Associations between the home physical environment and child self-regulation: A conceptual exploration

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ARTICLE INFO

ABSTRACT

The environment is an important external source that affects a child's cognitive, behavioral, mental, and social development. According to Bronfenbrenner's ecological system model, the interaction between a child and his/her environment can influence and shape the development of self-regulation. A child's home is part of a complex microsystem referred to as the immediate environment, consisting of different factors such as family socioeconomic level, chaotic home environment, and other factors. Interior design is a component in the child's physical environment and can play a role in improving self-regulation. There is very little research addressing physical environmental factors in low socioeconomic households and how these affect children's self-regulation. The current research builds a framework that ties together theories on environmental design and establishes a relationship between the physical environment and a child's ability to self-regulate and manage stress. This review addresses the following research question—What is the association between the home physical environment and child self-regulation? A scoping review was conducted that included 52 sources of published literature and theories from different disciplines including mathematics, psychology, family science studies, and environmental design. A variety of theories, such as Self-regulatory Model of Behavior, Bronfenbrenner ecological model, and Allostasis Theory were used to establish a foundation for further study on the importance of physical environment. The principal finding is that according to these theories there is a link between the home environment and a child's self-regulation. By understanding the relationship be-tween physical environment and self-regulation, future research can identify aspects of the physical environment with the greatest impact on a child's self-regulation. This research contributes to the theories, principles, and practices of the field of environmental psychology and interior design.

1. Introduction

Can the home physical design play a role in improving self-regulation (SR) in children? There are a number of different environmental factors discussed in the literature which show an association with child self-regulatory skills such as family socioeconomic status (Evans & Rosenbaum, 2008), caregivers' physical and mental wellbeing (McClelland et al., 2010), child-peer interaction (Baumeister & Vohs, 2004; McClelland et al., 2010), and parenting interaction (Baumeister & Vohs, 2004; Rosanbalm & Murray, 2018). Home is part of the environment that a child is exposed to, and it has an impact on the child's development (Matheny et al., 1995). Literature has mentioned the need of studying the home environment to understand the development of self-regulation in young children (Baumeister & Vohs, 2004; Evan's,

2003). However, most of the literature covering the topic of self-regulation focuses on psychological, emotional, and social environments affecting child self-regulation. The objective of this paper is to search the literature for empirical studies and theories supporting any plausible association between attributes of the physical environment and children's self-regulation.

1.1. Background information

Self-regulation is an important aspect of child development because it deals with everyday struggles and has lifelong effects. Effective self-regulation promotes positive physical and psychological health, well-being, and fosters high academic achievement and job performance into adulthood (Kuhl et al., 2006; Rosanbalm & Murray, 2018). Low

self-regulation has been linked to adulthood instability, crime, high arrest levels, lower levels of success in adulthood, and lower levels of cognitive achievement (Baker & Brooks-Gunn, 2019; Baumeister & Vohs, 2004). Similarly, early regulatory difficulties predict later problematic social behavior (Baumeister & Vohs, 2004, p. 342). Stuart Shanker (2012) defines self-regulatory skills as the ability to manage stress and deal with stressors effectively and efficiently, then return to a state of being calmly focused and alert. Executive function is the cognitive domain of self-regulation and include shifting attention, working memory, and inhibitory control which are employed in planning, problem solving, and goal-directed activity (Baker & Brooks-Gunn, 2019). Studies indicate that children gain self-regulatory skills during the first five years of their life, which determines the robustness of executive functions (Baker & Brooks-Gunn, 2019; Razza et al., 2010; Sarsour et al., 2010). Self-regulatory skills also refer to "the ability to delay gratification, pay attention, and control impulsivity, which "… undergird children's behavioral adjustment and early learning" (Roy et al., 2014, p. 1). Evans and Rosenbaum (2008) suggested that self-regulation consists of a monitoring component and an action component which involve cognitive and emotional processes. Scholars have examined various dimensions of self-regulation pertaining to emotions and behaviors, including executive functions, delay of gratification, cognitive or inhibitory control, motor control, sustained attention, and working memory (Baker & Brooks-Gunn, 2019; Baumeister & Vohs, 2004). These dimensions have been used as a rubric to measure the level of self-regulation among children. The executive functions comprise the primary groups of behavior for the intent to self-regulate. Specifically, "[An] 'executive act' is any act toward oneself that functions to modify one's own behavior, so as to change one's future outcomes" (Baumeister & Vohs, 2004, p. 305). Delay of gratification can be defined as the ability to control impulses by resisting a smaller and immediate reward in order to receive a larger or more enduring future reward. Cognitive or inhibitory control refers to the ability to think before acting or inhibit automated responses in favor of a less dominant behavior (Baumeister & Vohs, 2004). Motor control refers to the regulation of movement such as initiating, guiding, and classifying purposeful voluntary movement. Sustained attention is the ability to focus on a task at hand and filter out external information (Baumeister & Vohs, 2004). Finally, working memory is the "ability to process and remember information and is linked to a range of cognitive activities from reasoning tasks to verbal comprehension" (Alloway & Alloway, 2010, p. 20).

The earliest self-regulatory skills form in infancy and include things such as the infant sucking on their fist to soothe themselves and shifting attention during overwhelming situations. In toddlers, self-regulation enables children to do things such as prevent themselves from falling from a sofa by choosing to slide down it instead; self-regulation permits toddler-age children to adjust their behavior to achieve goals. However, at this age, children are still dependent on the caregiver. As they grow, children's regulatory skills grow as well, and they move from external control (the caregiver) toward more internal control (the self). As we age, self-regulation plays an important role as we select a college major or a professional pathway, manage life transitions, confront difficult events, and optimize our health (McClelland et al., 2010). A growing body of literature has shown that self-regulation is a critical component of a child's school readiness, academic success, and social and behavioral development (Baumeister & Vohs, 2004; Carver & Scheier, 2000; McClelland et al., 2010; Rosanbalm & Murray, 2018). Various self-regulatory skills have been found to uniquely predict future success in adulthood, because they incorporate the coping skills needed to manage minor and major life events (Bandura, 1991; Baumeister & Vohs, 2004; Carver & Scheier, 2000; McClelland et al., 2010; Rosanbalm & Murray, 2018).

During the developmental stages of a child, the first few years of their life play a critical role in building and increasing self-regulatory skills, in the same fashion as learning math and language skills, due to the

capacity of the brain to absorb and develop. At this young age, "the brain is primed to create connections that support the beginnings of self-regulation" (Rosanbalm & Murray, 2018, p. 2). Harvard's Center on the Developing Child stated that in the early years "more than 1 million new neural connections form every second," which increase the efficiency of the brain circuits (Wpengine, 2015). Despite the brain's capabilities, support from the environment is at the heart of building these brain processes. Learning self-regulation skills varies from child to child just like any other skills. Different physical, biological, and psychosocial factors influence the differences in the developmental level of a child. Therefore, focusing on development at a young age can foster a stronger foundation of self-regulation skills (Baumeister & Vohs, 2004).

1.2. Poverty and child self-regulation

Published literature suggests that poverty may impede children's self-regulatory skills, directly and indirectly, (Baumeister & Vohs, 2004; Hardaway et al., 2012). Poverty refers to an individual or household income that is below what is needed to obtain basic human needs such as food and shelter (What Is Poverty? n. d.). In the US, the government establishes poverty guidelines each year that outline how the government measures whether a family and household is in poverty. For 2022 a household of one in the 48 contiguous states is considered in poverty if they earn less than $13,590, and for a family of four the value is set at $27,750 (Poverty Guidelines,n. d.).

Poverty and self-regulatory skills have clear correlations. The reasons for the observed correlations between poverty and self-regulation were explored by Evans and Kim (2013), who propounded three causal pathways. First, children in poverty are more likely to experience a lack of parental investment. For example, parents in poverty may allow their children to be exposed more to television and may provide less cognitively stimulating environments such as lack of age-appropriate toys, learning sources, educational digital materials, and language development. Second, children in poverty have a higher probability of being involved in harsher relationships with their parents. Child-parent interaction in low-income families may have more controversy and unfriendly environments and may provide less attention and social and emotional support. Third, children in poverty may fall under more elevated chronic stress. Children who experience poverty may struggle with different types of stressors that damage their biological and psychological regulatory systems. These stressors are caused by elevated environmental demands and damage self-regulatory capacities and coping mechanisms (Evans & Kim, 2013).

1.3. Statement of the problem

The predominant emphasis in the literature concerning self-regulation has been on the non-physical environment (e.g., parenting responsivity and emotional climate) and excludes the material resources (e.g., physical environment). Studies that have examined some aspects of the physical environment focused on environmental confusion (i.e., noise, crowding, and traffic pattern), but not other aspects of the physical design. There are a few studies that have examined some aspects of the physical design in relation to self-regulation such as accessing nature (Mueller & Flouri, 2020), organization of the environment (Linver et al., 2004), and lighting design (Steidle & Werth, 2014). The lack of previous research examining the impact of physical design on self-regulation underscores a missed opportunity for optimizing design interventions in improving self-regulation skills. Furthermore, understanding the relationship between physical design environment and self-regulation skills may be an area of socio-economic importance because of the possible link between poverty and self-regulation deficiency. In 2020, nearly one in six American children were growing up in poverty according to childrensdefense.org (Dawson, 2020). Emphasizing the importance of the link between the physical design environment and child self-regulation may further help by

adding additional interventions in this area which could help theorists and developers of socio-economic programs/policies as well as researchers. Considering this gap in knowledge, the purpose of the current inquiry is to explore the existence of any conceptual link between the physical environment and child self-regulation. The key question driving this inquiry is: Is there a plausible conceptual link between home physical environment and child self-regulation?

2. Methodology

The purpose of this inquiry was to explore the relationship between physical environment (PE) and self-regulation (SR) skills in children from lower socioeconomic status homes. A search for relevant literature was conducted in multiple disciplines including psychology, family science studies, and environmental design, to identify any potential pathway between physical environment and child self-regulation. The search was guided by different keywords including "child self-regulation", "physical environment", "child development", "family system", "home environment", "chaos", "chaotic environment", and "stress". Books and journal articles included in this review were related to child development and self-regulation, child poverty and family SES, child development and the physical environment, and theories related to child development and self-regulation. All articles and books used in the review were written in English. This review excluded articles focused on a special population, disability, or disease, non-humanistic technological and virtual reality environments, and environments focused on adult or animal populations.

2.1. Search strategy

The search utilized Google Scholar and the author's university library databases and e-journals. The databases targeted include Academic Search Complete, Jstor. Wiley, and Psychology and Behavioral Sciences Collection. A total harvest of 35,400 publications was obtained after removing all duplications. The search strategy was refined using a time filter of literature between 1990 and 2022 with a harvest of 19,700 publications. However, some earlier studies were included after the search due to the need to find the original definitions and/or concepts of that area of study. Another round of filtering the findings was performed by selecting the peer-reviewed publications with a harvest of 1920 publications. A title screening of relevant studies was used to identify applicable findings following the study's inclusion and exclusion criteria which resulted in a total of 860 publications. An abstract review was conducted by the researcher to identify only relevant publications which resulted in 390 publications. A total of 45 sources of published literature from different disciplines were found to be relevant to the study's inclusion and exclusion criteria by reviewing the full text, and in-depth reviews and analyses were performed to articulate key constructs, relationships, theories, and empirical findings. Fig. 1 outlines the search strategy of included study.

2.2. Data extraction

Of the 53 sources, findings were classified into two sets of information: (1) empirical evidence under three categories (family poverty/SES, child development/self-regulation development, and home physical environment), and (2) theoretical propositions related to the study constructs. The first set (including 4 books and 39 journal articles) provided information on self-regulation and its relation to various variables such as child development, income, SES status, family system, physical environmental factors, non-physical environmental factors, and home environment. These sources provided empirical evidence that supports the relationship between the two constructs. The second set of literature (including a book and 9 journal articles) offered theoretical propositions surrounding these areas of research: child self-regulation and family's socioeconomic status, family systems, self-regulation, and
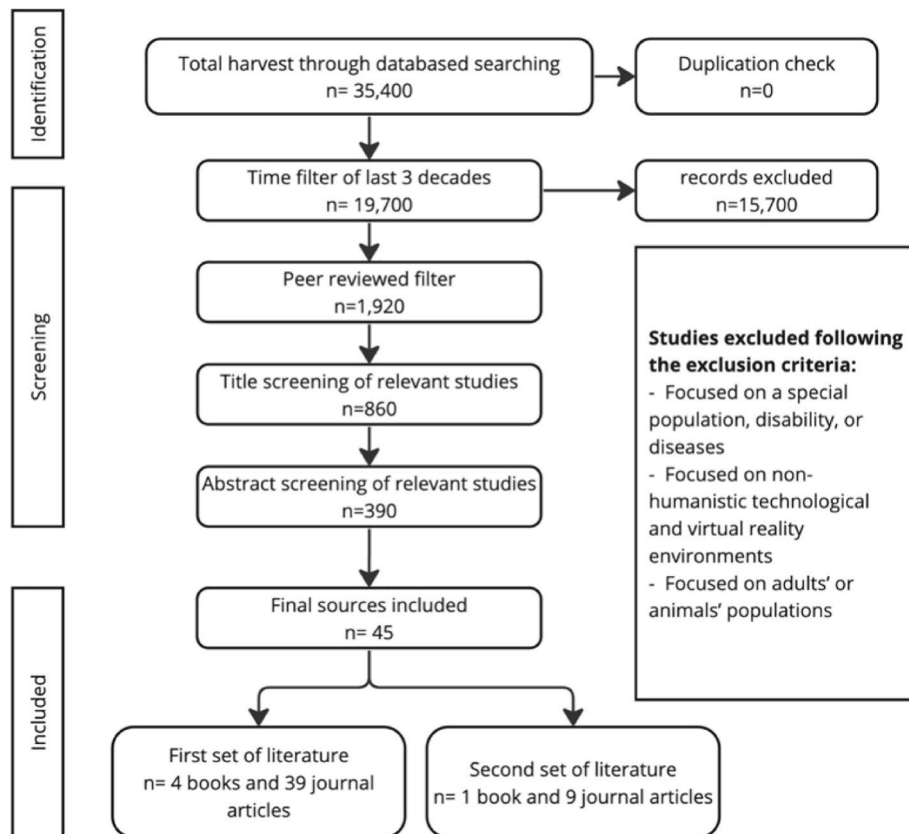

Fig. 1. Prisma flow chart illustrating the study research strategy of included studies.

child development, the home environment and self-regulation, and allostasis load and home environment. Theories used in the study emerged as a result of the search process. Definitions of terms used in this paper are outlined in Table 1.

3. Findings

Four theories, the Self-regulatory Model of Behavior, Shanker Self-regulation Model, Bronfenbrenner's Ecological System Model, and Accumulative Risk and Allostatic Load, and the empirical studies in the first set of literature suggest a plausible conceptual association between the physical environment and self-regulation. A potential explanatory framework articulating a pathway between the physical environment and self-regulation is sequentially discussed in this section.

3.1. The relation between Family's socioeconomic status and child self-regulation

Research suggests that there are correlations between a family's socioeconomic status (SES) and child self-regulation in both children and adolescents (Evans & English, 2002; Hardaway et al., 2012; Lawson et al., 2018; Li et al., 2017; Sarsour et al., 2010). This correlation does not suggest any causality. SES refers to "the social standing or class of an individual or group. It is often measured as a combination of education, income, and occupation" (American Psychological Association, n. d.). Low socioeconomic status (LSES) refers to individuals with low educational achievement, lower occupation, and/or poverty or lower-income (American Psychological Association, n. d.). According to Lawson et al. (2018), although poverty and SES are distinct constructs, they are related. Poverty is mostly related to the lower end of the SES. Socioeconomic status, which is typically divided into three classifications, low, middle, and high, can be used as a means of categorizing income levels (Bennett, Fry, & Kochhar, 2021. n. d.). In general, income has an

Table 1
Important definitions of the study constructs.

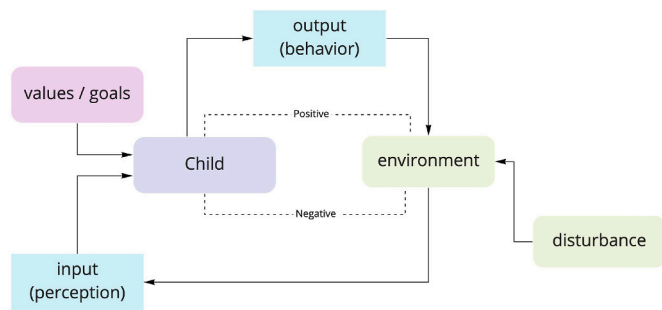| Term	Definition
Self-Regulation Theory developed by Roy Baumeister (Baumeister & Vohs, 2004)	The cognitive, behavioral, and emotional processes involved to drive motivation and actions toward controlling oneself (Baumeister & Vohs, 2004).
Ecological Model Theory developed by: Bronfenbrenner and Morris (1998)	A theory in which development is understood to be shaped over time by the systematic interplay of multiple bodily and environmental qualities (Evans, 2003).
Allostatic Load developed by (McEwen & Stellar, 1993)	Wear and tear on the regulatory systems in the brain and body due to the accumulation of stress (McEwen, 2005).
Home Stressors	In this study home stressors are defined as all different sources of stressors related to any system or subsystem in the home environment, such as psychological, social, economic, biological, personal, emotional, physical, and so on.
Physical Environment	In this study physical environment refers to both affordance aspects and environmental confusion aspects.
Affordance Aspects of Physical Environment	Affordance Aspects of Physical Environment are the factors related to resources which can afford the child specific uses (e.g., play materials, furniture, and space layout). The definition is adapted from Gibson ecological model (Gibson, 2014).
Environmental Confusion Aspects of Physical Environment	Environmental Confusion Aspects of Physical Environment are related to chaos (e.g., noise, crowding, and environmental traffic patterns) Matheny et al. (1995).

impact on occupation and education (Murrell & Meeks, 2002), and sometime the opposite could be true.

Various researchers have focused on studying the relationship between socioeconomic status and child self-regulation. For example, Lawson et al. (2018) used a meta-analysis to study the relationship between family SES and children's executive function across 33 studies. According to their study results, "SES was significantly associated with executive function, although the strength of the association varied markedly between studies" (p. 16). In addition, Evans and English (2002) reported in a cross-sectional study of 287 rural children that children from low-income families failed a delay of gratification task used to measure self-regulation compared with middle-income children. Also, Sarsour et al. (2010)discussed the association between family SES and child executive function skills, and stated that, "The association between family socioeconomic status (SES) and child executive functions is well-documented" (p.120). For example, the study reported different interactive associations from different studies between family SES and children's physical health outcomes, school achievement, math and language skills, cognitive function, alerting, orienting, and executive attention.

It is worth noting that poverty or LSES are merely classifications, and that the literature only indicates that their presence is correlated with negative outcomes. Most likely, this means that a family's inability to access the resources associated with these categories—stable income, educational opportunities, and employment that provides a living wage and basic benefits—is what is detrimental to child development. The circumstances that have brought about this inability to access the resources will vary from one example to the next.

Early exposure to poverty has been shown to have an effect on children's physiological, emotional, social, and cognitive development (Baker & Brooks-Gunn, 2019; Evans & Kim, 2013; Evans & Rosenbaum, 2008). Families who live beneath the poverty threshold are more susceptible to multiple interconnected environmental risk factors, including decreased access to education, a higher prevalence of single parent homes, an increase in ineffective parenting practices, negative life events, and residential instability (Baker & Brooks-Gunn, 2019; Evans & Kim, 2013; Hardaway et al., 2012; Tomalski et al., 2017). As a result, poverty can lead to self-regulatory failure through children's physiological stress responses (Evans & Kim, 2013; Roy et al., 2014). A study that focused on the relationship between systemic neighborhood poverty and children's self-regulation demonstrated that a change in a residence can influence one's economic conditions, leading to instability and stress which negatively affect children's self-regulatory skills (Roy et al., 2014). Children whose families live in a low-income neighborhood are less likely to move out of the poverty cycle and more likely to have life patterns that fall under the Family Stress Model (Baker & Brooks-Gunn, 2019). This model describes how economic hardship in the family causes economic pressures which can lead to an increase in parental emotional distress. Experiencing parental emotional distress strains parent–child interactions, which in turn affects children's cognitive development and future behaviors.

3.2. Self-regulatory model of behavior

To understand the link between home environment and child self-regulation, it is important to investigate the theory behind regulation. Behavior self-regulation is a continual process of regulating behavior. This process involves moving toward achieving or avoiding different goals and being integrated into a feedback loop (Rasmussen et al., 2006). Goals guide actions and serve as reference values for the feedback loop (Fig. 2). The feedback loop process for a child to self-regulate includes four elements: an input function, a reference value, a comparator, and an output function. According to Self-regulatory Model of Behavior, an input function, the child's perception, gives information about what the child's thoughts are on the existing state. The reference value or the goal offers information about what the child wants or intends. The

Fig. 2. The self-regulation feedback loop described by Carver and Scheier.

comparator (being the child) compares the two sources of information coming from the input and the reference value. The results of the comparison of the information can be either aligned or different. The output function is represented in the child's behavior which can be reflected as mental or physiological action (Rasmussen et al., 2006). As described by Carver and Scheier (2000), "Behavior isn't for the sake of behavior, but occurs in the service of creating and maintaining conformity of input to standard" (p. 43). Standers refer to the goals or the reference values. In this feedback loop, behavior can lead to conformity with standards, and any alteration from the environment may still lead to conformity (Fig. 2) (Carver & Scheier, 2000). In other words, for a child to regulate the behavior, he or she will compare between their perception about the current state and the intended goal. Based on that comparison, the child will react in a form of action. Any disturbance from the environment that the child is exposed to can impact this loop.

This mechanism of regulating the behavior has two types of feedback loops, negative and positive, and the type of loop depends on the type of goals and the nature of the output. In a negative-feedback loop (Fig. 3), the child's output intends to reduce the differences between the child's perception and the intended goal, whereas, in a positive-feedback loop (Fig. 4), the child's output intends to increase the differences between the child's perception and an intended goal – to avoid an intended goal. The positive loop refers to the anti-goal which means the child aims to avoid the reference value. If no difference is found, no regulation is needed because the child's behavior will be in the same state. As the differences between the child's goals and perception decrease, the child's action will change; then an up-regulating or down-regulating is needed depending on the goal (Fig. 5). Disturbances from the environment can impact the type of feedback loop to be negative or positive (Carver & Scheier, 2000). If the impact is negative, "recognition of a discrepancy prompts a change in output" (Carver & Scheier, 2000, p. 44). If the impact is positive, "the disturbance preempts the need for an output adjustment, because the system sees no discrepancy. Thus, no output adjustment occurs" (Carver & Scheier, 2000, p. 44).

The self-regulatory Model of Behavior elaborates on self-regulatory mechanisms that can motivate and guide purposive action. According to Carver and Scheier (2000), humans, including children, regulate their behavior depending on internal sources (self-generated) and external sources (environmental influence). Thus, any disturbances from the environment will impact the SR feedback loop positively or negatively. As mentioned in the Bronfenbrenner Model, the home is part of the environment, and any source of disturbance coming from the home environment will have an impact on the self-regulation cycle including the physical environment.
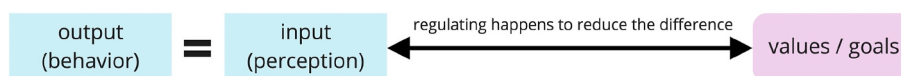
3.3. Shanker Self-regulation model

To incorporate Shanker's definition of self-regulation (the ability to manage stress and deal with stressors effectively and efficiently, then return to a state of being calmly focused and alert) into the Self-regulatory Model of Behavior, it could be argued that the goal is for the child to manage stress and deal with stressors. Co-regulation in young children plays a role in this process as well. The mechanism of co-regulation is called the Interbrain and acts as a wireless connection between young children and caregiver's brains. Parents/caregivers can learn to recognize a child's state, and by regulating their behavior, the child will have the ability to maintain optimal regulation (Shanker, 2016). There are a variety of stress responses across the continuum of the arousal state. There are six stages that help distinguish the child's level of arousal based on their responses to the stressors. The baseline is the alert stage, at which the child is calm enough to be focused (Fig. 5). According to Shanker et al. (2015), "Arousal regulation is best understood as the competing forces of the Sympathetic Nervous System's (SNS) activation, fight-or-flight responses, and the Parasympathetic Nervous System's (PNS) inhibition, feed-and-breed responses." (p.14). In effect, how much activation or recovery is necessary for any particular task is going to vary from child to child and situation to situation. It is important that parents learn to recognize these states of arousal so that they can adjust through up-regulating or down-regulating their behavior to maintain optimal regulation (Shanker et al., 2015). For example, a child who has just been yelled at by a parent or caregiver may be in a hyperalert or flooded state of arousal, or they may react by being in a hypoalert state and appear withdrawn or "zoned out." Note that a child cannot simply think their way out of that state (i.e., "calm yourself down") as that may add to their stress. Simply put, an arousal state is not a choice one makes for themselves (Shanker et al., 2015).

3.4. Bronfenbrenner's bioecological system model

With the importance of self-regulation to both a child's socio-emotional and cognitive development, it is essential to know how these capacities develop in young children. Both the Social Cognitive Theory and the Bioecological Model link child development with the environment. In Social Cognitive Theory, there are three components that explain psychosocial functioning - cognitive, behavioral, and environmental functions. Cognitive function is determined by the level of self-efficacy, setting personal goals, and the quality of analytical thinking; the behavioral function represents the decision-making process; and the environmental function comprises the social characteristics (race, culture, interaction, and home structure), and physical characteristics of the environment (neighborhood quality, and home settings) (Bandura, 1991).

From the Bioecological Model perspective, the interaction between a child and the environment, which is called proximal processes, is key to understanding their development. According to Bronfenbrenner (1989), the "home, nonparental childcare, peer, neighborhood, and cultural environments can influence and shape the development of self-regulation in young children" (p.343). In this theory, Bronfenbrenner categorizes child development into four environmental systems: micro, meso, exo, and macro (Baumeister & Vohs, 2004). In young children, the ability to self-regulate is linked with having secure attachments, "and is also predictive of emotional knowledge, social competence, conscience, and resiliency in early to middle childhood" (Baumeister & Vohs, 2004, p. 342).
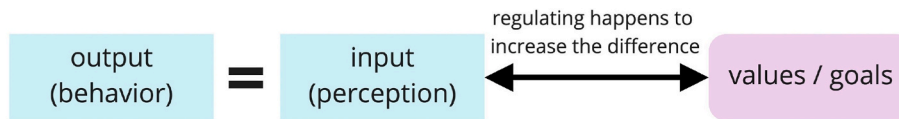

Fig. 3. Negative Feedback Loop: the difference between the child input (existing state) and the intended goal (reference value) needs to be reduced.

Fig. 4. Positive Feedback Loop: the difference between the child input (existing state) and avoiding the goal (reference value) needs to be increased.

Fig. 5. Arousal Regulation States adapted from (Shanker, 2016).

3.5. The integration between Bronfenbrenner's ecological system model, family SES, home environment, and self-regulation

Bronfenbrenner directly associates child development to the different types of environments. In his model, the home environment is one of the closest environments that young children are exposed to and learn from, and this environment influences and shapes the child's development. Larger social and cultural values feed the immediate cultural environment, which directly influences the home environment (Fig. 6).

3.6. Chaotic home environment

The term environmental chaos pertains to an overstimulated environment which can be an outcome of temporal as well as physical structuring. Instances of temporal components include noise, crowding, and instability, and physical structuring includes limited regularities, routines, or rituals (Evans & Wachs, 2010). Chaotic home environment fits under the home subsystem. Home environments comprise both psychosocial and physical dimensions and play a role in the association between family socioeconomic status and child self-regulatory abilities. For example, a longitudinal study found a link between the quality of home environments and child executive function skills (Sarsour et al., 2010). The study determined that the quality of home environments was lower for children in lower SES backgrounds. Sarsour et al. (2010) reported another longitudinal research study which found a link between poverty and child development but also determined that this link was mediated by a chaotic home environment.

Evans (2003) and Matheny et al. (1995) refer to chaotic environment as environmental confusion (noise, crowding, and traffic pattern). Unlike the definitions offered by these studies of chaotic home environment, the current inquiry refers to the broader aspects of a chaotic home and defines it as all perturbations or stressors that occur in the home environment from any system or subsystem in the ecological model.

3.7. Accumulative Risk and Allostatic Load

McEwen (2005) and his team established the term "allostasis," together with a novel conceptual framework looking at both the biological apparatuses brought to bear in mitigating stress and the brain's role in the process of allostasis as an adaptive response. This framework draws a distinction between allostasis as a protective and a damaging process. It used to be thought that stressors incited overall bodily and mental arousal responses. Half a century of biomedical research, however, has yielded a far more nuanced picture showing the cumulative effect of the social environment on physical and mental health, as well as the trajectory of specific diseases. The social environment has this effect because body and brain engage in constant two-way communication by way of the autonomic nervous system, the endocrine system, and the immune system. These pivotal systems permit adaptation to occur when
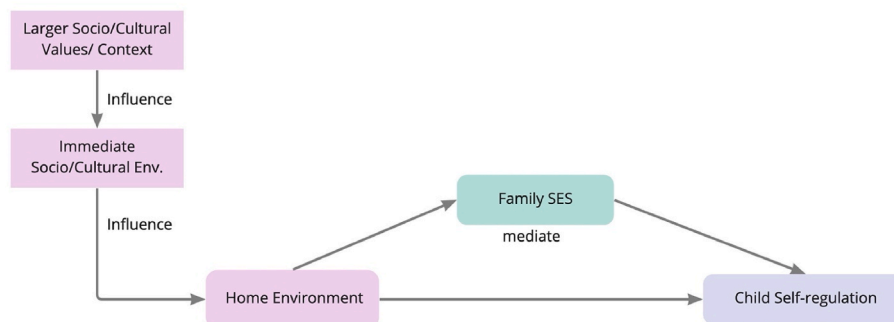

Fig. 6. The Bioecological Model explains the relationship between Home Environment and Children Self-regulation.

acute stress strikes, but these same systems also provide the entry point for the negative impact of chronic stress and unhealthy lifestyles. When people talk about the deleterious physical and mental effects of negative environmental situations, therefore, what they are actually referring to is not stressors but the state of being chronically "stressed out" (McEwen, 2005).

Allostatic state is defined as a chronic state of regulatory systems deviating from the normal function, to establish a new function (Koob, 2001), and can deteriorate the brain and body's regulatory systems. The terms "allostatic load" and "allostatic overload" denote the aggregate outcome of an allostatic state. Allostatic load and overload manifest from regular and cyclical routines that living beings apply to gather food for survival, ensuring the presence of the extra energy stores needed for energy-intensive processes such as molting, migrating, breeding, and other seasonal processes (McEwen, 2005). Within necessary parameters, these processes are adaptive responses to cyclical natural demands, but if unexpected environmental events occur (natural disasters, disease, human disturbances, intraspecies social disturbance), the allostatic load becomes overload. At that point, the organism becomes predisposed to disease (McEwen, 2005).

3.8. The integration between allostatic load, and home environments

Current literature has linked LSES homes with an increase in the likelihood that these environments are chaotic when compared to middle and upper class homes (Hardaway et al., 2012; Lawson et al., 2018; Li et al., 2017; Sarsour et al., 2010). This link is important because researchers have documented a connection between SES and chaotic environment (Evans & English, 2002; Sarsour et al., 2010; Tomalski et al., 2017). As established by literature, one important feature of LSES homes is the increasing association between chaotic home environments and self-regulation, which is partly explained by stress/allostatic load. Evans (2003) provides an important perspective on cumulative risk and human development from the Allostasis Theory approach. Allostasis is the dynamic and highly interactive process of achieving stability in response to physical and social changes. The Allostasis Theory has four important implications in the context of child development: (1) since allostatic load is cumulative and a long-term stressor, it has more chronic and harmful impacts than short-term stressors; (2) the accumulation of multiple small changes in physiological functioning increases the risk; (3) allostatic load accumulates from physical and social stressors throughout life, genetic tendencies, and regular daily routines such as diet and physical activity; and (4) allostatic load impacts the socioemotional and cognitive processes as well as physical morbidity such as "depression, anxiety, and self-regulatory behavior, selective attention and spatial and episodic memory" (Evans, 2003, p. 925).

Socio-economic factors should be the viewing lens for the relation among cumulative risk, allostatic load, and socioemotional development. The rise in inherent chaos, which may be linked to the level of SES, impacting families and children makes family lifestyle difficult to navigate and maintain healthily (Evans, 2003). Tomalski et al. (2017) argued that chaos in the home is creating psychological distress and precipitating long-term negative effects on children's socio-emotional functioning and cognitive development. According to Evans et al. (2005), overstimulation from chaotic environments can lead to stress and fatigue in children, interfering with the development of self-regulatory skills (Evans et al., 2005). This argument presents a mediational relationship, wherein the association between chaotic environments and self-regulation is mediated by the home environment's allostatic load, or stress in the home environment (Fig. 7).

Possible perturbations occurring in the home can come from any source in the family system. The accumulation of stressors can impact the self-regulatory processes negatively, thus interrupting the children's coping mechanism with external demands (Evans & Kim, 2013). This accumulation can come from different sources of stressors in the family system or subsystem such as psychological, social, economic, biological, emotional, physical, and so on. Home stressors are defined as the different sources of stressors related to any system or subsystem in the ecological model of the home environment. Published literature provides examples regarding economic factors in the home environment such as poverty and a family's socioeconomic status; and link it with children's self-regulatory skills (Baumeister & Vohs, 2004; Hardaway et al., 2012; Lawson et al., 2018; Li et al., 2017; Sarsour et al., 2010). Other literature links physical and social environmental factors, such as environmental confusion, to poverty and child self-regulation development (Evans, 2003; Matheny et al., 1995). Evans and Kim (2013) state that children who live in poverty struggle with multiple stressors accompanying the harsh financial status which are likely to damage their biological and psychological regulatory systems.

Based on Evans's (2003) assertions, cumulative risk and allostatic load is associated with self-regulation failure. In current literature, researchers have documented an association between self-regulation and stressors related to the non-physical environment, such as parenting responsivity, violence, financial stressors, academic achievement, stability, wellbeing, environmental confusion, and so on (Evans, 2003). The literature offers limited evidence for, and attention to, the sources of stressors emanating from the physical design of home environments (Baumeister & Vohs, 2004; Evan's, 2003).

4. Discussion

4.1. Conceptual framework that links physical environment, and self-regulation

Fig. 8 represents the theoretical framework posited to understand the relationship between the physical environment and child self-regulation. In summary, Bronfenbrenner's Ecological System Model represents a clear link between environments and child development. Within this model, there is a relationship between home environment and child self-regulation as part of child development. Evans further uses the terminology 'chaotic environment' to refer to environmental confusion as part of the physical environment occurring in the home. Chaotic home environment refers to all triggers that occur in the home from any system or subsystem in the ecological model. The Self-regulatory Model of Behavior explains how the environment has an impact on the feedback loop of self-regulation, and any disturbance from the environment can positively or negatively impact the child's regulatory feedback loop. The Allostatic Load Model partly describes the disturbances that come from the environment and shows that cumulative stress leads to self-regulation failures.

4.2. Physical environmental factors affecting child SR mentioned in literature

Some existing literature outlined different attributes of the physical environment that are hypothesized to influence child self-regulation. Examples of those attributes include the quality of the environment, environmental confusion, and organization of the environment.
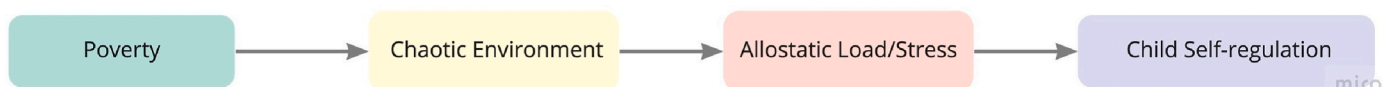

Fig. 7. Allostatic load mediates the association between chaotic environments and self-regulation.
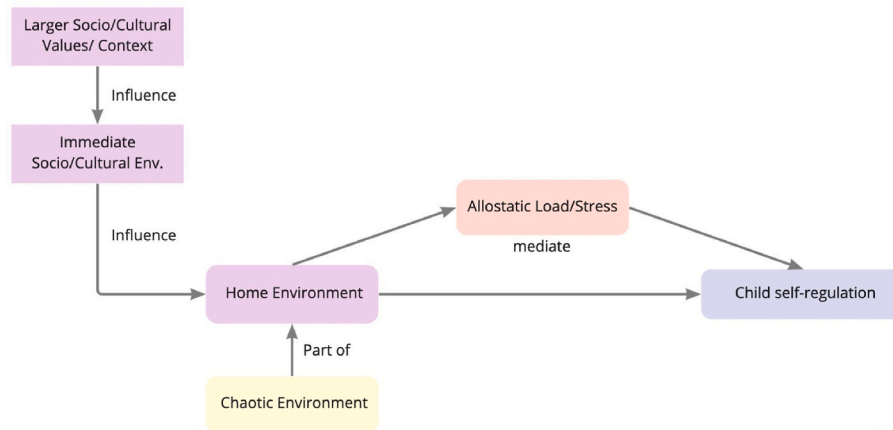
Fig. 8. Summary of the study framework that encompasses four main theories: ecological model, self-regulatory model of behavior, and allostatic load model.

4.2.1. Quality of the environment

Blair et al. (2011) examined the effect of poor housing quality on the stress levels of infants living in low-income households. This longitudinal study measured an infant's housing quality at four different stages: when they are 6 months, 24 months, 35 months, and 48 months. The 1292 children who participated in the study were from two of the four major high poverty rate areas in the US: North Carolina and Pennsylvania.

The housing quality represented four items: the cleanliness of the house, the number of rooms, and the interior and exterior safety of the building. A 0–4 Likert-type scale was used to assess these four items and an average score was reported to indicate low housing quality at the four time points. Infant cortisol levels were also measured at each time point to determine their stress levels. The findings indicate an association between poor housing quality, the African American racial group, and low positive caregiving behaviors; and an increase in cortisol levels between 7 months and 48 months. Blair et al. (2011) further explain that the stress level of children is associated positively with both the level of caregiver support and sensitivity and the level of child temperamental reactivity; thus, affecting the level of self-regulation skills.

Evans (2006) discussed the quality of the environment from the perspective of different factors such as housing quality, neighborhood quality, and natural settings. The potential adverse impacts of housing quality on children's and adolescents' socioemotional development emerge from the results of several studies he reviewed, most of which incorporate statistical controls for SES. Housing quality has also been linked to cognitive development, academic achievement, psychological distress levels, psychological well-being, and forgetfulness. For example, one study showed that housing quality affected elementary school children's psychological distress levels, as rated by both teachers and parents, independent of SES. In addition, among a sample of borderline-homeless community members, families who relocated to more stable housing saw notable upticks in grade-school performance matched against comparable families who remained in unstable housing communities (Evans, 2006).

The neighborhoods in which children are housed also pose developmental consequences. Some of the physical neighborhood characteristics that may shape developmental outcomes are housing quality, relative residential stability, noise, crowding, toxic exposure, municipal-service quality, the presence of particular retail services, recreational opportunities, natural settings, street traffic, transportation access, and the physical quality of both educational and health care facilities. For instance, being close to street traffic, increases the risk of pediatric injuries and causes limitations in outdoor play among 5-year-olds, which in turn engenders less robust social networks and less developed social and motor skills for these children. Households on higher-traffic streets interact less with their neighbors relative to those residing on less congested streets (Evans, 2006).

Natural settings matter to self-regulation, as well. Children prefer outdoor, particularly nature-centered, settings (Evans, 2006). Likely because such settings offer a wide array of active, independent, and social play choices. Both children and adults enjoy restoration in natural settings, which mitigate cognitive fatigue and enhance positive affect. Studies show that natural play spaces encourage more complex play than built play spaces in elementary-school children (Evans, 2006).

4.2.2. Environmental confusion (chaos)

Environmental confusion is defined by Matheny et al. (1995) as the environmental factors that include noise, crowding, and environmental traffic patterns. Noise is defined as a loud sound perceived from different sources and can be measured with decibels. According to Evans (2006), "A change in 10 dB is perceived as approximately twice as loud" (p. 426). The main sources of noise for children are transportation, music, and other people. It has been proven that noise levels impact children's academic performance and can lead to deficits in intellectual functioning. Crowding can be accomplished by controlling the number of people per room, where traffic patterns identify the number of people coming and going in the home. The association between crowding and child development has been established. Studies show that crowding can affect parents' responsivity toward young children, as well as the levels of child social withdrawal among preschoolers (Evans, 2006).

Based on Evans (2006) study, the environmental confusion factors influence child self-regulatory skills. The environmental confusion or chaos scale developed by Matheny et al. (1995) explores 15 home environment elements including the level of commotion, ease of finding things, feeling of being rushed, organization of tasks, running late, home clutter, personal space and interruption level, fuss level, argument, calm environment, time management, and regular routine.

4.2.3. Organization of the environment

Bradley and Caldwell (1984) established The HOME Inventory Scale to measure child emotional support and cognitive stimulation received in the home environment. The scale covers different age groups and comprises two parts, the parents' report, and an observational section. The parents' report includes questions about the child's activities, discipline, and parent-child interactions. The observational section discusses different domains related to the child's development. For example, the Infant and Toddler scale includes social environmental factors such as emotional and verbal quality, restriction and punishment, maternal involvement with the child, variety in daily stimulation, and physical environmental factors such as organization of the home and play materials. Items related to the physical environment mostly examine factors that are spatial, such as whether a child has substitute care, going out, and doctor visits, a special place for toys, a safe play

environment, and different toys supporting different kinds of development. Despite the importance of these factors, the HOME Inventory Scale items focus more on the spatial aspects rather than the affordance aspects, except for a few items that look at toys and toy materials (Bradley & Caldwell, 1984).

4.3. Physical environmental factors affecting child SR receiving some attention in literature

Even though there are some attributes mentioned in the literature dedicated to child self-regulation, there are several physical environmental factors that have received some or no attention. These factors include the hierarchy of space, spatial transitions, visibility, layout, circulation, access to daylight and lighting controls, soundproofing systems, lighting, visual clutter, privacy, and personal territory. These factors have been shown to impact human behavior in general (Aminpour, 2022; Weeland et al., 2019; Blair et al., 2011; Day et al., 2020; Health et al., 1998; Linver et al., 2004; Newell, 1995) and the list of factors included was created based on the personal experience of the author. Table 2 classifies some examples of physical environmental factors that received little attention and factors that did not receive any attention.

5. Significance of research

5.1. Contribution to theories

- This review constructed a theoretical framework that articulates a plausible conceptual pathway between physical environment and child self-regulation.
- This review suggests a logical explanation of the importance of physical environment as a component of the child environment and how it is critical to their self-regulation development.
- This theoretical framework significantly broadens the understanding of the family system by considering physical environment as a factor impacting child environment.

5.2. Contribution to practice

- This review is intended to help focus the design community on the impact of physical design on child self-regulation development, as a means to address the problem.
- This review directly benefits children in LSES homes, residential designers, and stakeholders.
- This research aims to make stakeholders and policy makers aware of the importance of design in improving self-regulation in order to transform the practice of interior design in low-income housing.

6. Future studies

Evans (2006) stated that limitations exist in the literature regarding the role of children's cumulative exposure to multiple environmental stressors. The current study opens the door for further research on the topic of the physical environment and its relationship to self-regulation skills. This theoretical framework connects the factors that occur in the home environment with self-regulation, including the contextual features of the physical environment, which, according to Matheny et al. (1995), refers to the affordance aspects of the environment. Future research can qualitatively examine different contextual features of the home's physical environment (affordances aspects) concerning self-regulatory behavior. For example, studies can focus on identifying physical environment factors (the affordance aspects of the environment) related to environmental stressors to assess whether positive changes in affordance aspects of the home environment improve self-regulatory behavior among young children in families with a low socioeconomic status. Also, the relationships between physical

Table 2
Summary of the physical environment factors related to child SR and level of attention in literature.

Physical Environment Factors	Definition	Attention in literature
Hierarchy of space	The articulation of the significance of a space by its size, shape, or placement relative to the other spaces of the home environment.	No attention in literature
Layout	How the parts of the house are arranged to serve occupants' needs	Aminpour (2022)
Circulation	How the movement and the flow from or around the house is working	No attention in literature
Soundproofing systems	Isolation systems that minimize excessive noise in every room/space	No attention in literature
Daylight and lighting controls	Access to day light through windows and/or doors	Weeland et al., 2019 and Day et al., 2020
Visual clutter	How organize are the items that we typically leave out on countertops, surfaces, and shelves.	No attention in literature
Privacy	The space that allows being free from any family member's attention	Newell, 1995; Health et al., 1998
Personal territory	The space in the house that you have a full control of.	No attention in literature
Spatial transitions	This movement between floors	No attention in literature
Physical barrier	Any physical barrier that challenges the movement. It could be intentional such as a stair safety gates, or unintentional such as an object blocking the way.	Blair et al., 2011; Linver et al., 2004

environmental factors which have previously received limited attention (as mentioned previously) and self-regulation can be examined.

7. Limitations

Limitations of the current study include that the initial search may not have captured all relevant studies because of two reasons: (1) the data reported in this study were from the last three decades (1992–2022); (2) the study used only four databases for the search (Academic Search Complete, Jstor. Wiley, and Psychology and Behavioral Sciences Collection). Limiting the search using a time filter may have excluded other publications available in the study area of interest. There was a limitation related to the databases and e-journal used in the study. There might be other literature that were not captured in this review and have a relevant content to the study constructs. Future studies should consider expanding the search time, and databases in order to further refine this relationship between the physical environment and child SR skills.

Another limitation of this study could be that the list created by the author regarding the factors of the physical environment receiving limited attention does not cover all areas of the physical environment. Other factors could show an impact on child SR and are not listed in this review.

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