), and modify expectations about infants' motor skills in different environments (e.g., estimate the steepest slope infants can crawl down successfully; Mondschein et al., 2000).

In our case, mothers' knowledge and perceptions of their infants played a role in shaping the physical environments they created. Mothers reflected on who their infants were (e.g., personalities, preferences), what their infants enjoyed doing (e.g., favorite play routines, idiosyncratic interests), and which experiences their infants had in the past (e.g., activities in childcare centers, family outings). Moreover, across all interviews, mothers emphasized the importance of creating spaces that encouraged infants to practice postural and locomotor skills.

To our surprise, safety was not a common topic of conversation. This is likely due to the study context: Mothers arranged spaces using foam blocks in an infant-friendly lab playroom with foam-tiled flooring. However, in everyday contexts, caregivers undoubtedly make decisions about the organization of home environments to ensure infant safety and respond to changes in infants' propensity for risk-taking as new locomotor skills emerge (see Murrugarra & Goldstein, 2025). Indeed, when mothers did mention safety, they often talked about it in terms of risk management. For example, one mother described the importance of her infant learning the "art of safe dismounts" from their couch at home. Future research can continue to explore how caregivers modify home environments to ensure safety and provide challenge as infants acquire new locomotor skills (e.g., Bryant et al., 2023; Ishak et al., 2007; Tamis-LeMonda et al., 2007).

4.3. Infant locomotor status shaped locomotor exploration

Despite research demonstrating the impact of environmental organization on child behavior in educational settings (e.g., classrooms and childcare centers; Burgess & Fordyce, 1989; Morrissey et al., 2015; van Liempd et al., 2018, 2020), we found no evidence that the characteristics

of mothers' play spaces were related to infant locomotor exploration. We initially expected such environment-behavior relations, but this hypothesis was not supported. Instead, infants' locomotor status (pre-walker versus walker) was the more powerful driver of infant movement and travel. Consistent with prior work (e.g., Adolph et al., 2012; Hoch et al., 2020; Schneider & Iverson, 2022), walking infants spent more time in motion and traveled greater distances than pre-walking infants. These results also align with lab studies of locomotor exploration in different environments (e.g., infants' walking quantities are similar in toy-filled versus empty rooms; Hoch et al., 2019).

The discrepancy between our findings and those from studies in educational settings likely reflects differences in sampling and context. Research reporting environment-behavior relations in classrooms and childcare centers generally focuses on older children (2–6 years), for whom locomotor skills are well-practiced and may support more advanced exploratory behaviors (e.g., running, jumping, climbing on tall elevations). For these children, skills like walking are no longer novel and environmental design may shape opportunities for exploration and children's learning about new affordances more directly (Gibson, 1979). In contrast, for the 12-month-olds in our study, walking was a transformative skill that overshadowed differences in environmental layout. Nonetheless, this research occurred in a lab setting and captured a limited number of features of the environment, precluding our ability to make strong inferences about the nature of connections between environment and exploration. Future research can continue to investigate these constructs in infants' natural home environments by leveraging longitudinal house mapping to examine whether caregivers modify physical spaces as infants' locomotor skills develop—and whether environmental characteristics (e.g., occupied versus open floor space) shape patterns of locomotor exploration.

5. Conclusions

This study provides an initial examination of developmental processes that may shape how caregivers structure infants' physical environments. Mothers of pre-walkers constructed larger and more complex play spaces than mothers of walkers and explicitly shared intentions to encourage exploration. However, mothers' efforts did not translate into significant effects of environmental design on infant behavior. Instead, infants' locomotor status shaped differences in how much they moved and how far they traveled. Collectively, findings underscore the importance of conceptualizing development as a process embedded within the physical environment—an evolving context influenced by infants and their caregivers.

CRediT authorship contribution statement

Joshua L. Schneider: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jana M. Iverson:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Funding acquisition, Conceptualization.

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