



Do spatial characteristics influence behavior and development in early childhood education and care?



Ine H. van Liempd*, Ora Oudgenoeg – Paz, Paul P.M. Leseman

Utrecht University, Department of Child, Family, and Education Studies, Heidelberglaan 1, 3584 CS, Utrecht, the Netherlands

ARTICLE INFO

Handling Editor: L. McCunn

Keywords:

Early childhood care and education
Indoor play environment
Social behavior
Cognition

ABSTRACT

There is increasing awareness that the physical environment plays a critical role in young children's cognitive and social development, by offering opportunities for exploration and interaction. In this article a narrative review is presented of 19 studies, published between 1987 and 2017, into the relation between spatial characteristics of the indoor play environment of center-based early childhood care and education settings and children's social and cognitive behavior and development. Studies involved children between six months and six years of age. Several studies reported consistent, interesting outcomes. A layout with an open-zoned arrangement, enabling children to keep eye contact with the caregiver was found to stimulate children to use the space more fully. Designated activity areas for activities such as pretend play and construction elicited different types of social and cognitive behaviors. However, the number of studies is small, and very diverse, both in content and in methodology. Suggestions for future research are discussed.

In this paper we present a *narrative review* of studies, published between 1987 and 2017, addressing the relation between spatial characteristics of the indoor play environment in early education and care (ECEC) settings and young children's social and cognitive behavior and development. The choice for a narrative review is motivated by the fact that only a limited number of studies addressing this relation were found, which, furthermore, focused on a wide variety of topics, making a systematic review or quantitative meta-analysis premature. Moreover, given the small number of studies on this topic, selecting studies based on rigorous methodological quality criteria, as is standard in systematic reviews and meta-analyses, would have resulted in only very few eligible studies.

First we will explain why such a review is appropriate and briefly describe how research into this topic evolved in the period before 1987.

1. ECEC quality and the physical environment

The quality of early childhood education and care (ECEC) settings is related to structural characteristics such as group size, adult-child ratio and teacher education (Burchinal et al., 2000; Phillips & Lowenstein, 2011). Whereas several studies have addressed the effects of these structural characteristics on interaction processes in the ECEC setting and child outcomes (e.g., NICHD Early Child Care Research Network, 2002; Pianta, Barnett, Burchinal, & Thornburg, 2009), the relationship

between the physical environment and children's outcomes is an understudied topic. Yet, both in recent research into child development and in the applied field of early childhood education and care there is an increasing interest in the influence of the physical environment on children's behavior and development. One line of study is motivated by the increasing awareness that the physical environment plays a critical role in children's cognitive and social development by affording opportunities for action, exploration and interaction (Iverson, 2010; Smith, 2005; Thelen, 2000). Research in this line is related to the theoretical perspective of embodied cognition, which focuses on relations between perception, action, sensorimotor cognition and the development of cognitive and linguistic skills (Garbarini & Adenzato, 2004; Smith, 2005). In this paradigm, acquiring knowledge about the spatial environment through exploration is assumed to be of central importance for children's cognitive and language development (Iverson, 2010; Oudgenoeg-Paz, Leseman, & Volman, 2014) as well as their social development, in particular perspective-taking skills (Creem-Regehr, Gagnon, Geuss, & Stefanucci, 2013). This research aligns with ideas and principles of ecological psychology (Gibson, 1986), the core of which is the concept of affordances: the idea that objects and spaces offer opportunities for action relative to what a person can perceive and perform. Thus, affordances are defined by both the object (or the spatial lay-out) and the acting agent (E.J. Gibson, 1988). A second line of study is motivated by a growing concern about children's health, especially

* Corresponding author.

E-mail addresses: inevanliempd@akta.nl (I.H. van Liempd), O.Oudgenoeg@uu.nl (O. Oudgenoeg – Paz), P.P.M.Leseman@uu.nl (P.P.M. Leseman).

regarding the observed lack of physical activity as a possible cause of overweight and obesity in children (Hodges, Smith, Tidwell, & Berry, 2013; Monasta et al., 2010), but this topic is not within the scope of the current review.

The importance of the physical environment is also acknowledged in early childhood education and care practice, where the relation between the furnishing and spatial lay-out of the physical environment and children's behavior and development is recognized as an essential component of curriculum and pedagogy. This, for example, is reflected in the pedagogical approach of Reggio Emilia in which a well-designed esthetical space is seen as the "third educator" (Gandini, 1994; Musatti & Mayer, 2011), in curricula like Tools of the Mind (Barnett et al., 2008) and, much earlier, in the pedagogy developed by Maria Montessori (Montessori, 2013/2013). These approaches require specific environmental features, such as special furnishings or play equipment and activity areas. Furthermore, widely used instruments for measuring the quality of child daycare, such as the Infant-Toddlers Environment Rating Scale Third Edition (ITERS-3; Harms, Cryer, Clifford, & Yazejian, 2017) and the Early Childhood Environment Rating Scale Third Edition (ECERS-3; Harms, Clifford, & Cryer, 2014), comprise sections about spaces and furnishings, recognizing their importance as a quality characteristic (see also Abbott-Shim & Sibley, 1998). However, though being used as indicators for evaluating process and structural quality, little is known about the specific impact spaces and furnishings as such could have on ECEC quality and child outcomes.

In sum, whereas theoretical insights, quality assessment instruments and common practices in the field of center-based ECEC recognize the importance of the physical environment, knowledge is lacking about how children's social and cognitive behavior and their development are related to spatial characteristics of the indoor physical environment in center-based ECEC settings. To the best of our knowledge no systematic review on this topic has been published since the review by Moore (2002), who summarized results of studies published between 1970 and 1987. Therefore, given the rising interest in the effects of the physical environment on child development, a review of recent work on this topic is warranted.

2. Early studies (1970–1987)

Under the influence of the eco-behavioral approach, developed by Barker (1968), and the interdisciplinary approach of environmental psychology, research focusing on the relations between the physical environment in which children grow up and their behavior and development prospered for a short period of time around 1980. Barker's concept of behavior settings implies that both the social and the physical environment influence behavior, and it stresses the importance of studying behavior in the natural setting in which this behavior normally occurs (Barker, 1968). In about the same period, James Gibson developed the principles of what came to be known as ecological psychology, building on his previous work on perception-action couplings as the basis of human cognition (Gibson, 1986). Both Barker and Gibson concluded that, in studying person-environment relations, researchers need to take into account characteristics of the environment, of the person, and of the actions of the person concerned (Heft, 1988). In his ecological systems theory Bronfenbrenner (1979) also emphasized the importance of studying children in their natural, ecological environment, stipulating that child development does not occur in a physical-social void but is co-determined by the characteristics of the immediate environments (such as the family, but also the ECEC setting), and indirectly via these environments by factors at the meso- and macro-system level. These theoretical perspectives have been applied in different empirical studies into the relation between the quality of the space in early childhood education and care settings, and children's behavior.

A dominant theme of study in ECEC physical settings has been the effect of *density*, commonly defined as the amount of space available to

a group, on children's social behavior (e.g. Fagot, 1977; Rohe & Patterson, 1974; Smith & Connolly, 1980). A review by Driscoll and Carter (2004) of twelve studies on density conducted between 1970 and 1987 showed that researchers differed considerably in their definitions of high vs. low density. This, and other methodological issues, complicated a straightforward interpretation of the seemingly inconsistent findings in the reviewed studies.

Another theme of study concerned the layout of the play space in child daycare centers (Field, 1980; Moore, 1986). Moore (1986), going beyond a characterization of the play space in mere square meters, introduced the concept of *well-defined settings*, referring to recognizable areas within the playroom or classroom that are limited to a single type of activity and well-equipped with relevant materials, as opposed to poorly defined settings that are lacking these resources or are not suited for a particular activity. He found that exploratory behavior, social interaction and cooperative behavior occurred more frequently in well-defined settings than in ill-defined settings. Also the availability of play resources (e.g., toys, construction materials) has been found to affect children's behavior (Rohe & Patterson, 1974; Smith & Connolly, 1980). Aggressive behavior increased if more children had to share the same play resources, and, conversely, cooperative behavior increased if more equipment was provided to a particular group of children.

In 1987, an edited collection of articles on the relation between the built environment and children's development marked a milestone in the field, describing the state of knowledge regarding the impact on children of various environments, including early childhood education settings (Weinstein & David, 1987). By combining theoretical and methodological issues with empirical research outcomes, and by identifying topics for future research, this publication can be regarded as the most complete synthesis of knowledge concerning the relation between children and the built environment until then. Another landmark publication in this field was the comprehensive narrative review by Moore (2002) of the extant research until 1987 on the relation between the physical environment and young children's behavior and development in early childhood education and care settings. In Moore's review, studies were summarized that focused on several aspects of the physical environment as discussed above, and also on characteristics such as the overall center size, group size and child-caregiver ratio, and how they impacted on children's task-focused behavior and involvement. However, although these topics can be considered to be related to the physical environment, assuming, for example, that group size is related to the size of the space, direct evidence linking the physical environment to children's behavior was lacking in these studies.

In conclusion, empirical research into the physical environment in early childhood education settings, published between 1970 and 1987, addressed different topics such as density, number of square meters and spatial layout, and suggests that there is a relation between the physical environment and children's behavior and development.

3. Current review

In view of a renewed interest in environment-behavior studies in early childhood education and care provisions, both driven by new theoretical insights and by a growing interest of the child daycare sector as well, we conducted a review of the studies on the indoor physical play-environment of ECEC settings and its relation with young children's behavior and development that were published since 1987 until 2017. We focused specifically on studies that examined spatial characteristics of the physical environment that define the space children can use. Spatial characteristics as defined in this review refer to the spatial arrangement of the indoor play-environment (Legendre & Fontaine, 1991; see also; Moore, 1986), including aspects such as: the placement of furnishings and play-equipment in the playroom, providing for separate zones and activity areas, the number of square meters, functional and esthetical quality, and the design of activity areas (type, physical properties and variety of activity areas).

In this review we aim to discuss the research of the last thirty years into the relation between spatial characteristics of the indoor physical environment in early childhood education and care settings with young (0- to 6-year-old) children's behavior and development. We focus on the following questions:

1. Which spatial characteristics have been examined?
2. How are different spatial characteristics of the indoor physical environment related to social and cognitive behavior of young children, and their development in these domains?

4. Method

4.1. Search strategy

Studies in this review were found by conducting a search in the digital databases PsycInfo, ERIC and Web of Science. An additional search was conducted in Google Scholar, by going through the first 200 results provided upon entering keywords. This was considered as sufficient as Google Scholar does not have much added value beyond this number when the purpose is to find peer-reviewed papers, most of which are already indexed in databases such as Web of Science (Haddaway, Collins, Coughlin, & Kirk, 2015). The following combinations of keywords were used: terms related to child behavior (behavior, behaviour, activit*, involvement, play), terms related to the physical environment (space, environment*, play area, indoor, design*, furnish*), and terms related to the type of institution (child care, childcare, preschool, kindergarten, daycare, early childhood). Asterisks are options in the search strings that enable also variations of the key terms to be found. In addition a search was performed in three journals with a special focus on environment and behavior: the Journal of Environmental Psychology, Environment and Behavior, and the electronic journal Children, Youth and Environments. A second phase consisted of searching for references to other studies in the obtained studies.

4.2. Inclusion criteria

Studies were included in this review if they met three criteria. First, studies had to relate to early childhood education and care settings, and had to examine relations between spatial characteristics of the indoor physical environment and children's social or cognitive behavior, or children's development in one or both of these domains. Second, children in the studies had to be between zero and six years of age. Finally, papers had to be peer-reviewed and published in English in the period between January 1987 and December 2017. We excluded publications that did not report original empirical research and studies reporting research carried out in a lab situation. Studies that measured the overall quality of early childhood education and care settings using global instruments (e.g. ECERS-R, Harms, Clifford, & Cryer, 2005), comprising some aspects of the physical environment next to other features such as program structure or quality of staff, but not reporting separately on these physical aspects in the study, were also excluded. Likewise, if a study focused on both the indoor and the outdoor physical environment, it was included only if separate data were reported for the indoor environment.

A first selection was made based on a combination of keywords in the titles, resulting in 2522 hits in the digital databases. After screening for duplicates, we found 127 articles that were assessed for eligibility, based on reading of the abstracts. Of these articles, 108 studies were rejected because they did not meet the criteria for inclusion, for instance because articles were not peer-reviewed, focused on the outdoor environment or on physical activities only (e.g., Gubbels, Van Kann, & Jansen, 2012), or were not reporting original research, leaving 19 studies that were included in the current review. Two publications pertained to the same intervention study, but were both included as

they reported on different outcomes (Legendre, 1999; Legendre & Fontaine, 1991).

4.3. Coding of study characteristics

Relevant information was extracted from the selected studies using a coding scheme, consisting of four sections. First, studies were coded in terms of setting (preschool, kindergarten, daycare center), number and age of participants, and number of centers involved. The second section related to spatial characteristics. Building on earlier studies (Maxwell, 2007; Prescott, 1987), spatial characteristics were coded in four sub-categories: available square meters per child, design of activity areas (type and variety, spots for group- and solitary play, spots for privacy, circulation space for moving from one spot to another), spatial arrangement (layout of furnishing and play areas within playrooms), esthetical and functional quality of space (color, texture, tidiness, storage, accessibility for children). The third part of the coding scheme involved methodological characteristics of the study. A study was coded as correlational if relations between aspects of the physical environment and child behavior were examined without implementing changes in the environment. A study was categorized as quasi-experimental if an intervention in the physical environment was involved, for instance by rearranging furnishings or by introducing new spatial objects, and a comparison with an equivalent, but not randomly assigned control group was applied, or when a pre-post intervention comparison without control group was used. A study was categorized as experimental if random assignment was used. The fourth and final part of the coding scheme related to the outcome measures of the study regarding children's behavior and development. Reported outcomes were categorized in three domains: cognitive play and development (e.g., problem solving ability, intelligence, development of language, literacy, math, daily life skills), social behavior and development (e.g., social play, interaction with adults, interaction with peers, problem or positive behavior), and exploratory behavior. Following Moore (1986) we defined exploratory behavior as an activity that is aimed at investigating a (new) object, person or setting. The quality of exploratory behavior can be measured by assessing the degree of involvement in the activity.

4.4. Reliability

All studies were independently coded by two researchers. Codes were compared and discrepancies were discussed until agreement was reached. Inter-coder reliability was evaluated with Cohen's kappa for nominal variables and the intra-class correlation coefficient (ICC, absolute agreement) for interval variables. Inter-observer reliability was satisfactory to excellent, with Cohen's kappa varying between 0.64 and 1.00 (mean = 0.87), and the ICC being 1.00. Most studies identified in the search included multiple outcomes reflecting different aspects of the hypothetical relation between the indoor physical environment in center-based ECEC settings and child outcome measures. Studies were classified according to their main child outcome measures, resulting in 13 studies with a focus on social behavior and development, and six studies with a focus on cognitive behavior and development. No studies were found with a main focus on exploratory behavior, although some studies also reported outcomes on children's involvement in (exploratory) play.

4.5. Study demographics and design

The ages of participants ranged from six months to six years, but most studies (17) concerned children between two and six years of age. Only two studies pertained to children younger than 12 months. Studies were conducted in Brazil, Canada, France, Italy, Malaysia, Turkey and the US. No experimental studies were found. Seven studies had a quasi-experimental design. In these studies, part of the physical environment

Table 1
Main characteristics of studies included in the review.

Study	Participants	Study design	Spatial characteristics	Type of behavior	Outcomes
Abbas, Othman, and Rahman (2012)	N = 494; 20 groups in 10 preschools. Age range 5-6 years, means not reported	Correlational, contrasting groups	Well-defined, poor defined classrooms	Appropriate, inappropriate, non-interactive and appropriate interactive behaviors during free play	MANOVA tests showed that appropriate ($F = 8.798, p \leq .002$) and interactive ($F = 4.892, p < .021$) behaviors occurred significantly more in well-defined classrooms than in moderately or poorly defined settings
Acer, Gözen, Firat, Keçeli, and Aslan (2016)	N = 4 to 13; 1 group in 1 preschool. Age 5 years, means not reported	Quasi-experimental pretest and post- test	Rearrangement of open classroom (one learning center at tables) vs. classroom with designated learning centers	Proportion of social, parallel and individual play during free play time	Frequencies were calculated, indicating an increase in solitary play and a decrease in parallel play in the classroom with designated learning centers. No further analyses were executed
Burgess and Fordlyce (1989)	N = 12; 1 group in 1 daycare center. Age 22-32 months ($M = 25.4, SE = 1.1$)	Correlational	Open arrangement classroom vs. classroom with visual barriers	Child-to-peer and child-to-adult proximity during free play	Three-factor repeated measures analysis of variance showed no significant change in distance to peers in open vs. visually restricted classroom. In visually open classroom children stayed significantly closer to nearest teacher
Campos-de-Carvalho & Rossetti-Ferreira, 1993	N = 28; 2 groups in 2 daycare centers. Age range 19-35 months, mean = 28 months	Quasi-experimental pretest and posttest in both groups	Open arrangement vs. semi-open arrangement	Use of space and child-to-adult proximity during free play	Wilcoxon's matched-pairs signed-ranks test showed that circumscribed zones were used significantly more than open zones ($T = 2, p < .005$).
Harper and Huie (1998)	N = 244; 6 groups in 6 pre-schools and daycare centers Age 3-5 years, means not reported	Correlational (observations during 7 years)	Use of activity settings during free play	Social, parallel, individual play, contact with adult during free play. Different use for gender and age	Friedman two-way analysis showed that zone near adult was used significantly more in open than in semi-open arrangement ($\chi^2 = 10.5, p < .006$)
Kantrowitz and Evans (2004)	N = 21; 3 groups in 3 daycare centers Age range 4-5 years ($M = 48.6$ months, $SD = 7.9$)	Correlational	Amount of space and number of activity areas	Off-task behavior, social, parallel and solitary play. Functional, constructive, dramatic play during free play	Expected amount of time use of activity settings, calculated with binomial tests of significance, assuming $p = .5$ showed mostly parallel play at the art setting (74.7%, $p < .001$), social play in housekeeping setting (76.2%, $p < .0001$), play with adults in cooking setting (84.2%, $p < .0001$), solitary play in cubby area and bathroom (87.2%, $p < .0001$). Age differences approached significance, $F(9, 91) = 1.908, p = .06$. Younger children ($p < .063$) spent more time in music/gross motor areas, older children in arts
Legendre (1999)	N = 45; 3 groups in 3 daycare centers. Age range 21-37 months ($M = 27, SD = 3.9$)	Quasi-experimental pretest and posttest in all groups	Spatial arrangement: visually open-zoned vs. visually restricted. Three sectors: adult-distant, intermediary, adult- proximal	Child-to-peer proximity and proportion of positive interaction during free play	A proc-mixed procedure showed a marginal increase of constructive play if child/activity (c/a) area ratio was lower ($b = -.13, SE = .08, t = -1.61, p < .11$). No significant relation between c/a area and social, solitary, parallel play. If c/a area ratio was higher, (more children shared these areas) more time spent in off-task (less involvement in play): $r = .440, p < .01$. No effects for SES

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Table 1 (continued)

Study	Participants	Study design	Spatial characteristics	Type of behavior	Outcomes
Legendre and Fontaine (1991)	N = 45; 3 groups in 3 daycare centers Age range 21–37 months (M = 27, SD = 3.9)	Quasi-experimental pretest and posttest in all groups	Spatial arrangement: visually open-zoned vs. restricted. Three sectors: adult-distant, intermediary, adult-proximal. Household area: with vs. without visual barrier	Time spent in social interaction and attention, peer-oriented behavior, friendly interactions and conflict during free play	ANOVA showed children spent more time in adult-distant sector in open arrangement ($F(1, 42) = 27.47, p < .001$). More time spent in social interaction/attention ($F(1, 42) = 4.74, p < .05$) and peer-oriented behavior ($F(1, 42) = 5.95, p < .025$) in open arrangement. More friendly interactions in open arrangement ($F(1, 42) = 9.36, p < .01$). In visually restricted areas more time was spent in conflict ($F(1, 42) = 6.53, p < .025$). More time was spent in peer interactions in housekeeping area without barrier ($F(1, 15) = 9.86, p < .01$)
Lowry (1993)	N = 33; 2 groups in 2 daycare centers Age range 3–5 years, means not reported	Quasi-experimental, no pretest	Introducing two types of privacy spaces: closed vs. open structure, tested in two centers with different density (sq. ft. per child)	Use of privacy spaces for solitary and interactive play during free play	T-tests show a significant preference for solitary play in the closed structure ($M = .31, SE = .05$) than in open structure ($M = .10, SE = .03$). $p < .0007$ ($t = 3.2589$) ($df = 1154$), $N = 78$ in the high density group. No significant difference found in low density room. Interactive play occurred significantly more in the closed structure ($M = .25, SE = .06$) than in open structure ($M = .04, SE = .02$). $p < .0001$ ($t = 4.0084$) ($df = 1105.8$), $N = 78$ in the high density group. No significant differences were found in the low density room
Mashburn (2008)	N = 540; 124 groups in 124 preschools Age 4 years, means not reported	Correlational. Children's development was rated by using a pre-test in the first 2 months of preschool and a posttest after 6 months	Quality of space (ECERS-R: spaces and furnishings)	Academic achievement (Woodcock-Johnson III test of Achievement, 1990), language skills (PPVT, 1997 and OWLS, 1995), emerging literacy (Story & Print Concepts, 1998)	Hierarchical linear modelling showed that low SES children's academic skills were higher in centers with high quality of space ($B = 2.42, SE = .92, p < .01$). Interaction between race/ethnicity and quality of space was significant for literacy skills ($B = .47, SE = .23, p < .05$)
Maxwell (1996)	N = 114; 8 groups in 7 daycare centers Age range 46–66 months, median 57 months	Correlational	Amount of space per child (M = 36 sq.ft. range: 27.3–52.3 sq.ft. Home density was co-variable	Cognitive competence with Preschool Inventory (Caldwell, 1970) and Children's Embedded Figures Test (CEFT) and emotional/behavioral problems with Behar Springfield Behavioral Problems Scale (1974)	Analysis of variance (ANOVA) showed that children scored higher on CEFT in centers with more space per child (low-density): ($t = .000$). Behavioral problems were highest in centers with high density ($t = 4.981, p < .001$)
Maxwell (2007)	N = 79; 8 groups in 4 daycare centers Age range 36–48 months (M = 52.7)	Correlational, contrasting groups	Classroom physical quality measured by the Classroom Rating Scale (social spaces, boundaries, privacy, personalization, complexity, scale, and adjacencies)	Cognitive (McCarthy's Scale of Children's abilities, 1972) and social competence (Pictorial Scale of Perceived Competence and Social Acceptance, 1984)	A linear regression model showed that cognitive competence in 3-year-olds classrooms was higher in classrooms with higher physical quality ($B = 43.06$ [14.31], $p < .004$). No significant relation was found for 4-year-olds classrooms. Higher perceived competence was significantly related to higher scores on subscale 'adjacencies'.
Musatti and Mayer (2011)	N = 12–14; 2 groups in 1 daycare center Age range 9–14 months (first year), 22–28 months (second year); means not reported	Correlational (case study: one group observed during two years using first infant- and then toddler room)	Spatial arrangement of furniture and play materials: well-defined and structured in both infant- and toddler room	Social and cognitive processes and relation to toddler's independent locomotion during free play	Qualitative study. Toddlers were using well-defined areas. In the first year mainly gathering around teacher, not much movement. In the second year clustering and sharing attention in three well-defined activity areas initiated or followed by teacher
Neuman and Roskos (1990)	N = 37; 2 preschool groups Age range 4–5 years, means not reported	Quasi-experimental using pretest and posttest in both groups	Redesigned classroom defining play areas by using boundaries, labels, rearranging and redefining, and adding literacy prop.	Literacy play activities during free play	Qualitative study observations showed that after intervention literacy became more interactive, activities more purposeful and complex. Interactions with peers and teachers increased

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Table 1 (continued)

Study	Participants	Study design	Spatial characteristics	Type of behavior	Outcomes
Pellegrini and Perlmutter (1989)	N = 86; 3 groups in 1 preschool Age range 26–68 months (group 1: M = 37.35, SD = 4.93; group 2: M = 48.95, SD = 2.60; group 3: M = 60.16, SD = 4.29)	Correlational	Play areas: replica, art and blocks	Social-cognitive aspects of play during free play time. Focus on functional, constructive and dramatic play; solitary, parallel and interactive play, and gender	MANOVA showed a significant effect for play area on play behavior: $F(4, 322) = 2.39, p < .05$. Children engaged in dramatic & interactive play in the replica area and in constructive & solitary play in block and arts areas. Chi-square analysis showed that boys used the block area more frequently: $\chi^2(2, N = 86) = 15.26, p < .0001$, and girls the art area $\chi^2(2, N = 86) = 23.51, p < .0001$. Multiple chi-square analyses showed more solitary play in solitary-designed settings $\chi^2(1, N = 31) = 20.47, p < .05$. More group-play occurred in group-designed settings $\chi^2(2, N = 31) = 9.94, p < .05$, more dramatic play in redesigned settings $\chi^2(1, N = 31) = 8.86, p < .05$
Petrakos and Howe (1996)	N = 31; 2 groups in 1 daycare center. Age range 43–64 months (M = 56.9)	Quasi-experimental pretest and posttest in both classrooms	Redesign of dramatic play settings	Social and solitary play, dramatic play during free play	Qualitative study showing that tables were most used for solitary, parallel & interaction w. teacher. Spaces without resources were hardly used. Access to affordances altered the propensity and type of interactions. Boys showed different types of social activities in different spaces, girls did not. Changes in population resulted in shifts in hotspots for social and solitary play
Torrrens and Griffin (2012)	N = 84; several groups in 1 pre- school Mean age 44.9 months (SD = 0.90)	Correlational (case study with observations during 2.5 years)	Indoor areas and specific design features	Social interaction (solitary, parallel, social, teacher-oriented) during free play, and gender differences	Outcomes showed positive correlation between positive rating ($r = .47, p < .001$) and frequency ($r = .31, p < .01$) of caregiving and higher quality of the physical environment
Vandell (1996)	N = 105; number of groups and centers not reported Age 6 months	Correlational	Quality of indoor environment based on: cleanliness, safety, crowdedness, clutter, appropriate variety of toys, protected and quiet play areas (measured by a subset of the Assessment Profile for Early Childhood Programs (APECP); Abbott-Shim & Sibley, 1998)	Caregiver-child interactions: positive caregiving frequencies (positive, responsive and stimulating behavior), measured by the Observational Record of the Caregiving Environment (ORCE; NICHD, 1996)	
Wachs et al. (2004)	N = 86; 23 groups in 8 preschools Age range 31–78 months (M = 50.3, SD = 11.6)	Correlational	Environmental chaos (measured by Life in Early Childhood Programs (LECP); Kontos & Wilcox-Herzog, 1997), after statistical correction for temperament, childcare quality and use of control	Committed, situational and passive non-compliance during cleaning-up and group times	Hierarchical regression analyses showed that environmental chaos (LECP) negatively related to situational compliance ($\beta = -.29, p < .05$). Passive noncompliance was positively related to environmental chaos ($\beta = .42, p < .01$), more for boys than girls. No significant relation was found for committed compliance, except for boys

was modified and changes in children's behavior were observed. Six of these studies used a pre- and posttest design, one study only tested child outcomes after the intervention. Twelve studies were correlational and studied the relation between spatial characteristics of existing indoor play environments and children's behavior or development. Two of these studies used a design with contrasting groups. Three correlational studies were longitudinal, with observations covering a relatively long period of time, ranging from two to seven years. In [Table 1](#) the main characteristics and results of the studies included in this review are summarized.

The findings from the included studies are presented using a narrative approach. This type of review summarizes and synthesizes independent studies that focus on the same topic, thus providing insight in the current state of knowledge, and can identify leads for future research.

5. Results

Studies into the relation between behavior and the indoor play environment focused on different aspects of the physical environment and different types of behavior.

Twelve studies reported on the social economic status (SES) of the parents (not included in [Table 1](#)). Two of these studies involved low SES families, six involved middle class families, while in four studies both low and middle class families participated. Six studies reported on ethnicity. Two of these studies involved white (middle class) children, four studies children from both white and non-white families.

Only four publications explicitly referred to a theoretical concept as a basis for the study. Two studies referred to Bronfenbrenner's ecological theory of child development ([Musatti et al., 2011](#); [Wachs, Gurkas, & Kontos, 2004](#)). One study ([Legendre & Fontaine, 1991](#)) used Bowlby's attachment theory ([Bowlby, 1988](#)) to investigate caregiver's proximity as related to environmental characteristics. The study by [Pellegrini and Perlmutter \(1989\)](#) referred to [Lewin's \(1954\)](#) context-theory, stating that children's behavior is a function of personal and physical variables.

The majority of outcomes reported were relating to social behaviors and social development. Therefore we first review the studies that focused on this domain, and then look into studies with a focus on cognitive behavior and cognitive development.

5.1. Social behavior

Social behavior was the main focus in 13 studies. Twelve studies reported child behaviors during free play, one study ([Wachs et al., 2004](#)) focused on clean-up activities and teacher-guided group time. The studies reported mainly about the relations of social behavior with the spatial arrangement, activity areas, and overall quality of space. Below we discuss these studies in more detail.

Spatial arrangement and peer interactions. Four studies reported effects of the spatial arrangement, that is the layout, furnishing and play equipment of a playroom, with creating separate zones or activity areas, on peer interactions. In one study, among 2- to 3-year-olds, existing furniture was rearranged, creating a visually open arrangement with activity areas with low boundaries that allowed children to oversee the whole room. This arrangement was compared to a visually restricted arrangement, in which children were not able to see the entire playroom if they were in an activity area. Outcomes showed that children stayed closer to one another and had more friendly interactions in the open-zoned arrangement ([Legendre, 1999](#)). The open-zoned arrangement also elicited more social interaction. Children's behavior was more peer-oriented and children were watching other children more often in open-zoned areas, while more conflict situations occurred in the visually restricted areas. After removing an 80 cm high barrier in front of the housekeeping area in the playroom, positive peer-interactions in this area increased significantly ([Legendre & Fontaine, 1991](#)). A correlational study, also among 2- to 3-year-old children, with access to

two classrooms of similar size, one with an open arrangement and one with three low (80 cm) cupboards as visual barriers, showed only a minimal effect of the visual dividers on children's proximity to one another. Other types of interactive peer-to-peer behaviors were not reported ([Burgess & Fordyce, 1989](#)). In a study among 5-year-olds, a classroom with only tables in the center and cupboards along the wall was reorganized in an arrangement with various zones with designated activity areas. No changes in the number of social interactions were observed, but the frequency of solitary play increased while the frequency of parallel play, that is, play near but not with another child, decreased. However, no statistical data were provided, making evaluation of the outcomes difficult ([Acer et al., 2016](#)).

The three studies discussed above that used an intervention to create zoned arrangements consistently showed that changing the spatial arrangement affected children's social behaviors, but the outcomes across studies differed. The correlational study that found no effect of the presence of visual barriers, did not provide information about the spatial configuration, for instance if the barriers marked activity areas, which makes comparing the outcomes with those of the other studies difficult. Furthermore, the situation that was investigated was atypical, involving two large classrooms for one small group of children.

Spatial arrangement and caregiver-child interactions. Four studies examined the relations between changes in spatial arrangement and adult-child proximity. The previously mentioned study by [Legendre and Fontaine \(1991\)](#) showed that children spent significantly more time in the area most distant to the caregiver if they were still able to see the caregiver, that is in the open-zoned arrangement. In a study involving children between 1.5 and 3 years of age, where the intervention consisted of changing an open arrangement without zones into a semi-open arrangement with two activity areas with low (50 cm) visual barriers, children stayed closer to the adult in the open arrangement and moved further away from the adult in the semi-open arrangement ([Campos-de-Carvalho & Rossetti-Ferreira, 1993](#)). A similar result was found in the aforementioned study by [Burgess and Fordyce \(1989\)](#). Children stayed closer to the adult in the open arrangement. In a qualitative case study, involving children between 9 and 28 months of age, children's free play was observed during two consecutive years, in two playrooms with well-defined thematic units. The authors found differences in the use of play areas between infants and toddlers. Infants who were able to move independently by crawling or walking, tended to gather around the teacher and were not moving around very much. In contrast, toddlers were observed to move around between different well-defined areas with low or no barriers, gathering together and sharing attention in a well-defined activity area for more than 10 min before moving to another activity area. The teacher either initiated the activity or joined in a child initiated activity. Both the well-defined areas and the presence of the teacher were found to stimulate prolonged engagement in the activity ([Musatti & Mayer, 2011](#)).

In sum, although these studies differed in design and methodology, they focused on the same age-group, and outcomes quite consistently indicated that dividing the playroom in zones allowing children to keep visual contact with the caregiver, enabled children to move further away from the adult and, thereby, to use the space more fully than when there are either high visual barriers or when there are no barriers at all. An open-zoned spatial arrangement could thus encourage children's spatial and object exploration, as was suggested by the [Musatti and Mayer \(2011\)](#) study, which shows that especially when children get older, a clear zoning of areas fosters attention sharing and prolonged involvement in an activity.

Activity areas and type of play. Five studies focused on the link between activity areas, defined as an area within the playroom equipped for a specific activity with physical boundaries, and social behavior. A study using [Moore's \(1986\)](#) definition of well-defined versus ill-defined settings to assess 20 classrooms with children between 5 and 6 years of age, reported a higher occurrence of socially

appropriate and interactive behaviors in well-defined classrooms than in moderately- and poorly-defined classrooms, which corresponds to the outcomes reported by Moore (Abbott et al., 2012). However, no information about the criteria that were used to define classrooms as well-, moderately- or poorly-defined was reported. Moreover, presentation of statistical information was inconsistent, outcomes presented in tables differed from outcomes that were discussed. The results should, therefore, be treated with caution. A longitudinal study, among children between 3 and 5 years of age, reported considerable differences in the uses of activity areas for social, parallel and solitary play. The doll play/household area elicited mostly social play, whereas the arts setting was strongly related to parallel play. Foyers, cubby areas and bathrooms were places favored for being alone. Older children were more often involved in arts, whereas younger children spent more time in music and gross motor areas (Harper & Huie, 1998). In a paper reporting on three studies, involving children between 3 and 5 years of age, linking children's play behavior and use of play areas for arts, blocks and replica (dramatic) play, two studies involved the use of experimental (lab) playrooms. Only the results of the study that was executed in the context of real classrooms are discussed here. In the latter study, the results of three observation sessions across four weeks showed that children mostly used the arts and blocks areas for solitary play, whereas in the dramatic play area they were mostly engaged in interactive social play (Pellegrini & Perlmutter, 1989).

Two studies, both involving 3- to 5-year-old children, examined the effects of (re)designing an activity area on social behavior. One study introduced two 30 × 30 inch structures (one open and one closed) for creating privacy in two playrooms, which differed in density (number of children per square meters). In the high density playroom children favored using the closed structure for both solitary play and interactive play over the open structure, but both structures were used most often for solitary play. In the playroom with more space per child, both structures were favored equally and were mostly used for interactive play. However, the different outcomes should be treated with caution, because only two playrooms were involved, with different group sizes of 14 and 19 children, and with a big difference in the number of square meters per child. Girls were reported to use both structures more than boys, but data regarding significance levels and boys-girls ratio were not presented (Lowry, 1993). In the other study a dramatic play area was redesigned into an extended thematic play area, alternately furnished for solitary and group use, which led to more use for solitary and group play, respectively, and to an overall increase of dramatic play (Petraikos & Howe, 1996).

To summarize, all studies described above involved children older than 3 years of age, and except for the first study which did not differentiate between types of activity areas, consistently showed a link between the presence of one or more types of activity areas and children's social behavior. Dramatic play areas were found to elicit social play, provided they were designed to offer sufficient space for a group of children, as was shown by Petraikos and Howe (1996). In arts settings, investigated in two studies, children were found to play more often alone or near each other (parallel play). Overall, outcomes regarding solitary play showed mixed results. The study that included a range of activity areas found that, for solitary play, children mainly resorted to areas that were not designed for play (foyer, bathroom). The finding that special privacy structures in a high density playroom elicited mostly solitary play suggests that children need such a place to be on their own, especially if there is no other space for retreat. However, because the studies including solitary play as outcome only focused on part of the activity areas in their research and did not report on the characteristics of the remaining areas, the only conclusion regarding solitary play that can be drawn is that solitary play was not consistently related to specific types of activity areas, but that children maybe just need an area for retreat to play on their own. However, if an area was specifically designed for solitary use, it was used in that way.

Quality of space. Three studies focused on the indoor physical

environment as a whole. As part of the NICHD Study of Early Child Care and Development, a study was carried out among infants at 6 months of age, with a focus on positive caregiving as related to (among other aspects) the quality of the physical environment. Quality was measured by the Assessment Profile for Early Childhood Programs (APECP; Abbott-Shim & Sibley, 1998). Outcomes showed that a higher quality of the physical environment in daycare centers was strongly related to both a higher frequency and higher quality of positive caregiving behaviors (Vandell, 1996). Another study, investigating the relation between environmental chaos and children's compliance behavior showed (after statistical correction for child temperament, ECEC quality as measured by the ECERS-R (Harms et al., 2005), and teacher's use of control strategies) that children's situational compliance (obeying a request by an adult) was lower if there was more environmental chaos and child care quality was lower. Children's ages ranged between 2.5 and 6 years. More environmental chaos was also related to more passive non-compliance and, only for boys, to less committed compliance. The scale measuring chaos assessed teachers' perceptions of use of space, crowding, environmental traffic, and the degree of control and organization in the classroom (Wachs et al., 2004). In a longitudinal case study, involving 4-year-old children, children's use of space as related to social behavior was observed using a gridded map to code the child's location. Tables were found to be used mostly for solitary and parallel play, and for interactions with teachers. Transitional spaces without resources for play were hardly used, whereas resource-rich locations were used for various types of social activity (interaction, solitary, parallel play). A lofted area was popular both for social interaction and for solitary play. No observations of other specific activity areas were reported (Torrens & Griffin, 2012).

Although the three studies described above showed a relation between quality of space and social behavior, outcomes are difficult to compare because of differences in focus and age-group. The study on caregiver interactions with infants is especially interesting as it is the only study involving children this young, whereas the longitudinal design and exploratory character of the study by Torrens and Griffin (2012) offers new insights in the use of spatial attributes such as tables, that were not studied before. The study on (non-)compliance is of interest, because to the best of our knowledge it is the first study relating this type of behavior to the physical environment, while at the same time showing that the physical environment is also related to behavior in situations other than play, for instance during meal and group times.

5.2. Cognitive behavior and development

Besides focusing on social behavior, studies have also looked into the relation between the indoor physical environment and children's cognitive behavior and cognitive development. These studies report mainly about the relations between the use of designated play areas and types of cognitive play, or about the relations between the overall quality of the space and children's cognitive behavior and development.

Activity areas. Three studies examined the relation between activity areas and aspects of children's cognitive behavior. One study focused on the ratio of children, aging between 4 and 5 years, per activity area. These areas were defined as "section(s) of the learning environment described by specific materials and physical boundaries". Results show that, if more children had to share an activity area (high child/area ratio), children were significantly less involved in play activities and spent more time off-task (e.g., onlooking, lying on the floor, staring into the space). Following Moore (1986), this lower involvement could be interpreted as a lower engagement in exploratory play. No effects were found on the occurrence of social, solitary or parallel play. If fewer children had to share an activity area, this led to a marginal increase of time spent on constructive play, but no effects were found on functional or dramatic play. The increase of constructive play was to be expected, as constructive play, such as building with blocks or creating artwork, requires both free space and resources (Kantrowitz & Evans, 2004). In a

quasi-experimental qualitative study, investigating literacy development among 4- to 5-year-old children, four kinds of physical changes were introduced: demarcating play areas, labelling toy storage places, enriching areas by adding literacy props, and rearranging the playroom. After the intervention children were observed to be more engaged in literacy play, and literacy play was more interactive and situated than before (Neuman & Roskos, 1990). The study by Pellegrini and Perlmutter (1989) that was discussed earlier reported that children mostly used the art and blocks areas for constructive play, whereas in the dramatic play area they were indeed mostly engaged in dramatic play.

In sum, the outcomes of the studies described above show that engagement in an activity was related to the presence and design of special activity areas: if there were more activity areas per child, and if the areas were well-defined this increased involvement in activities. If the activity area had a recognizable function, for instance was designed for dramatic, constructive or literacy play, the activities taking place in the area strongly corresponded with these functions. This suggests that if the number of activity areas is low, or areas are not recognizable or ill-defined, children will be less involved in activities, which might hamper their exploratory behavior and subsequent learning and development.

Quality of space. Two studies related overall quality of the child centers' indoor space to cognitive development. The first study, among 4-year-old children of 124 preschools and Head Start centers, controlling for family-income and race/ethnicity, found that quality of space, as measured by the ECERS-R Spaces and furnishing scale (Harms et al., 2005), was positively related to academic skills of children of low SES families. These children's academic skills were rated as higher in centers with high quality of space than in centers with low quality of space. No such effects were found for overall quality as measured by the ECERS-R, which comprises of several other quality dimensions. Likewise, non-white children's literacy skills were higher in centers with a high quality of space than in centers with low quality of space. However, no relations between the global quality of space and children's academic and literacy skills were found for high SES or for white children (Mashburn, 2008). In a second study, classroom physical quality was rated testing a new instrument, the Classroom Rating Scale (CRS), in four classrooms with 3-year-olds and four classrooms with 4-year-olds. Children were predominantly Caucasian with parents with a college degree. Children's tested cognitive competence and self-perceived competence were the dependent variables. In the classrooms with 3-year-olds, a higher quality of space was related to higher tested cognitive competence. In both age groups, children's self-perceived competence was specifically related to the subscale Adjacencies of the CRS, meaning that children rated themselves as more competent if they had easy access to play materials, toilet areas, and other in- and outdoor play areas (Maxwell, 2007).

Thus, both studies found interesting effects of the overall quality of the child center's space on children's cognitive competence. The outcomes of the first study, with children of different backgrounds, indicate that children's cognitive competence might be less affected by spatial quality, if they are from high SES or from white or Caucasian families. An interesting finding from the second study was that supporting children's autonomous play behavior, by giving them access to sources for play and personal care, made children feel more competent. The difference in outcomes between the two age groups could indicate that younger children are more susceptible to influences of the physical environment, but additional research is needed to corroborate this finding.

Quantity of space. One study, investigating the amount of available space per child, showed that children's cognitive competence was higher in centers with more space per child than in centers with less space per child, whereas behavioral problems were highest in centers with less space per child. Density at home was used as a covariable. All children were from low-to middle-income families, living in an urban-

metropolitan area, and their ages ranged from 4 to 5 years. The interaction effect of home and center density was not significant for cognitive competence. Yet, children living in high density homes who were enrolled in high-density centers scored significantly higher on behavioral problems than children who lived in low density homes and visited high density centers, and vice versa (Maxwell, 1996). Note that group sizes in this study ranged from 16 to 23 children, but that the number of teachers per group was not reported. Therefore, we cannot rule out that the effects that were found are, at least partly, due to differences in group size and adult-child ratios.

6. Discussion

In this paper, we reviewed studies published in the last 30 years relating spatial characteristics of the indoor physical environment in center-based early childhood education and care to young children's social and cognitive behavior, and their development in these domains. The studies focused on different aspects of the indoor environment and addressed mainly social and cognitive behavior. Only three studies specifically addressed children's development, and only in the cognitive domain (Mashburn, 2008; Maxwell, 1996 and 2007).

6.1. Spatial arrangement

An interesting finding of a number of studies that examined the relation between spatial arrangement and social behavior, was that young children of 2–3 years of age felt more free to move further away from the caregiver if the room was divided in open zones so that they could keep eye-contact with the caregiver. The results suggest that young children need the security of being able to see the caregiver. At the same time such a spatial arrangement apparently encourages children to use the space more fully, and, thereby, enables them to autonomously explore the physical environment, which is regarded of central importance for cognitive and language development (e.g., Ginsburg, 2007; Iverson, 2010; Oudgenoeg-Paz et al., 2014). It would be worthwhile to extend research into the role of spatial arrangements to older children, for example 4- to 6-year-olds, because it is conceivable that at this age children do not so much need the security of visual eye contact with the caregiver as they do need the privacy and the feeling of competence to play with peers out of sight of the caregiver (Weinstein & David, 1987).

6.2. Activity areas

The outcomes of studies that investigated the effect of specific activity areas suggested that not only the theme of a play area affects the type of social behavior, but also the design of that play area. Solitary play was overall an understudied aspect in the studies that were included in this review. However, the findings indicated that if a 'special' place was created where children could play alone, this place was rather frequently used for solitary play, and if such a place was not present, children turned to other (non-play) areas to be alone. This suggests that children need a place to be alone where they are enabled to play uninterrupted, as has been previously suggested in the literature (Prescott, 1987; Wachs & Gruen, 1982), or possibly to withdraw from overstimulation (Olds, 1987).

The studies relating cognition to activity areas were not easily comparable with regard to focus and design. The outcomes of the study that focused on literacy development are in line with the outcomes of an experimental study by Morrow (1990), which did not include spatial-physical changes in the playroom and was for that reason not included in this review. The study by Kantrowitz and Evans (2004) is of interest and should be replicated. If indeed off-task behavior increases when there are insufficient activity areas, as this study found, it would be interesting to know if there is a certain threshold in the child/activity area ratio that should be considered. Adding Moore's (1986)

classification of well-defined vs. poorly-defined settings to such a study could possibly lead to a better understanding of the relation between behavior and activity areas.

6.3. Quality and quantity of space

The studies that reported on the relation between the overall quality of space and children's behavior, focused on different aspects of behavior. Therefore, the outcomes are difficult to integrate. A problem of using global measures to investigate the relations between the physical environment and children's behavior and development, is that, although adequate psychometric properties have been reported for the most frequently used instrument, the ECERS-R, the diverse set of items involved in this instrument makes it difficult to assess which specific physical components affect child outcomes most. As the subscale analysis of the CRS instrument (Maxwell, 2007) suggests, some spatial characteristics may relate to children's competence development, whereas others do not.

The studies reporting an association between the amount of space available per child (density) and children's social and cognitive behavior, should be treated with caution because of the small sample sizes in one study and the differences in group sizes between both studies. The findings concerning density and problem behaviors are in line with earlier studies by Smith and Connolly (1980) and Rohe and Patterson (1974). However, the effects that were found could be equally well related to the available space per child as to the number of children in the group.

6.4. Demographic characteristics

Studies in the present review stem from different continents, but most of them were conducted in the United States. Although 12 studies reported information on the socioeconomic background of the children, only one study (Mashburn, 2008) reported interaction effects of SES with spatial characteristics, finding that academic skills of children from low SES families were higher in centers with a higher quality of space. Future studies should further investigate relations between spatial characteristics and SES. This fits with Bronfenbrenner's bio-ecological approach as it shows how factors at different system levels may interact in children's development. SES is a factor at the exo-system level that influences development in the micro-system of the family. The stronger effect of spatial quality of the ECEC center on low-SES children suggests that the quality of the ECEC center can compensate for lower quality of the home environment (Raudenbush & Eschmann, 2015). Various studies have indeed shown that high quality early education and care especially benefits children from lower socio-economic backgrounds (Heckman, Moon, Pinto, Savelyev, & Yavitz, 2010). The Mashburn study suggests that this also applies to quality of space as a component of overall quality of ECEC settings.

The present review furthermore showed that studies involving very young children, below age 2, in early childhood education and care settings are rare. Remarkably, we found no studies relating activity areas to children's social or cognitive behavior that involved children younger than 3 years of age. Although in daycare practice it is quite common to create areas for specific activities (for example, construction, arts, pretend play areas) for infants as well as toddlers, how these areas should be arranged, and whether this affects young children's behavior and development, has not been a subject of recent studies. In the same vein, it is remarkable that no study into the relation between spatial characteristics and cognitive behavior or cognitive development pertained to children below age 3. The relation between the physical environment and young children's sensorimotor development, cognitive development and language acquisition has been a topic of recent studies in infants and toddlers in both the home environment and in lab situations (e.g., Clearfield, 2010; Clearfield, Osborne, & Mullen, 2008; Thelen, 1994). This line of study should be expanded to center-based

early childhood education and care.

Differences between boys and girls in relation to spatial characteristics were investigated in only four studies, and addressed very different topics. It is not clear if space as such caused the reported differences in behavior between boys and girls. Several studies have shown that differences in teachers' attitudes towards boys and girls can affect children's behavior as well, regardless the spatial characteristics (e.g., Beaman et al., 2006). Therefore, studies relating gender to spatial characteristics should also look at the role of the teacher.

6.5. Theory and methodology

Research into the relation between children's behavior and development and the physical environment requires a strong theoretical framework. Most studies in this review did not present a clear theoretical foundation. It is remarkable that none of the reviewed studies used Gibson's concept of affordances, a concept that has been applied in various studies regarding children's use of the outdoor space (e.g. Drown & Christensen, 2014; Kernan, 2010). Nor did the studies in this review refer to the theoretical approach of embodied cognition. This theory, which defines movement, action and perception as primary ways to explore and learn about the world and would be a good candidate for a unifying theoretical framework (Creem-Regehr et al., 2013; Soska, Adolph, & Johnson, 2010). In this line of thought, children's development is embodied and embedded, and learning new cognitive and social skills is related to both the child's current bodily status and to the possibilities for (social) action the physical environment offers.' Two studies referred to Bronfenbrenner's bio-ecological theory (Musatti & Mayer, 2011; Wachs et al., 2004) studying interactions between children and their proximal social (other children, caregivers) and physical environment. While all these theoretical concepts focus on the interaction between children and the physical environments, they differ in their emphasis on the role of spatial characteristics and social processes in children's development.

Most studies retrieved for this review were field studies, in line with Gibson's and Bronfenbrenner's suggestion that behavior should be studied in the child's natural setting. This may also partly explain the lack of truly experimental studies, since it is difficult to conduct (randomized) experiments in practice. Also the limited theory building in this field, from which clear testable hypotheses could have been derived, may explain the lack of experimental studies. Future studies should use experimental designs with clear hypotheses derived from theory to be able to draw grounded causal conclusions from study findings (Marczyk, DeMatteo, & Festinger, 2005). The present review of literature, by giving an overview of what is already known, can contribute to the development of this urgently needed theoretical framework.

6.6. Implications for practice

Although the studies included in this review were too diverse and suffered from several limitations to draw firm conclusions, some consistent findings are of interest for practice. Particularly the spatial arrangement (e.g., the layout of the playroom and the furnishing with play equipment, providing separate zones and clearly recognizable activity areas) shows a strong relation with, especially, young children's social behavior. Daycare educators wanting to encourage young children's autonomous exploration of the playroom and to stimulate peer interactions should create playrooms that are divided in zones by way of low visual barriers, where children can see the caregiver, but also find a variety of designated, appropriately equipped play areas. Outcomes from several studies also suggest that enriching existing activity areas, by adding materials that can trigger children's exploration, can positively affect children's social and cognitive behavior. Findings also showed that offering a variety of activity areas may foster diverse social and cognitive behaviors, and support holistic child development. In addition, daycare centers should be more aware of children's need

not only to interact with others, but also to be enabled to play or be alone. However, more research is needed into the exact relation between children's social, cognitive and exploratory behavior and development, and the indoor physical environment in early childhood education settings.

6.7. Future directions

This review shows that both the focus and the quality of studies into the relation between the indoor environment of center-based early education and care settings and children's behavior and development diverged considerably, and more research in this field is clearly needed. Some studies had a robust design (Kantrowitz & Evans, 2004; Legendre, 1999; Legendre & Fontaine, 1991) or combined a relatively large sample size with longitudinal data (Harper & Huie, 1998), and these studies should be replicated to determine if the results can be confirmed in different samples and contexts (Westfall, Judd, & Kenny, 2015).

Few studies were found that investigated the relations between spatial arrangement and children's cognitive development. These studies mostly focused on global environmental quality and were not informative about the effects of specific arrangements on children's cognition. Future studies addressing this topic could integrate the findings on how spatial arrangements relate to young children's use of the playroom and their social interactions, summarized in this review, with outcomes from studies emphasizing the importance of spatial exploration for cognitive development (e.g., Iverson, 2010; Smith, 2005). Such studies could shed more light on how the playroom arrangement, via children's exploratory behavior and use of various parts of the playroom, relates to the development of both cognitive and social skills.

The majority of studies reviewed in this article focused either on the spatial arrangement of the whole playroom or on specific activity areas within the playroom. Future studies should investigate the combination of both, because both seem important components of the physical environment, and their effects could reinforce each other in stimulating child development. It would be interesting to investigate how combining an open-zoned arrangement of the playroom with well-defined and enriched activity areas affects children's social and cognitive behaviors. Future studies that focus on specific activity areas (e.g., Lowry, 1993; Petrakos & Howe, 1996) should at least also include observations to children's use of other parts of the playroom, to avoid misinterpretation of the data regarding the specific area under investigation (Westfall et al., 2015).

7. Conclusion

The results of this narrative review of studies on the relation between spatial characteristics and children's behavior and development suggest that the indoor physical environment of daycare centers is indeed related to children's social and cognitive behavior and development. The most important finding of this review is that much more research in this field is necessary, and that there is an urgent need for a strong theoretical basis to do so. The current review of what is known about this topic, may contribute to the development of this theoretical basis and offers leads to new research.

Acknowledgments

The authors gratefully acknowledge the support provided in the development of a coding system in the initial stage of this study by Ruben Fukkink, and wish to thank Theo van der Voordt for his useful comments.

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