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DOI
10.1016/j.ecresq.2017.11.005

Publication date
2018

Document Version
Final published version

Published in
Early Childhood Research Quarterly

Early Childhood Research Quarterly 43 (2018) 33–41

Contents lists available at ScienceDirect

Early Childhood Research Quarterly

Young children's exploration of the indoor playroom space in center-based childcare☆

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ARTICLE INFO

Article history:
Received 9 March 2017
Received in revised form 30 October 2017
Accepted 20 November 2017
Available online 15 December 2017

Keywords:
Day care centers
Exploration
Task-orientation
Spatial characteristics

ABSTRACT

Exploration plays a key role in the development of children. While exploring, children develop new skills by perceiving and acting upon the possibilities for action that are specified in the environment. This study examined the relations between young children's exploration during free play and the spatial characteristics of the indoor playroom space in childcare centers, using an observation scheme based on Gibson's theory of perception-action affordances. The study was carried out in mixed-age groups, with ages ranging between 11 and 48 months. The results showed that depth of exploration of space was positively related to the use of tables and activity centers, and also to the child's task-orientation as rated by the caregivers. Breadth of exploration revealed a reversed pattern of relations. The findings indicate that studying children's exploration of indoor playroom space as affordances-guided perception-action cycles can contribute to a more comprehensive understanding of the role of spatial attributes in children's exploratory play.

1. Introduction

Young children discover the world around them by actively exploring the possibilities for action their environment offers and by doing so they not only acquire information about the environment, but they also improve their abilities to act upon the environment. A growing number of children worldwide attend a day care center or preschool in the first years of their lives before enrolling in primary school (OECD, 2014), raising interest in the developmental effects of child day care. Most studies into the effects of child care on children's social-emotional and cognitive competence development have focused on the quality of caregiver-child interactions and on structural quality characteristics such as group size, adult-to-children ratio and caregivers' pre- and in-service professional training (Burchinal, Vandergrift, Pianta, & Mashburn, 2010; Slot, Leseman, Verhagen, & Mulder, 2015). Studies relating developmental effects to the physical environment provided by child day care centers, however, are scarce. The present study focused on a particular aspect of child development, exploratory play, seen as driver of both cognitive and social-emotional development. We examined how young children in childcare centers, in mixed-age groups with ages ranging from one to four years, explore the playroom during episodes of free, unguided play. We studied differences in intensity (depth) and variety (breadth) of exploration as related to characteristics of the child and the playroom characteristics. More specifically, we examined how children's exploration is related to the physical-spatial lay-out and presence of particular components in the environment provided by the centers.

The present study relates to previous work on the role of exploratory play in children's cognitive development (e.g., Oudgenoeg-Paz, Leseman, & Volman, 2015; Ginsburg, Cannon, Eisenband, & Pappas, 2006). However, the current perspective differs from that of the earlier work. We did not examine how exploration of spatial characteristics relates to cognition, but instead how particular constellations of spatial characteristics of playrooms relate to the nature of children's exploration of the playroom space.

1.1. Exploration and development

Exploration is an essential condition for development. Having opportunities to discover the environment and to practice skills in acting upon the environment, stimulates the development of new,

☆ This work was supported by the Dutch organization for childcare Kinderopvang Humanitas.
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https://doi.org/10.1016/j.ecresq.2017.11.005
0885-2006/

more complex skills (Oudgenoeg-Paz, Boom, Volman, & Leseman, 2016). By actively exploring the features in the environment that are accessible to them, children learn to solve context-dependent problems (Thelen, 2000) and they discover the causal relations between actions and outcomes, which can facilitate logical reasoning (Legare, 2014). Exploring the spatial-relational properties of objects, for example by stacking objects or by putting objects in containers, provides children with opportunities to learn about spatial relations and sets the stage for acquiring spatial language such as prepositions and verbs of movement (Oudgenoeg-Paz et al., 2015). Likewise, exploring the spatial properties of objects and environments provides children with opportunities to develop basic mathematical ideas about shape, size, order and number (Ginsburg et al., 2006). Exploratory play in young children can have long-lasting effects on cognitive functioning in middle childhood and adolescence. In a longitudinal study a significant relation was found between infants' motor maturity and active exploration at age 5 months and their academic achievement at age 14 years (Bornstein, Hahn, & Suwalsky, 2013). Similarly, parent-reported exploration behavior in infancy and toddlerhood was found to predict children's spatial memory at age 6, while controlling for fluid intelligence, gender and socioeconomic background (Oudgenoeg-Paz, Leseman, & Volman, 2014).

Exploration has often been defined as a goal-oriented activity, the goal being to learn about an object or a situation, and to simultaneously learn how to interact with that object or situation (Rusher, Cross, & Ware, 1995; Weisler & McCall, 1976; Wohlwill, 1984). Recent studies of young children (Koziol, Budding, & Chidekel, 2012; Smith & Gasser, 2005; Thelen, Schöner, Scheier, & Smith, 2001) indicate that exploration often starts with a spontaneous movement, which elicits an effect, for instance a noise or the displacement of an object. Perceiving this effect, in turn, leads to acquisition of knowledge, at first coincidentally, and next to a new stage, where movement and cognition become coordinated to reach a goal or to master a skill (Koziol et al., 2012). The child that accidentally causes an effect can use this experience to intentionally repeat, alter or extend his or her activities by reproducing the newly discovered effect and by elaborating on it.

Children's exploration of spatial characteristics is obviously related to their motor development. For example, in order to be able to explore and manipulate particular objects the stage of neuromuscular development of the child's hand skills and the body-scaled relations for grasping should afford grasping these objects (i.e., the objects may be too big or too heavy for the child). Similarly, reaching important motor milestones such as sitting, crawling and walking enables new ways of exploring the environment (Oudgenoeg-Paz et al., 2015). Yet, exploring the environment while being guided by the spatial structures of the environment, in turn, leads to new motor skills and thereby propels motor development (e.g., Adolph & Robinson, 2015; Thelen, 2000).

Most studies investigating exploration behavior in young children have focused on children's use of play objects (e.g., Caruso, 1993; Fitneva, Lam, & Dunfield, 2013; Oudgenoeg-Paz et al., 2014; Power, Chapiesky, & McGrath, 1985; Schuetze, Lewis, & DiMartino, 1999), using various methods to assess exploratory play (e.g., Oudgenoeg-Paz et al., 2016; Soska, Adolph, & Johnson, 2010). Some studies found a relation between object exploration and motor skills, indicating that the way a child explores and uses a three-dimensional object is linked to his or her motor abilities, such as being able to crawl or to sit (Oudgenoeg-Paz et al., 2014; Soska et al., 2010). Power et al. (1985) investigated exploratory styles, using the concepts of breadth of exploration, referring to the diversity of ways a toy was used, and depth of exploration, referring to the amount of time a child was engaged in playing with an object. Both breadth and depth of exploration were related to children's developmental level. In studies among infants between 9 and 12 months of age, Caruso (1993) and Schuetze et al. (1999) found that a greater variety in use of an object was related to more time spent on exploring and higher problem-solving ability.

1.2. Exploration of the playroom space

Various aspects of exploration of space in young children have been studied in laboratory and home situations. Studies have shown that once a child is able to move independently, by crawling and subsequently by walking, he or she is able to perceive the environment in new ways and to explore it by moving objects, by going from one place to another, and by manipulating the spatial arrangement of the environment (Karasik, Tamis-LeMonda, & Adolph, 2011). Other studies have shown a connection between the way in which children explored their environment and the characteristics of this environment. For instance, the onset of locomotion was found to be delayed in infants growing up in an environment that restrained their movement by placing them on a soft mattress (Campos et al., 2000). A study testing young children's walking on uneven floors demonstrated that subtle variations in floor height led children to adjust their steps to stay upright, indicating real-time coupling of perception and action (Gill, Adolph, & Vereyken, 2009). In a cross-cultural study into unsupported sitting of 5-month-old infants remarkable differences were found between sitting habits of children which were related to mother's behavior toward the child and to postural positions. In cultures where children sit on the floor unsupported, children sit stable at an earlier age than in cultures using supportive child furniture (Karasik, Tamis-LeMonda, Adolph, & Bornstein, 2015). These studies indicate that having opportunities to practice and develop new skills, made possible by both the social and the physical environment, stimulate children to gather knowledge about the environment and to simultaneously acquire new skills. Possibilities for exploration thus not only depend on the child's exploratory abilities, but also on characteristics of the physical environment. Also adults can influence children's exploration, either directly by guiding children's attention or by modelling exploration behavior, or indirectly by arranging the physical environment (Weisberg, Hirsh-Pasek, Golinkoff, Kittredge, & Klahr, 2016).

To the best of our knowledge only a few studies to date have investigated the relation between exploratory behavior and spatial characteristics of the environment in center-based childcare (Kantrowitz & Evans, 2004; Moore, 1986). Exploration in these studies was defined as the type of play behavior that is directed toward investigating an object, a person or a space. Moore (1986) introduced the concept of well-defined settings, referring to recognizable areas within the playroom that are limited to one activity and well-equipped with relevant materials, as opposed to ill-defined activity settings. He found that exploratory behavior occurred more frequently in well-defined than in ill-defined settings. Kantrowitz and Evans (2004) discovered a relation between the child-activity-area ratio and the time children spent off-task. If there were more children per activity area, children spent less time on play activities. In this study, an activity area was defined as a section of the environment delineated by specific materials and physical boundaries, for instance an area for arts and crafts, dramatic play or construction play.

1.3. The concept of affordances as theoretical framework

Although sophisticated methods were used in the studies reviewed above, a coherent and comprehensive theoretical framework for relating exploration behavior to physical characteristics of the environment is still lacking. A promising framework is provided by the ecological psychology theory developed by James and Eleanor Gibson (Gibson, 1986, 1988). The core of this framework is the concept of affordances, entailing the idea that objects and spaces offer opportunities for action relative to what a person can perceive and perform (Gibson, 1988). Following Chemero (2003), affordances exist in the relationships between physical features of the environment and the abilities of an organism to perceive and act upon them. When a child perceives new stimuli in the environment and reacts to it by, for example, moving towards it, reaching for it, looking at it and manipulating it, the child gathers both new information about the environment and learns new skills, which subsequently enable the child to perceive new affordances to act upon (Gibson, 1988). Exploring affordances thus consists of recurrent perception-action cycles: perception leads to action, action leads to new information to be perceived, which in turn elicits new actions (Oudgenoeg-Paz et al., 2016; Soska et al., 2010). Young children's action-abilities develop rapidly and changes in body and posture due to neuromuscular maturation result in new possibilities for action (Adolph & Robinson, 2015). In the course of development, children learn to be flexible and to adapt their actions to the maturing body within a natural environment that offers a variety of affordances (Adolph & Robinson, 2015). To stimulate children's development, environments are required that offer a diversity of opportunities for perception and action, matching the rapidly developing abilities of the child. An important question, to be addressed in the current study, is whether early childhood childcare provides such an environment.

To the best of our knowledge, only one study to date used the concept of affordances to study children's exploration behavior in an early childhood classroom. McLaren, Ruddick, Edwards, Zabjek, and McKeever (2012) investigated exploration behavior in an integrated kindergarten playroom which enrolled disabled and non-disabled children. Children's interactions with the physical features of the indoor play environment were observed, with a focus on children's movement and exploratory behavior being defined as goal-directed movement. The results showed that open, non-designated areas such as circulation paths were used the most often and elicited the biggest variety of non-habitual uses. The present study extended the method used in the study of McLaren and colleagues to examine to what extent childcare centers provide environments that can stimulate children's development through offering a diversity of opportunities for exploratory perception and action. The concept of affordances was employed to investigate children's exploration of the indoor playroom space. An observation instrument was developed to observe children's acting upon the wide array of affordances provided by designated areas, special furniture and other elements in indoor playrooms, further elaborating on McLaren's set of affordances (McLaren et al., 2012). The observation instrument used in this study was based on a preliminary model for analyzing affordances in outdoor environments developed by Heft (1988), using functional categories such as 'climbable feature' or 'flat smooth surface' in combination with the possible actions they entail, such as 'affords running'. Following earlier studies regarding styles of object exploration (Caruso, 1993; Power et al., 1985; Schuetze et al., 1999), both breadth of exploration (how extensively children explored a wide variety of affordances in the playroom) and depth of exploration (how intensively children explored a smaller subset of affordances in the playroom) were investigated.

1.4. Present study

The main objective of the present study was to examine how spatial characteristics of objects and areas in the playroom of childcare centers relate to the breadth and depth of children's exploration of playroom space as observed in free play situations. The purpose of this study was also to investigate if using an observation instrument, based on the concept of affordances, would offer new leads to measure quality of early childhood childcare centers. The choice for free play was based on the consideration that guidance of exploratory play by caregivers could obscure the relation between spatial characteristics and exploration. Free play is a relevant context in Dutch childcare. Several studies have shown that children in Dutch childcare spend an important part of the day, often up to one third, to free play (De Haan, Elbers, & Leseman, 2014; Slot et al., 2015; similar findings are reported for the USA, see Ansari & Purtell, 2017). The present study involved children between one and four years of age. Since active self-induced locomotion has been found to play an important role in exploring the physical environment (e.g. Adolph & Robinson, 2015), only children that could already crawl or walk were included. The age heterogeneity allowed us to examine age effects that might reflect constraints of the stage of motor and cognitive development. To the best of our knowledge, no studies to date have investigated exploration of the indoor playroom space in center-based childcare involving children below 2.5 years. Moore's study (1986) involved children between 2.5 and 6 years of age, the other studies concerned children between 4 and 6 years of age. In addition, we included a measure of children's general task orientation, as a temperamental characteristic that could influence their exploration behavior, as was found in previous research (Kantrowitz & Evans, 2004; Power et al., 1985).

2. Method

2.1. Participants

Participants were 61 children (49.2% girls) from ten child day care centers, all part of a large provider of childcare in the Netherlands. In each center one group participated in the study. The selection of centers and groups was based on two criteria. To avoid disturbing effects of recent changes in group composition, the groups had to function as a mixed-age group for at least six months. Each group had to consist of both young (under 18 months) and older (above 18 months) children, to guarantee that we could recruit enough children from different ages. In each group 5–7 target children were observed. Because the study focused on exploration of space, only children that could actually move around without help by crawling or walking were included. The mean age of the observed children was 29 months and use of the childcare facility varied between one and five days a week (see Table 1). At the time of the study, children had been attending the center on average for 21 months. The total number of children in the groups during the observations ranged from 8 to 11 (M = 9.98; SD = 0.88). Informed consent of the parents was obtained for 88% of the children. The remaining children, for whom no consent of the parents was obtained, were temporarily cared for in another group during the observations or carefully kept out of sight.

2.2. Procedure

Children were observed during free-time play periods on two different mornings, with one to two weeks between the first and the second visit. On both mornings video recordings were made during two rounds of 30 min. Recordings started with a period of about ten minutes to make the children familiar with the observer and the video camera. During each round every target child was followed for a continuous period of five minutes. In this way each child was observed during a total of four episodes of five minutes on the two mornings, 20 min in all. Some children were absent on the second day. To collect sufficient data per center extra children were recruited in these cases. This resulted in 7 children who were observed on only one morning. After removing interruptions (for instance because of diapering, leaving the room) and episodes that were not suited for the study purpose (e.g., when children became involved in a teacher-led activity), a total of 216 episodes remained for analysis (*M* = 17.5 min per child), with 7% of the episodes being excluded from the analysis for the reasons mentioned above.

Coding of the video recordings was done by dividing each 5-min episode into 10-s intervals (*N* = 6419). Recordings were paused after each interval to enter the codes for the spatial component and affordance acted upon during that interval. If a child during an interval switched between components, for instance moved from the table to the activity center, or used different affordances, the code for the component or affordance used most frequently, that is during the largest part of the interval, was entered. If two components were used together at the same time, for instance a table and chair, the component most relevant for the ongoing activity of the child was coded. For example, if the child was wobbling on the chair and doing nothing else, this component was coded. If the child was sitting on the chair at the table but actually busy with something on that table (for example reading a book), the table was coded. Prior to the first visit a plan of the indoor playroom(s) of each group was obtained and a square meter grid with coordinates was drawn to be able to register the exact location of the child during the observations. In addition, the spatial components in the room (e.g., tables, cupboards, activity centers) were drawn on the plan and the teachers were asked not to make any major change in the room between the two visits. For every 10-s interval, the location where the child spent most of the time during that interval and the components used by the child were coded based on the grid-plan. In addition, the global quality of the playroom was evaluated focusing on the spatial lay-out, available square meters, furnishing, and the presence of activity centers. Finally, teachers were asked to fill out a structured questionnaire on characteristics of the children participating in the study.

2.3. Measures

2.3.1. Using spatial affordances

An observation instrument was developed to code children's use of the spatial components and playroom space in detail, the Spatial Affordances in Childcare Interior Design (SACID) tool. This tool builds on previous studies by Heft (1988) and McLaren et al. (2012), and was designed to collect detailed behavioral data of children's exploration of space. It consists of two main coding categories (for a complete overview, see Table A1 in the Appendix A). The first category comprises of a list of spatial components that frequently occur in playrooms for childcare. Components can be movable objects (such as a table, chair, decorations) or fixed areas (activity center, floor, door, window). The second category features a list of potential affordances for each component, for instance 'affords climbing' or 'affords crawling under'. After a training session, the instrument was tested in a pilot study by the three observers who also conducted the main study. Codings of the pilot data were compared and discrepancies were discussed until agreement was reached. A few additional affordances were detected and added to the final version of the tool, for instance 'banging on the table' and 'standing on big play object'. For each interval the observer scored which component (e.g., table, floor, chair) the child used and which affordance specified by this component the child acted upon (e.g., by climbing on the chair, crawling over the floor, sitting on the couch). For the main analyses of the current study, the data were aggregated to the episode level, yielding counts of component and affordance use per episode (see below). In line with this, the inter-rater reliability was determined on a random selection of 40% of the episodes that were independently scored by two researchers. *ICC*s were satisfactory, ranging between 0.70 and 0.99, with a mean value of 0.88.

To construct measures of quantity, breadth and depth of exploration of space, data were aggregated to the level of episodes (*N* = 216), with each episode comprising of 30 intervals of 10 s each. For each component, the *total number of affordances used* was calculated as the number of intervals in which at least one affordance of a spatial component was used during a five minute episode (with 30 as maximum). In line with Caruso (1993), for each component, *breadth* of exploration was defined as the number of different types of affordances of a component used by the child during the five minutes episode; *depth* of exploration was defined in terms of the mean number of uses per type of affordance during this episode and was calculated by dividing the total number of affordances used by the breadth of use. If, for instance, during a 5-min episode, the child used the table during 10 intervals, while using two different types of affordances (e.g., affording climbing, sitting), and the floor during 20 intervals, while acting on three types of affordances (e.g., affording crawling, standing, running), breadth of exploration for the table would be 2 and for the floor 3. Depth of exploration for the table would be 5 and for the floor 6.7.

Finally, the total number of affordances explored, and the breadth and depth of exploration were summed over all components.

2.3.2. Quality of playroom space as assessed with the ITERS/ECERS

The global quality of the playroom spaces in the ten centers involved in the study was assessed using a combination of the space and furnishings scales of the Early Childhood Environmental Rating Scale (ECERS-R) (Harms, Clifford, & Cryer, 2005) and the Infant Toddler Environmental Rating Scale (ITERS-R) (Harms, Cryer, & Clifford, 2003). The ITERS-R is designed to assess the quality of spaces for children up to 30 months and the ECERS-R for children between 30 and 48 months. Therefore, given the current age range, the two instruments were used in combination. The observed quality aspects were rated on 7-point scales varying from 1 (inadequate), 3 (minimal), 5 (good) to 7 (excellent), focusing on the indoor space, furniture for routine care, play and learning materials, furnishings for relaxation and comfort, room arrangement for play, space for privacy, and child-related display. Assessments were made by two observers during the first visit to the center. The internal consistency of the combined scales (Cronbach's Alpha) was $\alpha = 0.76$. In all groups, the combined scales were independently applied by two researchers to determine the inter-rater reliability. *ICC*s were satisfactory and ranged between 0.75 and 1.00, with a mean value of 0.91. In addition, the available space in square meters per child and the number of activity areas in the playroom were determined.

2.3.3. Child characteristics

The caregiver caring for the child on a daily basis at the center was asked to fill out a child profile questionnaire (Veen et al., 2013). The questionnaire contained questions about the child's age, age of enrollment and number of days per week the child attended the center. In addition, caregivers were asked to rate children's task orientation, a construct closely related to the construct of executive functioning and effortful control, using a scale from the Early Childhood Behavior Questionnaire (ECBQ; Putnam, Gartstein, & Rothbart, 2006). Sample items of this scale are: 'While playing, this child can be busy with an activity for a long time' and 'This child is not quickly distracted'. Caregivers were asked to rate to what extent the presented behaviors were true for a child on a 5-point scale, varying from 1 (false) to 5 (true). The internal consistency of the scale was satisfactory with Cronbach's $\alpha = 0.77$.

2.4. Analytic procedure

Data analysis proceeded in three steps. First, a descriptive and correlational analysis was conducted of global spatial quality of the 10 centers involved in the study. In addition, descriptives of children's personal characteristics were calculated. Second, a descriptive analysis was conducted of the key variables of the current study describing children's use of spatial components, the affordances they acted upon, and the breadth and depth of their exploration. Third, two series of multilevel regression analyses were carried out with breadth and depth of exploration as dependent variables and the most frequently used spatial components as independent variables. Child, group and global center characteristics were added as control variables.

3. Results

3.1. Descriptive data

Table 1 shows the descriptives of the spatial characteristics of the centers, children's characteristics and children's observed exploration of space behavior. The quality of space as assessed with the ITERS/ECERS diverged widely between the centers, with two centers slightly scoring below 3, which is considered 'minimal', and three centers scoring 5 or higher, which is considered 'good'. Large differences were also found regarding the square meters available to the child for free play. Available square meters and the number of activity areas were highly inter-correlated ($r = 0.80$, $p < 0.01$). The ITERS/ECERS-scores and the number of activity areas were also highly inter-correlated ($r = 0.75$, $p < 0.01$). No significant relations were found for the ratio of square meters per child.

Children's task orientation showed a positive tendency, with children on average being moderately task-oriented according to their caregivers. The wide score range, however, suggests that children diverged rather strongly with regard to this characteristic.

Children were observed to act upon affordances during every interval included in the current analysis, but the breadth and depth of their affordance use diverged. Depth of exploring affordances varied most strongly, with scores ranging from 2.0 to 30.0. Overall breadth and depth were negatively related ($r = -0.71$, $p < 0.01$). Note that this strong correlation is partly due to the way in which these variables were constructed, the variable types of affordances was used to calculate both breadth and depth of exploration.

Upon closer examination, the results for exploration of space showed that, during free play sessions, children spent most of the observed intervals on the floor (see Table 2), mostly for moving from one place to the other (in 54% of the intervals; not presented in Table 2), but also for standing, sitting or crouching. Other relatively frequently used spatial components were the activity centers, the table and big play objects. Tables, but also chairs and cupboards, were often used by children to pull themselves up or to stabilize their standing. Overall, 94 different types of affordances were coded, excluding affordances that were acted upon only once. Spatial components that were used in less than 4% of the intervals (see Table 2) were because of the low prevalence not included in further analyses.

Table 1
Means, Standard Deviation and Range for Spatial Characteristics, Child Characteristics and Exploration of Playroom Space.

Variables	N	M	SD	Observed range
Spatial characteristics				
ITERS/ECERS spaces and furnishings	10	4.16	0.96	2.5–5.2
square meters per child (play area)	10	6.60	2.35	3.8–10.4
number of activity areas	10	9.07	1.54	7.0–11.0
Child characteristics				
age (months)	61	29.30	9.85	11–48
attendance (days a week)	58	2.20	1.00	1–5
time being enrolled (months)	59	20.42	10.82	1–44
task orientation	61	3.45	0.52	2.3–5.0
Exploration of playroom space				
total uses of affordances	216	28.77	2.68	8.0–30.0
overall breadth of affordances	216	7.14	2.70	1.0–14.0
overall depth of affordances	216	5.16	4.23	2.0–30.0

Note. N = childcare centers (10); children (61); 5-min episodes (216).

Child characteristics such as age, gender, number of days and time being enrolled in childcare center were related to the behavioral characteristics, as rated by the child's teacher. Age, gender and time since enrollment correlated with task-orientation ($r = 0.43$, $p < 0.01$, $r = 0.30$, $p < 0.05$, $r = 0.33$, $p < 0.05$ respectively). Children were rated as overall more focused in activities when they were older, if they were girls and when they had been attending the center for a longer time. Age and time since enrollment, as expected, correlated strongly ($r = 0.69$, $p < 0.01$), therefore only age was included in further analyses. Regarding spatial characteristics, a negative correlation was found between the number of children and the available square meters per child ($r = -0.57$, $p < 0.01$).

3.2. Multi-level analysis of depth and breadth of exploration of space

To examine the relations of the depth and breadth of children's exploration of the playroom space with child characteristics and spatial characteristics of the playroom, multi-level analyses were conducted using MLwiN (Rasbash, Steele, Browne, & Goldstein, 2009). Breadth and depth of exploration were significantly and substantially inter-correlated due to the way in which these variables were constructed. Note that the two constructs were not mutually

Table 2
Exploration of Playroom Space: Use of Spatial Components and Affordances per 5-min Episode (N = 216).

Spatial component	Affor-dances	Intervals	Breadth of use		Depth of use		Affords*
	#	%	M	SD	M	SD	
Floor (flat, smooth surface)	11	38.3	2.97	1.36	4.20	2.45	walking, sitting, standing
Activity centers (for dramatic play, construction, reading)	8	17.9	2.12	1.16	5.48	5.31	sitting, standing, walking
Table (child height)	7	13.2	1.61	0.89	5.83	7.01	sitting at, standing at, pull oneself up/stabilizing,
Big play objects (play house, tunnel, car)	9	8.0	2.15	1.35	3.38	2.54	sitting, standing, climbing/sliding
Chair (child height)	12	5.6	1.76	1.02	2.69	2.69	sitting, moving it, pull oneself up/stabilizing
Bars (door, fence)	6	4.6	1.68	0.93	2.50	1.68	standing at, opening/closing, looking through,
Cupboard	10	4.0	1.58	0.89	2.78	3.43	take things out/in, stand at, play at
Carpet	10	3.2	1.70	1.02	2.63	2.15	sitting, kneeling, standing
Chair (adult height)	8	2.1	1.52	0.71	2.42	1.84	pull oneself up/stabilizing, climbing, moving (around)
Window	4	2.1	1.39	0.63	3.06	2.13	looking through, touching, standing at
Table (adult height)	6	0.8	1.17	0.39	2.75	3.33	sitting under, standing at, sitting at
Decorations (photos, drawings)	3	0.2	1.33	0.82	1.72	0.77	looking at, touching, pointing at

Note. Spatial components are ordered according to frequency of use. N = 216 episodes. # = number of affordances. * The three most frequently used affordances.

exclusive and thus could in principle provide different information on how children's exploratory play relates to spatial and child characteristics. Therefore, separate analyses were conducted with breadth and depth of exploration as dependent variables. Breadth and depth of exploration were calculated at the 5 min episode level (see Method section). Therefore the analyses were run on data aggregated to the episode level ($N = 216$). The distribution of the scores for depth of exploration appeared to be skewed. A log-transformation was applied to this variable to better meet the normality assumption.

As first step, two empty two-level fixed effects models were estimated, with depth of exploration respectively breadth of exploration as dependent variables. The levels distinguished were the child level ($N = 61$) and the episode level ($N = 216$). Because of the small sample size at the center level ($N = 10$), it was decided not to add a third level. As second step, child and group characteristics were added to the models as control variables. Child characteristics were age, gender, number of days in childcare, and teacher rated task orientation. Attendance of the childcare facility varied and differences in familiarity with the playroom setting were expected to influence exploration of space. Therefore attendance was included as a control variable. The number of children in the group was found to be negatively related with available space per child. Less space per child was expected to lead to more disturbances and to decrease depth of exploration. Therefore, the number of children was included as a control variable as well. Due to missing data in one of the control variables (number of days attending the center) the sample size decreased to $N = 205$ at the episode level and to $N = 58$ at the child level. As third step, the spatial components that were used during more than 4% of the intervals were added to the models. Use of components was aggregated to the episode level, representing the proportion of intervals during an episode that a particular component was used. Proportions were converted to z-scores to avoid problems of multicollinearity. As a final step, indicators of global spatial quality at the center-level as measured with the ITERS/ECERS and the number of square meters per child were added to the models. Another measure of global spatial quality, the number of activity areas, was strongly correlated with both the ITERS/ECERS scores and the square meters per child, and was therefore not included.

Table 3 shows the results for the different models. Models were evaluated by comparing the relative model fit using the $\Delta Dev\,(\Delta df)$ index and by inspecting the R^2s. Regarding depth of exploration, adding the spatial components resulted in the biggest improvement of model fit (Model 2). Adding the quality of space scores as assessed with the ITERS/ECERS and the square meters per child did not lead to a substantial improvement of the model fit. Regarding breadth of exploration, adding child characteristics, in particular the child's task orientation, led to the biggest model improvement (Model 1), but also the spatial components were found to be important predictors (Model 2).

Table 3 shows that the use of tables and activity centers was significantly positively related to depth of exploration. Also children's task-orientation was significantly positively related to depth of exploration. A reversed pattern of outcomes was found for breadth of exploration. Use of tables and activity centers and children's task-orientation were significantly negatively related to breadth of exploration. No significant relations were found for other child characteristics, such as age and group size. Depth and breadth of exploration of space were not related to the indicators of global spatial quality (ITERS/ECERS) at the center level.

The proportion of variance in depth of exploration explained by Model 3 corresponds to a medium to large effect. A closer look at the results shows that most of the variance is explained by the use of the spatial components, which were added in Model 2. The proportion of variance in breadth of exploration explained by Model 3

Table 3
Multilevel-analysis Depth of Exploration of Space and Breadth of Exploration of Space (N = 205).

	Depth of exploration				Breadth of exploration			
	Model 0	Model 1 child characteristics	Model 2 spatial components	Model 3 spatial characteristics	Model 0	Model 1 child characteristics	Model 2 spatial components	Model 3 spatial characteristics
Fixed effects								
Intercept	0.506* (0.016)	0.643* (0.173)	0.554* (0.160)	0.491* (0.238)	7.135* (0.198)	6.883* (2.317)	9.697* (2.003)	9.096* (2.999)
Age(gm)		0.001 (0.002)	−0.000 (0.002)	−0.000 (0.002)		−0.009 (0.023)	0.004 (0.022)	0.004 (0.021)
Gender (boy = 1)		−0.004 (0.033)	−0.005 (0.031)	−0.006 (0.030)		0.064 (0.408)	0.058 (0.384)	0.075 (0.375)
Child-profile: task orientation (gm)		0.068* (0.036)	0.076* (0.033)	0.068* (0.033)		−0.965* (0.439)	−1.064*(0.417)	−0.948* (0.414)
Number of days		0.021 (0.016)	0.020 (0.015)	0.021 (0.015)		−0.231 (0.199)	−0.216 (0186)	−0.248 (0.189)
Number of children (gm)		−0.018 (0.017)	−0.009 (0.016)	−0.013 (0.021)		0.103 (0.214)	−0.005 (0.201)	−0.013 (0.263)
Table			0.063* (0.024)	0.071* (0.025)			−0.635* (0.308)	−0.739* (0.312)
Chair			−0.017 (0.018)	−0.014 (0.018)			0.253(0.230)	0.207 (0.231)
Floor			0.020 (0.028)	0.023 (0.028)			0.269 (0.354)	−0.323 (0.354)
Activity center			0.064* (0.029)	0.071* (0.029)			−0.712* (0.370)	−0.800* (0.372)
Big play object			−0.004 (0.020)	0.003 (0.020)			0.070 (0.249)	0.061 (0.247)
Bar (fence, door)			−0.026 (0.018)	−0.025 (0.018)			0.102(0.240)	0.114 (0.225)
Cupboard			−0011 (0.019)	−0010 (0.019)			0.136 (0.224)	0.080 (0.241)
ITERS/ECERS spaces and furnishings				0.027 (0.018)				−0.296 (0.228)
Square meters per child				−0.002 (0.010)				−0.006 (0.121)
Random parameters								
Variance: child-level	0.003 (0.003)	0.001 (0.003)	0.001 (0.002)	0.000 (0.002)	0.449 (0.475)	0.177 (0.427)	0.089 (0.373)	0.000 (0.000)
Variance: episode-level	0.044* (0.005)	0.044* (0.005)	0.037* (0.004)	0.037* (0.004)	6.813* (0.769)	6.599* (0.764)	5.946*(0.688)	5.962* (0.589)
R^2	–	4.3%	19.2%	21.3%	–	6.7%	17%	17.9%
Deviance (-2 LL)	−47.44	−54.73	−90.94	−93.44	1040.18	973.82	950.18	947.77
$\Delta Dev\,(\Delta df)$	–	7.29 (5)	36.21* (7)	2.50 (2)	–	66.36*(5)	23.64*(7)	2.41 (2)

Note. * $p < 0.05$.

shows a medium to large effect as well. Again most of the variance is explained by the spatial components.

4. Discussion

The aim of this study was to examine relations between young children's exploration of space and spatial characteristics of the playroom in center-based childcare during free play. Exploration of the playroom space was studied by observing children's use of affordances, for which a new observation instrument was developed based on Gibson's ecological psychology theory of affordances (Gibson, 1986, 1988).

The results of the present study, first of all, showed that during free play children use a wide variety of spatial components in the playroom. The floor, activity centers and tables, however, were used most frequently, amounting to 70% of the observed time-intervals. The floor was the component used most often and also the component related to the largest variety in affordance exploration, showing actions such as jumping, running, kneeling, riding cars, crawling, sitting, walking and standing. This suggests that free floor space is an important component of the playroom, not only for moving from one spot to another, but also for affording a variety of actions, which is in line with the outcomes of the study by McLaren et al. (2012).

Based on previous studies (McLaren et al., 2012; see also Caruso, 1993; Moore, 1986; Power et al., 1985), we expected the depth of children's exploration of a subset of different affordances to be positively related to the use of designated, well-defined spatial components, and the breadth of children's exploration of a wide range of different affordances to be related to the use of non-designated, less well defined spatial components. The results of the multi-level analyses provided partial support for this expectation. Depth of exploration was significantly positively related to the use of designated spatial components such as the table and the activity center, whereas breadth of exploration was negatively related to the use of these components. For the other spatial components, including the non-designated, ill-defined spatial component floor, no clear pattern of relations with children's exploration of space was found.

The outcomes suggest that in-depth exploration of space indeed occurs mostly in distinct, recognizable and well-equipped play areas (tables, activity centers for construction, fantasy play etc.), as was suggested by Moore (1986), whereas these same areas were not or negatively related to the breadth of exploration. The most frequently used spatial component, the floor, was not significantly related to either depth or breadth of exploration. A possible explanation is that the floor has a multi-functional character. The floor is used for transition and moving around, but also for toy play, physical play and expressive activities, and therefore specifies combinations of diverse affordances for both broad and in-depth exploration. Big play objects are also clearly recognizable, well-defined spatial elements, but no relation was found with depth or breadth of exploration. A possible explanation is that big play objects often had a limited function (car, slide) and often lacked additional materials that could be moved or manipulated to expand an activity. In contrast, activity centers, such as the construction area, were always equipped with a variety of movable and manipulable materials, likely stimulating children to prolong their use of this area and to explore materials in-depth. Tables provided a limited set of affordances in this study, and were mostly used to sit or stand at while playing in-depth with small toys or doing a focused creative activity.

Children who were rated by the caregivers as more task-oriented displayed more depth in their exploration of space. This is in line with findings by Power et al. (1985), who found that depth of exploration of an object was related to children's persistence in executing the task. While Power and colleagues investigated persistence by observing a child executing a single task (removing a toy from a jar) in a single session, task-orientation in the current study was based on teacher reports of the children covering a longer period and a variety of situations. The current study thus extends the findings by Power and colleagues by providing evidence that task-orientation, as perceived by the caregiver during daily activities, is a child-characteristic that is related to the depth of exploration of space. Task-orientation and age were significantly inter-correlated, indicating that older children were more task-oriented. The results of the multilevel analysis showed that task orientation was a stronger predictor of depth of exploration than age. This is also in line with outcomes of the study of Power and colleagues, who found no direct relation between the age of the children (ranging from 12 to 24 months) and their exploratory style.

We further examined to what extent the overall quality of space and furnishing, as measured by the ITERS/ECERS at the center-level, was related to depth and breadth of exploration. No relations were found. Although the ten centers varied in quality and amount of space per child, they all met the minimum standards of the Dutch childcare quality regulations. A possible explanation for the lack of correlation, therefore, might be that the overall quality was sufficient. It is conceivable that the results could have been different in more extreme circumstances. Another explanation for the fact that no relation was found between exploration of space and the quality of space as assessed with the ITERS/ECERS, is that the scale evaluates spatial quality in a rather global way and pools the scores of several different spatial quality dimensions into a single score. It would be interesting to examine if the underlying quality dimensions are differentially related to children's exploration and, through exploration, to developmental outcomes. To the best of our knowledge, this has not been studied yet (see also Mashburn, 2008).

To summarize, investigating the use of playroom spaces by observing the affordances specified by these spaces allowed us to obtain detailed information not only about the possibilities for action particular spatial components offer to children, but also about children's actual use of these action possibilities. The results of this study show that exploration of playroom space during free play comprises of a broad range of varying uses of spatial components, and that different spatial components are associated with different patterns of use. Designated and well-defined activity centers and tables were associated with depth of exploration, regardless of children's age. Dutch childcare centers usually offer a variety of activity centers for children of 2.5 years and older, but for younger children the playroom mostly consists of a more open, less well-defined play area. The results suggest that for stimulating in-depth exploration of space in younger children who can crawl or walk, the playroom should also contain activity centers and tables at child height.

Earlier studies into the relation of spatial characteristics and exploration in childcare centers have mainly focused on designated activity areas (e.g. Moore, 1986), neglecting a major spatial attribute in the playroom space, the floor. The floor tends to be regarded mainly as a circulation space. However, the frequent use of the floor, not only as a circulation space, but also as a space for play, suggests there is more to it. Use of free floor space can satisfy the child's need for movement, which may partly explain why the floor was used so often during free play. On the other hand, frequent use of free floor space for movement can also lead to a turbulent atmosphere, for instance by disrupting quiet play at a table or activity center, especially if circulation space and activity centers are not well separated. In the current study, we found that in almost half of the time-intervals children used the floor for stationary actions (e.g., sitting, standing, kneeling). Perhaps this concerns activities that do not fit well in an activity center due to the limited space within the center or to other factors. Future research should investigate if there is a relation between number and type of activity centers and floor use, especially use of the floor for play and exploration activities other than circulation. Furthermore, it seems important to study if the design of the playroom is related to the frequency of moving around, comparing situations where space for circulation is clearly separated from activity centers with situations without clear boundaries.

Future studies could work with the concept of affordances as a theoretical framework to study the relation between physical-spatial environment, behavior, and development. Including the actual use of all spatial components in the playroom could help researchers to obtain a more comprehensive view on children's exploration behavior. Future research should include the use of small-sized play materials that are related to the relatively big spatial components studied here (e.g., small toys on the table desk), to examine if additional affordances for fine-motor actions are associated with depth of exploration of playroom space. In line with findings from recent studies on young children's spatial-object exploration using fine-grained play materials (e.g., Ginsburg, Lin, Ness, & Seo, 2003; Hendershot, Berghout-Austin, Blevins-Knabe, & Ota, 2016; Karasik et al., 2011; Oudgenoeg-Paz et al., 2016), we expect that adding a fine-grained affordance analysis to the present approach can contribute to the further understanding of children's exploratory behavior in childcare settings. Finally, future studies could look into the relations between affordance-based exploration and measures of children's emotional experiences while exploring, such as signs of excitement or boredom.

4.1. Limitations

A limitation of the present study is the relatively small sample size of 61 children attending ten childcare centers. This limitation was partly compensated by the detailed interval observation method used, resulting in a large number of data points. Yet, the present findings should be treated with caution. Another limitation of this study is the use of a newly developed instrument for measuring exploration of playroom space, limiting the possibilities to relate the current findings to findings in other studies. Moreover, information on the psychometric quality of the new instrument is still lacking. Note however that the inter-rater reliability for the new instrument was satisfactory and that the pattern of findings (e.g., in-depth exploration occurring more frequently in designated areas) and the observed inter-correlations (e.g., of depth of exploration correlated substantially with teacher rated general task orientation) attest to the reliability and validity of the new instrument. A third limitation is the relatively short time children were observed. Future studies should extend the observation time per child, to obtain more detailed and reliable information about the breadth and depth of exploration at the child level. Finally, only free play situations were examined in the current study for reasons outlined above. Exploration of space during caregiver-guided activities, however, may be very different from what has been observed in the current study. Future research should therefore also include use of space during caregiver-guided activities, such as eating, storytelling, resting and group play. Despite these limitations the current study contributes to the understanding of children's use of the physical environment in center-based childcare and offers new leads for future research into exploration of space.

4.2. Conclusions

This study used a fine-grained observation method to examine exploration of playroom space focusing on children's use of affordances. The results show that there is a relation between the physical characteristics of the playroom and young children's exploration of space in center-based childcare. Different spatial components are related to a variety of different uses. Carefully designing and furnishing playrooms following findings in studies like the present one can stimulate children to expand the range of exploratory behaviors and thereby foster their development. Future studies into young children's exploratory behavior could benefit from a strong theoretical basis provided by the Gibsonian theory of perception-action affordances.

Appendix A

Table A1
Spatial Affordances in Childcare Interior Design (SACID).

Spatial component	Affords:
Floor (flat, smooth surface)	walking (around); crawling; sliding; jumping, dancing; riding with play material; laying; sitting/crouching; standing; falling; running; kneeling
Activity centers (for dramatic play, construction, reading)	hiding/withdrawing; climbing/sliding; quiet movement (crawling, rolling); active movement (dancing, jumping); sitting; walking (around); manipulating parts; pulling oneself up, stabilizing; standing
Table (child height)	putting something on/taking something off; standing at; sitting at; crawling under; sitting under; to pull oneself up/stabilizing; banging on
Big play object (play house, tunnel, car)	hiding/withdrawing; climbing/sliding; quiet movement (crawling, wobbling); active movement (jumping); sitting, kneeling; walking around; standing in/on; climbing/crawling in/out; manipulating parts
Chair (child height)	sitting on; sitting while moving (wobbling); moving it (pushing, pulling); pulling oneself up, stabilizing; climbing on/off; standing on; kneeling on; crawling under; knocking down; retreating/withdrawing; putting things on
Bars (door, fence)	standing at; opening/closing; looking through; pulling oneself up, stabilizing; hiding behind
Cupboard	taking off/putting in things; standing before; playing at; opening/closing door/drawer; crawling/sitting inside; pulling oneself up, stabilizing; climbing on; hiding behind
Carpet	sitting, squatting; laying; falling; jumping/dancing; standing; walking; crawling; (re)moving it
Chair (adult height)	pulling oneself up, stabilizing; climbing on/off; moving it; sitting; retreating/withdrawing; taking off/putting on things
Window	looking through; touching with mouth/hands; standing/kneeling at; looking at oneself
Table (adult height)	sitting/crawling under; standing at; sitting at; taking off/putting on things; pulling up/stabilizing
Decorations (pictures, drawings)	looking at; touching; pointing at

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ecresq.2017.11.005.

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