Chapter 20
An Ecological–Contextual Model of the Development of Executive Functions: Identifying Target Areas for Its Promotion in Children in Socially Disadvantaged Contexts

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Abstract Children growing up in socially disadvantaged conditions are exposed to numerous risk factors that impact their cognitive development. Neurosciences have identified executive functions (EFs) to be some of the cognitive systems that are the most sensitive to environmental influence. EFs involve a set of high-order cognitive functions that control and regulate behaviors, emotions, and cognitions necessary to reach goals and solve problems. EFs are essential for self-regulation and play a key role in children's cognitive, emotional, and social development. EFs are significant predictors of health, quality of life, and well-being throughout the life cycle. EFs' development is lengthy, multi-staged, and extends from early childhood to adulthood. Various sensitive periods in the EFs' development have been identified, which creates different time windows in which the experience has a maximum impact on brain maturation. Research studies have identified factors in the child's family, school, and community context as possible modulators. For family, they are rearing practices, cognitive stimulation, stress, and caregiving. For school, they are classroom management, classroom climate, and teacher scaffolding. For the community, they are cultural norms, ethical values, and social practices. However, these factors have not been integrated into an ecological model that allows visualizing their differential weight within the set. The goal of this study is to present an ecological and contextual model of EFs' development that integrates the most significant research studies on the topic published in the last 20 years. In conducting this study, 50 peer-reviewed academic publications, issued between 2000 and 2020, were selected for review. Identifying and understanding the differential weight of the modulatory factors of the EFs' development help to identify target areas of intervention aimed at promoting their development, which is of particular interest for the design of programs aimed at improving the developmental trajectory, health, and well-being of children growing up in socially disadvantaged contexts.

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Introduction

Executive Functions: Its Implication in Healthy Development

Executive functions (EFs) constitute one of the most distinctive aspects of the human being, as they enable the ability to act with purpose and in a self-regulating manner in the various contexts of social interaction (Blair & Raver, 2014; Walk et al., 2018). Executive functions describe a set of high-order cognitive abilities that control and regulate the behaviors, emotions, and cognitions necessary to achieve goals, solve problems, and provide adaptive responses to novel or complex situations (Diamond, 2013).

Three core EFs have been identified: inhibitory control, working memory, and cognitive flexibility. Inhibitory control involves mental operations aimed at suppressing inappropriate behavior, or an attention tendency toward irrelevant or distracting stimuli that can interfere with the deliberate resolution of a problem (Friedman & Miyake, 2004). Working memory refers to the ability to keep information online and to operate on it, beyond distractions or despite carrying out another task (Davidson et al., 2006; Diamond, 2013). Finally, cognitive flexibility compromises the ability to shift attention, adapting mental activity, and behavior according to the demands of the environment (Diamond, 2013; Fine et al., 2009). During the development process, these three basic executive functions mature, differentiate, and enable the development of more complex ones, such as planning, organization, metacognition, monitoring, fluency, and decision making (Diamond, 2013; Miyake et al., 2000). These functions act in an interrelated way, enabling flexible, pro-positive, and self-regulated behavior.

EFs are implemented in a wide variety of situations, in essence those that are characterized by being novel and complex, their competence being crucial for an optimal functioning and socially adapted to the changing demands of the environment (Lezak, 1982). The essence of EFs is cognitive control, which involves a set of interconnected neural networks that operate in a coordinated way across an integration zone located in prefrontal areas (Fuster, 2001; Koechlin & Summerfield, 2007). EFs have a hierarchical place in human cognition, from which they orchestrate the necessary resources for the achievement of a goal or the resolution of a problem. The "cold" EFs are involved in reasoning and efficient information processing. However, the "hot" EFs play a key role in emotional competence, as they enable the regulation of emotional expression, the knowledge of one's own emotions and others, and their monitoring and adjustment to the situations of the context (Hongwanishkul et al., 2005).

EFs play a critical role in cognitive, social, and emotional development of children and predict many life outcomes. Their adequate performance in childhood is

associated with good school performance, purposeful social relationships, emotional well-being, and behavioral self-regulation (Diamond, 2013; Walk et al., 2018).

Children who show a greater capacity for self-regulation are better able to regulate their emotions, establish positive relationships with peers and adults, tolerate frustrations, expect rewards, adjust their behavior to the demands of the context, be more creative, be flexible, and present a better school performance. EFs are considered critical for school readiness, future academic performance, and successful learning (Nyroos et al., 2018).

EFs are considered resources for learning. Over the last 20 years, a body of research has documented its involvement in different subject areas, such as Literature, Mathematics, and Science, (i.e., Best et al., 2011; Fuhs et al., 2014; Welsh et al., 2010). EFs help children to set goals, initiate and complete tasks, direct and sustain their attention on relevant aspects of tasks, plan and organize activities, sustain cognitive effort and persevere in the face of difficulties, detect errors, recognize new perspectives, formulate alternative plans when atypical events occur, and reflect on thoughts and actions (Blair & Raver, 2014; Hodgkinson & Parks, 2016; Korzeniowski et al., 2016; McKinnon & Blair, 2018; Nyroos et al., 2018). In addition, they are involved in contributing to monitoring and reflection on learning processes, promoting emotional self-regulation, and enabling self-regulating behavior (Korzeniowski et al., 2020). For these reasons, EFs play a critical role both in self-regulated learning processes and for children's adjustment in the classroom setting (Fitzpatrick et al., 2014).

These achievements in childhood predict better health, better quality of life, greater academic success, better employment status, and a lower incidence of conduct problems, in adolescence and adulthood (Diamond, 2013; Moffitt et al., 2011). A longitudinal study (Moffitt et al., 2011) observed that self-control in early childhood predicts many life outcomes in adulthood, after controlling for the effect of IQ and socioeconomic status. This study reported that children with difficulties in self-control presented, in adolescence, a higher frequency of risk behaviors, such as greater consumption of tobacco, alcohol, school dropout, and teen parenthood. In adulthood, they presented: health problems, such as higher prevalence of metabolic syndrome, substance dependence, and sexually transmitted diseases; economic difficulties, such as financial planning problems, credit and savings difficulties; higher prevalence of single parenting; and, conduct disorders, such as disruptive social behavior and problems with the law. These data underscore the role of children's self-regulatory capacities in health and quality of life in human development, and identify them as a target of early intervention and prevention programs.

In sum, the adequate development of executive functions in childhood is a key factor for healthy development, well-being, and quality of life. From there, the importance of identifying the factors that shape their development arises, especially in children who grow up in socially vulnerable conditions.

Executive Functioning Development

Executive functions emerge in early childhood and present a protracted development that continues into adulthood. Its development is sequential, multi-staged and is associated with the late maturation of a set of neural networks coordinated by the prefrontal cortex (Fuster, 2001). The prefrontal regions show a late development in contrast to the early maturation of other cortical regions. This maturational pattern reflects the hierarchical organization of the brain (Koechlin & Summerfield, 2007), within which the prefrontal cortex is one of the structures that shows the most connections with the rest of the cortical and subcortical regions.

The gradual changes in the morphology and physiology of the prefrontal areas and their connections are associated with the emergence and maturation of EFs. Specifically, it has been suggested that EF development is closely related to myelination and synaptic pruning, which are the two events that are considered most responsible for brain maturation (Korzeniowski et al., 2021).

Myelination of the frontal lobes increases linearly from 4 to 13 years of age, which is associated with an increase in the speed of nerve impulse conduction between the connections of the prefrontal cortex and other regions of the brain. Synaptic pruning sculpts the neural connections of the prefrontal cortex with other cortical and subcortical areas, selectively removing non-functional synapses. This process is continuous from ages 5 to 16, leading to a decrease in synaptic density and changes in gray matter during childhood and adolescence (Sowell et al., 2001).

Morphological maturation of the prefrontal cortex is reached at puberty, but anatomical and functional changes continue for years to come. In this stage, the increase in gonadal hormone secretion plays an organizing effect on the neural mechanisms that support cognitive processing (Davies & Rose, cited in Hughes, 2011). Adolescence is characterized by a sustained increase in myelination, which is associated with faster and more efficient processing of information in the frontostriatal network (Giedd et al., 1999; Paus, 2010), and by a reduction in the gray matter, which is associated with the specialization of the neural networks involved in executive functioning. On the other hand, changes in interhemispheric connections, neurotransmission mechanisms, and increases in brain metabolism have been reported. An increase in dopamine and serotonin, as well as a modification in the biosynthesis of neurotransmitters and peptides, have been documented, affecting cognitive functioning and being associated with gains in EFs in adolescence (Tau & Peterson, 2010).

The extensive development of the neural networks that make up cognitive control is considered a facilitating factor of cognition as it creates time windows, in which the plasticity of the brain is increased and it is more susceptible to the environmental experience. This refers to the existence of sensitive periods (Armstrong et al., 2006), in which the development of executive functioning can be promoted and stimulated through appropriate experiences. Consequently, gains in children's executive abilities should be interpreted as resulting from the delicate and sustained interaction between brain maturation and the influence of the environment. The literature reports that an

adequate development of executive functions is reflected in the milestones described below.

In early infancy, around 6–8 months of age, the emergence of executive functions is recorded. The milestone of "permanence and recovery of the object" signals the emergence of behavioral inhibition, working memory, attention, and rudimentary problem solving (Korzeniowski et al., 2021). Later, between 3 and 5 years of age, important achievements and rapid advancement in EFs are observed. At this stage, children acquire the skills to keep more than one thing in mind, flexibly shift focus, inhibit a dominant response tendency, detect errors, begin to regulate the expression of their negative emotions, and have metacognition (Diamond & Kirkham, 2005; Hughes, 2011; Korzeniowski et al., 2021; Roebers et al., 2012).

During middle childhood and adolescence, EFs register a peak of intense growth between 6 and 10 years of age, after which EFs continue to develop more slowly. In this stage, EFs follow a process of sequential and multi-staged development, in which some functions, such as attentional control and inhibitory control, mature earlier, while others, such as planning, metacognition, working memory, show gains in adolescence and early adulthood. Advances in the development of EFs in this vital stage allow children to process and manipulate a greater amount of information, understand the most relevant conditions of the tasks, an efficient use of memory strategies, greater flexibility to solve problems and progress in the organization and planning of its activities (Flores-Lazaro et al., 2014).

EF development has an additive and systematic effect on the control of cognition. The maturation of each executive function makes a specific and selective contribution to the cognitive control process, which is associated with a greater capacity to create mental schemas, greater mental flexibility, greater planning of cognitive and behavioral activity, and greater cognitive fluency and creativity (Flores-Lázaro et al., 2014; Korzeniowski et al., 2021). These achievements will have a significant impact on the school, social and emotional environment of children.

Executive Functioning Development and Socially Vulnerable Contexts

EFs can be negatively affected by stressful environments and by the lack of quality and proactive interactions with adult caregivers. However, environments that promote healthy child development can help children to strengthen their EFs (Hackman et al., 2010).

Social vulnerability is a risky social condition that makes it difficult, in the present or future, to satisfy well-being in terms of subsistence and quality of life (Korzeniowski et al., 2020). It is a complex, multi-causal phenomenon that includes aspects such as helplessness, insecurity, exposure to risks and stress due to traumatic

socioeconomic events. However, it also involves, to deal with these events, the availability of resources and strategies that may arise from within the group itself or from external support (Golovanesky, 2007).

Children who grow up in socio-vulnerable conditions are exposed to numerous risk factors that impact their physical, social, emotional, and cognitive development (Hackman & Farah, 2009; Lipina et al., 2011; Noble & Farah, 2013). It has been documented that, compared to children from more favored socioeconomic strata, these children present: a higher percentage of physical and psychological health problems, such as depression and anxiety; more behavior problems, such as aggressiveness and impulsiveness; and, lower school and intellectual performance (Arán Filippetti & Richaud de Minzi, 2012; Farah et al., 2006; Noble et al., 2007).

Unfortunately, the socio-environmental conditions of the homes of children who grow up in socially disadvantaged conditions are different from those who live in better socioeconomic conditions. The former are exposed to a greater number of stressors, family instability, less cognitive stimulation, and more inconsistent parental discipline guidelines. Such children have poorer diets, are exposed to more toxins in the water and air, have less read to them and attend poorer schools (Evans, 2004). They are more likely to be victims of abuse and neglect and are often exposed to greater violence in their homes (Fitzpatrick, 2014). The cumulative experience of these factors negatively affects neurocognitive development.

Educational and cognitive differences between children from more affluent backgrounds than those growing up in socially disadvantaged conditions are evident in early childhood and widen even more with the passage of time. In early childhood, children from disadvantaged contexts have a lower vocabulary and have lower performance in cognitive and executive functioning tasks (Fitzpatrick, 2014). During the preschool and school stage, studies in developed countries (i.e., Crook & Evans, 2014; Fitzpatrick et al., 2014; Hackman et al., 2010; Noble et al., 2007) and developing countries (i.e., Ison et al., 2015; Korzeniowski et al., 2016; Lipina et al., 2011; Musso, 2010; Piccolo et al., 2016) have reported, for children from disadvantaged contexts, in comparison with their peers from more advantageous social contexts, a lower performance in: attention, working memory, cognitive flexibility, planning, overcoming difficulties in self-regulating emotions and resolving conflicts. These difficulties become apparent as children enter school, persist in elementary school, and generate greater differences in secondary school completion rates (Fitzpatrick, 2014).

Based on these reports, neurosciences have attempted to specify the factors that mediate the impact of the environment on children's cognitive development. During the last two decades, environmental factors that model the EF development have been studied, identifying factors from the family, school, and community.

Family Factors That Model Executive Functioning Development

Research focused on understanding the characteristics of early childhood development environments that could impact child cognitive development. Pioneering studies focused on the family, and identified environmental factors, health conditions, and social interactions, as predictors of EF development (i.e., Deater-Deckard, 2014; Hackam et al., 2010; Landry et al., 2002; Bibok et al., 2009).

At first, the home environmental and health conditions of children growing up in socially- disadvantaged conditions were addressed. The home environment determines access to learning opportunities and resources necessary to stimulate cognitive development. A study carried out in Argentina observed that exposure to lead, the quality of nutrition, the child's health status, and the environmental conditions of the home all modeled the development of executive functions in children (Arán Filippetti & Richaud de Minzi, 2012). The environmental conditions of the home that negatively affected the cognitive development of children were reported as: noisy, crowded environments, with inadequate sanitary conditions and limited space development (Arán Filippetti & Richaud de Minzi, 2012). In line with this report, a study observed differences in attention, planning, and verbal working memory in children based on characteristics of the home environment (Hackman et al., 2010).

Subsequently, it was analyzed whether the quality of the bounds between caregivers and children could model the impact of socially disadvantaged conditions on the development of self-regulatory capacities in children. Hackman et al. (2010) identified three mediating factors: prenatal factors, parental care, and cognitive stimulation.

During pregnancy, mothers who are in disadvantaged socioeconomic situations are often exposed to stressful events which compromise their health and that of their child. They tend to have high levels of stress, lower nutritional quality, and higher risks of infection, which is associated with higher chances of abnormal fetal growth and premature birth (Farah et al., 2006; Hackman et al., 2010; Noble & Farah, 2013). In particular, stress can increase cortisol levels in the fetus, which has been related to a delay in neuronal maturation, myelination, and synaptogenesis, thus affecting neurocognitive development (Lupien et al., 2001). Low birth weight and alterations in fetal development have been associated with a greater probability of suffering from mental illness and presenting a lower school performance (Hackman et al., 2010).

After birth, a high level of stress in the parents or caregivers of the children decreases the involvement, the sensitivity to the needs of the children, resulting in a lower quality of parental care (Blair et al., 2011). The presence of irritability, depression, anxiety in parents compromises the quality of interactions with their children. Likewise, the presence of stress in parents has been linked to the use of punitive and inconsistent parenting strategies, greater neglect, greater frequency of family conflicts, family violence, which promotes emotional and behavioral problems in children (i.e., Fitzpatrick, 2014; Hackman et al., 2010). Parents with high

levels of stress are less predisposed to interact and communicate with their children, which negatively affects the development of children's cognitive and emotional self-regulation abilities.

However, it is important to stop here and analyze the results of research that indicate that it is not possible to think of a linear relationship between poverty and lower quality of parental care. A research reported that proactive interactions between parents and children have been associated with resilient behavior in children living in impoverished environments (Orozco-Hormaza et al., 2012). In line with this result, parental education programs that aim to improve parenting practices in families at risk, improve social and emotional functioning in children. Together these results denote that the quality of care that children receive at home and the type of interactions they establish with their parents or caregivers constitute family resources that can reduce the impact of socially unfavorable conditions on child cognitive development.

Another variable of interest is the variety and quality of cognitive stimulation that children receive at home (Hackman & Farah, 2009). Cognitive stimulation is a broad concept that includes both the availability of material resources, number of books in the home, learning materials, internet access, computers, travel, as well as cultural and educational resources of the family, the educational level of parents, socioeconomic status, collaborative interactions between parents and children, parenting practices, communication between parents and children.

From the variables mentioned, the educational level of the parents constitutes the factor that has been consistently associated with differences in executive functions in children and adolescents (i.e., Ardila et al., 2005; Farah et al., 2006; Matute et al., 2009; Noble & Farah, 2013). Parents with a high educational level create a more intellectually stimulating environment for their children and generate richer formats of interaction in relation to the use of language (Ardilla et al., 2005; Hoff, 2003). It has been observed that university-educated mothers use a richer vocabulary when interacting with their children, dialogue with them more, and read more books to them (Hoff, 2003). These children tend to have faster language development and better cognitive performance.

Based on these results, the researchers began to investigate the type of collaborative interactions between parents and children in order to understand what types of scaffolds promoted a greater EF development (Bernier et al., 2010, 2012; Bibok et al., 2009; Roskam et al., 2014; Spruijt et al., 2018). Scaffolding is a metaphor that captures the idea of an adjustable and transitory support that enables the child to solve a problem that they could not achieve without receiving help (Brown & Palincsar, 1989). Through scaffolding, parents or caregivers plan and organize children's activity so children can perform a task that is beyond their current skill level. Consequently, parents need to adjust support to the children's cognitive level.

Some processes have been identified by which adults provide this help to children, such as (a) focusing attention on the requirements of the task; (b) maintenance of the goal; (c) frustration control; (d) decrease in the degree of difficulty of the task; (e) highlight the main characteristics of the task; and (f) modeling the ideal strategies to solve the task. In this context of social and emotional support that parents provide children, they develop the necessary skills to solve task independently, which traces

their cognitive development. However, the effectiveness of scaffolds is mediated by two factors, the use of language and timing (Bibok et al., 2009).

- The use of language in the construction of the scaffolding affects the EF development (Hoff, 2003; Landry et al., 2002). Two types of scaffolds have been identified, elaborative and directive. Expressly telling the child what to do, reducing the complexity of the tasks, that is, reducing the size of the problem, blocking the difficulties that the child must face, is what characterizes directive scaffolds. These are functional in early childhood, but then produce a counterproductive effect (Bibok et al., 2009). On the other hand, in elaborative interactions, parents provide the child with external and auxiliary resources, which allow him to face a challenging problem that requires partial constructions of new knowledge (Bibok et al., 2009). It has been observed that parents' who offer the child advanced linguistic models to represent problems and their possible solutions, predict the child development of language and EFs (Bernier et al., 2010; Hoff, 2003; Landry et al., 2002).
- Timing as to when it is offered to the child is the second factor that mediates the effectiveness of scaffolds. To be effective, the moment must be contingent on the child's cognitive construction activity. In a study with two-year-olds, the use of contingent directive and elaborative interactions was compared to solving a puzzle. The results indicated that only elaborative interactions contingent on the child's activity predicted improvements in child attention spans (Bibok et al., 2009).

Therefore, cognitive stimulation is not limited to the availability of material resources in the home, but finds its essence in the quality of interactions between children and their caregivers. Enriching the daily life of children with playful, recreational, and educational activities mediated by a caregiver, in which the caregiver organizes the activity in a way that facilitates its solving by the child and encourages him to reflect on their actions, is a way to create opportunities to promote EF development.

In summary, research in neuroscience and cognitive neuropsychology has collected empirical evidence that allows identifying factors and characteristics of the most disadvantaged family contexts that can negatively or positively impact the cognitive development of children. These data point out valuable areas of intervention and prevention to promote better development in children.

School Factors That Model Executive Functioning Development

The literature reports that the schooling experience is a factor that contributes to the promotion of EFs (Burrage et al., 2008; Fuhs et al., 2014). Entering the school offers children new learning experiences that boost the development of executive

functions. Recent research has documented bidirectional relationships between EFs and reading, writing, and math skills, indicating a mutual influence between both processes (McKinnon & Blair, 2018; Van der Ven et al., 2012). Furthermore, it has been documented that children who learn school content and skills more quickly are more willing to participate in increasingly demanding academic activities, which stimulate the development of EFs (Fuhs et al., 2014). Therefore, children's gains in school learning will lead to improvements in their self-regulation abilities.

On the other hand, it has been observed that the EF development is sensitive to the conditions of the school and classroom environment. The type of school, the availability of material resources for learning, the school climate, classroom management, the instructional and organizational support of the class, peer relationships, and the interactions between teacher and student are some of the factors that can modulate the self-regulatory capacities of students (Bardack & Obradović, 2019; Hu et al., 2020; Korinek & deFur, 2016; Nyroos et al., 2018; Rosen et al., 2014; Suntheimer & Wolf, 2020; Spilt et al., 2018; Vandenbrouck et al., 2018; Weiland et al., 2013).

In relation to the availability of material resources for learning, some studies have reported that schools from disadvantaged contexts have less resource in relation to those from more affluent contexts. These differences impact the learning of schoolchildren and reproduce the initial socio-cultural differences of children (Krüger, 2013). Although the material conditions and the availability of resources for learning shape the schooling experiences of children, there are other factors with greater explanatory force about the learning processes of children. The quality of teaching is one of the most important school variables influencing student achievement (Organisation for Economic Co-operation and Development [OECD], 2015).

Numerous studies document the relationship between the quality of teaching and children's school learning processes; however, few have asked how the teaching process shapes the cognitive development of students (i.e., Weiland et al., 2013). Initial studies analyzed this relationship in a broad way and indicated that the school climate, class management, and the structuring of teaching activities are factors that modulate the cognitive and emotional self-regulation capacities of schoolchildren. However, these studies did not detail the specific mechanisms by which schooling impacts children's performance of executive functions.

In an effort to provide clarity to this question, a body of recent research has focused on analyzing the role of the teacher as a mediator of the cognitive development of students (Bardack & Obradovic, 2019; Keenan et al., 2019; Korinek & deFur, 2016). Two ways have been identified by which educators promote the development of students' EFs: one, implicit, from modeling the use of EFs in daily school activities; and, the other, explicit, through scaffolding the development of the students' self-regulatory capacities (Bardack & Obradovic, 2019; Korinek & deFur, 2016).

Human beings learn by observing the behavior of others. Teachers model EFs for their students when they: organize content, plan and sequence the steps of learning tasks; use time productively; resist distractions; shift their focus of attention to serve diverse stimuli; control frustrations by maintaining a good school climate; or, use their cognitive flexibility to seek different solutions to problems (Badarack & Obradovic,

2019; Hodgkinson & Parks, 2016; Korinek & deFur, 2016; Nyroos et al. al., 2018; Rosen et al., 2014; Walk et al., 2018).

Research shows that the emotional and cognitive self-regulation of teachers plays a critical role in promoting and maintaining positive educational practices that contribute to students' EF development. A greater capacity for self-regulation of teachers, emotional support, instructional and class organization, and establishment of clear and consistent routines are associated with better stress management, better school climate, better class management, and greater students' EF development (Andersen et al., 2019; Badarack & Obradovic, 2019; Diamond & Lee, 2011; Hodgkinson & Parks, 2016; Rosen et al., 2014).

Furthermore, it has been observed that teachers who denote greater self-regulation capacities are more likely to use educational practices that explicitly support or scaffold students in the acquisition of self-regulatory capacities (Anderson et al., 2020; Korinek & deFur, 2016; Raver et al., 2012; Rosen et al., 2014).

In one study, it was observed that the scaffolding of planning-organization skills and cognitive flexibility offered by educators was associated with improvements in students' EFs six months later (Badarack & Obradovic, 2019). Among the strategies used by educators to scaffold EFs were: instructing students how to use time or how to keep materials organized; allowing students to choose topics or projects; communicating trust and respect; establishing clear routines; considering multiple perspectives; switching between perspectives; and, frequently using positive feedback (Badarack & Obradovic, 2019). The sustained practice of these strategies helps students take ownership of them, and use them to regulate their learning processes.

In sum, the school context is an environment with multiple resources and opportunities to promote the development of the self-regulatory capacities of its students, especially for those from vulnerable contexts.

Cultural Practices Within the Community, and Child Executive Functioning Development

EFs develop in social interaction. The socio-historical theory of development (Vygotsky, 1978) postulates that higher mental functions, such as self-regulation, develop within the context of interpersonal activity.

In order to analyze how social interaction directly influences children's behaviors that require executive control, Morguichi et al. (2007) examined whether children's executive control might be influenced by learning from another person's actions. They proposed an interference task and a card-sorting task to children, in a context of social interaction, in which an adult modeled the execution of the task in a wrong way (Moriguchi, 2012; Moriguchi et al., 2012). The finding indicated that children imitate adult behavior in solving executive functioning tasks, especially if they observed a confident adult model. Interpersonal interaction may facilitate internalizing some

views of another person's perspective on reality, which shape the development of EFs (Moriguchi, 2014).

These results provide evidence of the importance of social modeling in cognitive development, and raise the question of whether cultural differences can mediate the influence of social modeling on EF development. Morguichi et al. (2012) replicated their study on social imitation, with 3- and 4-year-olds in Canada and Japan, and observed a greater sensitivity to adult modeling in Japanese children than in Canadians. They interpreted these differences in terms of cultural psychology theories. They postulated that the differences between Canadian and Japanese children are probably due to the fact that the former may be more likely to separate themselves from another person, and, consequently, act more independently of the others (Morguichi et al., 2012). However, more studies are necessary to support this postulation.

A review study set out to examine the evidence for cross-cultural variation in socialization and children's self-regulation, based on a contextual-developmental perspective (LeCuyer & Zhang, 2015). The contextual–developmental perspective proposes that social values, beliefs, cultural norms and ethical values, shape the socialization process and the behavior of people, and consequently, they can affect the development of self-regulatory capacities in children (Bronfenbrenner, 1979, 1992). The analysis of comparative and correlational studies indicated coherent patterns of sociocultural influence on children's attention, compliance, delay of gratification, effortful control, and executive function (LeCuyer & Zhang, 2015). These findings postulate the importance of incorporating a socio-contextual view, to understand how the differences in parenting can distinctively shape the development of executive functions.

The social practices, cultural norms, values, and attitudes of socio-cultural context affect parents' rearing practices, their behaviors, and the interaction between parents and children. Parents from different cultures and communities will offer children distinctive learning experiences and opportunities, which will distinctly shape children's cognitive development. Likewise, culture and social values will shape children's schooling, the quality of teaching, and collaborative interactions between teachers and students. Considering that, schooling may affect, in a distinctive way, the development of students' self-regulatory capacities, perhaps strengthening certain executive functions more than others.

In a study carried out with a large and representative sample of 55,000 Argentine schoolchildren (Korzeniowski & Ison, 2019), in which the students' EFs were evaluated, cognitive flexibility was identified by teachers' reports as the strongest EF in the children. These data could be associated with learning opportunities and practices, in their homes and schools that often stimulate cognitive flexibility in children. Furthermore, these results could be associated with the practices reported by the Argentine teachers in another study (Korzeniowski & Ison, 2020), who use guidelines and strategies with high frequency to strengthen students' cognitive flexibility. However, future studies are necessary to test these associations directly and predictively, and to compare these findings with other sociocultural contexts.

In sum, the review carried out indicates that it is not possible to interpret the impact of social interaction on the development of executive functions without considering cultural differences. It is necessary to adopt a contextual perspective of development that allows understanding of the associations between differences in cultural norms and values, socializing behaviors, and children's self-regulation, in order to comprehend diversity in children's EF development.

An Ecological–Contextual Model of the Development of Executive Functions

From a contextual–developmental perspective (Bronfenbrenner, 1979, 1992), and to integrate the contributions of the environmental factors that model the development of executive functions, an ecological model is proposed that synthesizes variables from child, family, school, and community (see Fig. 20.1). The proposed model is flexible, and it is hoped that it can be enriched with future research.

Ecological Interventions for Improving Executive Functions in Children from Socially Vulnerable Contexts

The study of the environmental factors that shape EF development in children from socially vulnerable contexts has allowed us to identify areas of intervention. In recent decades, there has been a growing interest in designing ecological interventions aimed at enriching family and school resources in order to enhance the cognitive and socio-emotional development of children in conditions of social vulnerability (Diamond & Lee, 2011; Diamond & Ling, 2016).

One of the strengths of intervention methods in neuroscience is that they enable articulation with other intervention proposals and their application in natural contexts where the child grows up, such as school, home, and community (Lipina et al., 2011). Based on this postulate, two types of interventions have been developed: enriched curricula and psychoeducational workshops for parents.

Enriched curricula refer to cognitive training activities that are integrated into the school curriculum, forming part of the daily activities that children carry out at school. These interventions are accessible to more children, can be started early, and can be sustained longer. Its application is in charge of educators, and consequently, it is necessary to train them with knowledge and strategies aimed at promoting students' EFs (Andersen et al., 2019; Bardack & Obradovic, 2019; Keenan et al., 2019; Korinek & deFur, 2016). Enriched curriculum programs, such as Tools of Mind (Diamond et al., 2007), have generated promising results, indicating that participating children improve their self-regulatory capacities and school competencies. Likewise, these experiences promote the active participation of children, reduce stress in the

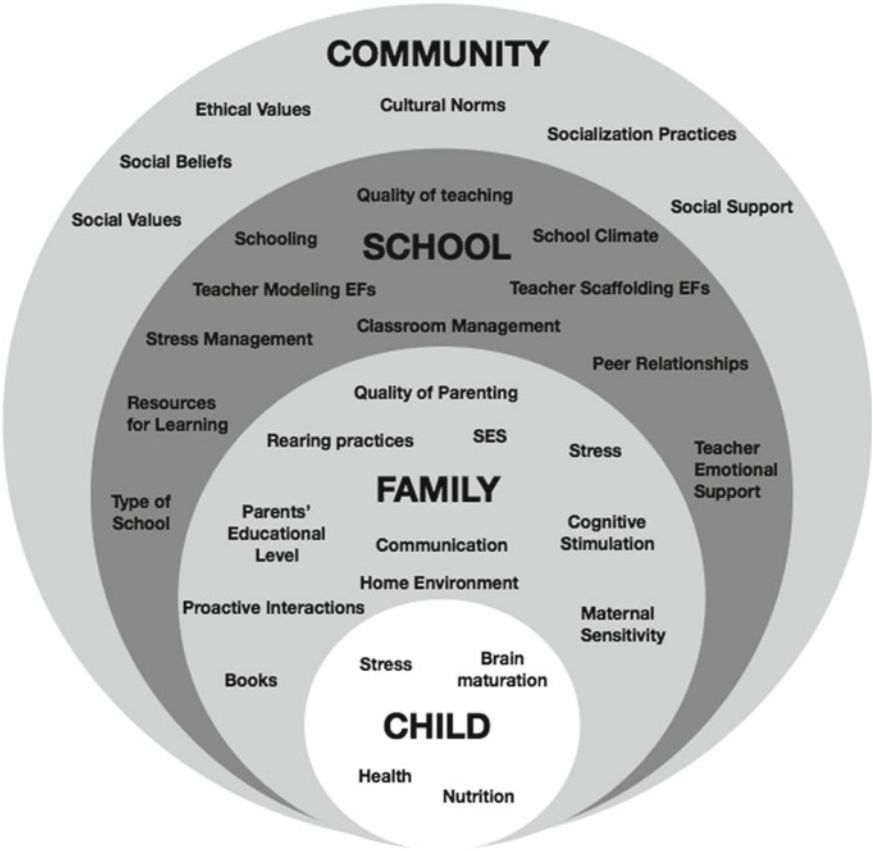

Fig. 20.1 An ecological–contextual model of the development of executive functions

classroom, and cultivate play, self-confidence, social and emotional development, accompanied by a greater EF development and school performance (Anderson et al., 2020; Cabanes Flores et al., 2018; Diamond & Lee, 2011; Domitrovich et al., 2007; Janz et al., 2019; Korzeniowski et al., 2017; Walk et al., 2018; Zelazo et al., 2018).

In order to improve family resources, training for parents has been implemented. Workshop for parents has focused on assisting parents in improving communication with their children, promoting the development of critical thinking skills, and providing techniques for family stress management and guidelines to enhance child development and learning (Diamond & Lee, 2011; Korzeniowski et al., 2017).

In one study, a series of workshops were carried out to train parents from socioeconomically vulnerable backgrounds (Stevens & Neville, 2011). Over eight weeks, parents learned strategies to improve communication with their children, reduce stress, and promote the use of critical thinking in children. The results indicated that the parents who participated in the intervention exhibited a decrease in stress in the face of parenting challenges and increased opportunities for dialogue and verbal

communication with their children. These changes were associated with children's improvements in language, memory, and attention.

The strengths of these interventions are several. Training caregivers is a way to enrich family educational resources, favor a climate of positive interaction, and promote better stress management, which results in benefits for parents, children, and the whole family.

The promising results of ecological interventions provide evidence of the importance of enriching the daily activities of children who grow up in socially vulnerable conditions, in order to promote their development. Ultimately, the aim of these interventions is to increase children's resources to cope with disadvantaged environments.

Conclusion

Executive functions play a key role in the cognitive, social, and emotional development of children. Their adequate performance in childhood is associated with self-regulated behavior, proactive social relationships, emotional well-being, and successful school learning in childhood. These childhood achievements predict better health, well-being, and quality of life in adolescence and adulthood.

Children who grow up in socially vulnerable contexts are exposed to numerous risk factors that impact their cognitive development. They present educational and cognitive disadvantages that are appreciated upon entering the educational system and are accentuated during the school career, due to the summative effect of risk factors.

EFs can be negatively affected by stressful environments and by the lack of quality and proactive interactions with adult caregivers. However, environments that promote healthy child development can help children to strengthen their EFs. Considering that the family and the school are the two social institutions that most shape the development of children (Gerrard & Soriano, 2020), the characteristics of these contexts that modulate child EF development have been studied. For family, the following factors have been identified: parents' educational level, prenatal and postnatal stress level, family socioeconomic level, rearing practices, cognitive stimulation, and quality of mother–child interactions. For the school context, these factors have been pointed out: school climate, classroom management, teacher's emotional support, and collaborative interactions between teacher and students that scaffold EF development. However, the impact of the family and the school on children's cognitive development should be understood and analyzed within the framework of their sociocultural context. The contextual–developmental perspective postulates that cultural norms and social values shape the socialization practices of children, and, by this path, the EF development. Based on that, it is necessary to adopt a contextual–developmental perspective, in order to comprehend diversity in children's EF development.

Knowing the explanatory value of these factors in the child cognitive development has made it possible to identify specific areas of intervention. The current challenge

is the design of ecological interventions aimed at increasing resources for family, school, and community, in order to promote child EF development. The experiences carried out provide promising results and underline the importance of training parents and teachers.

Interventions in the family indicate the need to transfer resources to the parents or caregivers of children, aimed at promoting the quality of parental care, increasing sensitivity to the needs of children, improving communication, and train them in using techniques and activities designed to promote the EF development. Through short, simple and playful activities, caregivers can create meaningful learning experiences for children to strengthen their self-regulatory capacities. The challenge for researchers and practitioners will be to create these resources and find the best strategies to bring them closer to less favored households.

In school, the key is the quality of teaching, which underscores the importance of revaluing the role of the teacher as a mediator of the cognitive development of students. This underlines the need to transfer knowledge and strategies to educators, so that they become able to create new and better educational practices aimed at promoting students' learning and EF development. The challenge for educators and researchers is to create bridges between neuroscience and education. Both must overcome barriers, articulate objectives and share perspectives and languages to create enriched educational practices.

The evidence gathered indicates that the cumulative and summative effect of enriched practices at home and at school is a possible way to reverse, or at least compensate for, the educational and cognitive gap between the most and least favored children. Ecological interventions for home and school can benefit many children. It is necessary to articulate efforts between researchers, educators, governors, and community leaders to extend these interventions to more children, families, and schools. The more bridges that can be established between these sectors, the greater the chances of providing children with better opportunities for healthy development and a better quality of life.

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