# EXECUTIVE FUNCTIONS IN EARLY CHILDHOOD

RUKIYE GÜNSELI YILDIRIM,[1] ENDAM DÜZYOL[2]

[1] Dokuz Eylül University, Buca Faculty of Education, Buca, Turkey
gunseli.yildirim@deu.edu.tr
[2] Dokuz Eylül University, Buca Faculty of Education, Turkey
endam.duzyol@deu.edu.tr

**Abstract** Executive functions are all mental skills that enable and direct behaviors for various purposes. Executive functions begin to appear in infancy, show rapid development from early childhood, grow mature in late adolescence, and regress in late adulthood. Early childhood, which includes critical periods for the development of executive functions, is considered important. In this study, it is aimed to share current studies on executive functions, which is a relatively new concept. In this study, data were collected through document analysis based on the survey model, one of the qualitative research methods. In this study, the definition of executive functions and their neurological basis, components, and development are discussed in the context of early childhood. In addition, executive functions in early childhood are explained in detail as they have an effect that predicts executive function potential in later life.

**Keywords:**
cognitive flexibility, early childhood, executive functions, inhibition, working memory

University of Maribor Press

DOI https://doi.org/10.18690/um.pef.3.2023.1
ISBN 978-961-286-707-2

## 1 Introduction

Although the concept of executive functions began to be used in the 1970s, the discussion and basis of the concept date back to the 1840s. The case of Phineas Gage is one of the most impressive examples demonstrating executive functions. In 1848, while working as a railroad foreman in the United States, Gage's frontal lobe was punctured by a large iron rod in an accident. Most of his left frontal lobe was damaged, but he survived. After the healing process, it was seen that there were significant differences in Gage's behavior and personality. This and other similar cases have led to various studies related to the frontal lobe and executive functions (Ratiu et al., 2004). As a result of many years of research, Karl H. Pribram named it "executive functions" while investigating the functions of the prefrontal cortex for the first time in 1973 (Pribram, 1973). More than thirty components have been included over time in this concept used by Pribram. Executive functions have been described in various ways using models that include multiple components.

Baddeley & Hitch (1974) named executive functions "central executive" and then Lezak (1983) considered it as a dimension that deals with "how" human behavior is expressed. Executive functions have been defined as the mental capacity required to effectively implement plans, such as being able to express goals clearly, plan how to achieve them, encode and process information in working memory, and determine the next stage in an organized manner in tasks that can occur in succession (Lezak, 1983).

Executive functions are all mental skills that provide and direct the implementation of behaviors for various purposes (Jurado & Rosselli, 2007). Executive functions represent cognitive control processes that aim to regulate, organize, and plan behaviors (Diamond & Lee, 2011). In this context, it can be inferred that executive functions are processes used in situations such as the individual's rapid adaptation to constantly changing environments, regulating his behavior, or controlling his own behavior to achieve a goal.

Executive functions, as an inclusive term, represent all interrelated processes responsible for purposeful and goal-directed actions. These executive processes are necessary for the composition of external stimuli, for shaping goals and strategies, for preparing for behavior, and for examining behavior and plans as they are appropriately implemented. When processes related to executive functions are

examined, it is seen that the most critical elements are "intuition, goal selection, planning, initiation of action, self-regulation, cognitive flexibility, regulation of attention and use of feedback" (Barkley, 2012). However, these processes are thought to contain a wide variety of elements in addition to those mentioned.

Within the scope of executive functions, high-level, top-down cognitive processes that are the source of purposeful behaviors are discussed. Although there are various opinions in the related literature on the definition of executive functions, they all converge on the point that executive functions are the basis of purposeful behaviors, are flexible, and include complex cognitive processes in directed behavioral responses to difficult or new events (Archibald & Kerns, 1999; Banich, 2009; Miyake & Friedman, 2012).

Executive functions in early childhood include all skills such as "working memory, emotion control, maintaining attention, planning, organization, using time, cognitive flexibility, target orientation, inhibitory control/inhibition, and starting a task" (Anderson, 1998). Individuals need these high-level cognitive processes in order to resist, reason, and solve problems during the process of struggling with difficulties from an early period (Diamond, 2013). Therefore, executive functions, as high-level cognitive functions, can initiate, direct, and maintain a cognitive action during this process.

Anderson (2002) suggested that executive function skills function holistically and can be conceptualized as a functional system consisting of four different domains. He proposed the executive function model, which consists of the sub-dimensions "attention control, information processing, cognitive flexibility and goal setting".

Attentional control is the determination and maintenance of attention over a long period, recognizing mistakes, and regulating correct actions during the process of achieving goals. Information processing is the integration of neural connections with frontal lobe processes. It focuses on speed, fluency, and efficiency to complete problem-solving tasks. Cognitive flexibility is the ability to adapt to changes, develop alternative strategies, multitask information, and process temporarily stored information. Goal setting, on the other hand, includes the capacity to plan actions in advance and approach tasks efficiently and strategically, as well as the ability to develop new initiatives and concepts (Anderson, 2002). According to this model,

executive functions operate effectively through the interaction of these areas. Executive functions develop rapidly from early childhood (Welsh et al., 1991).

## 2 Method

In this study, data were collected through document analysis based on the survey model, one of the qualitative research methods. Document review includes reaching the sources in accordance with the purpose of the research topic and analyzing the studies on the subject (Yıldırım & Şimşek, 2006). In this context, the literature on executive functions, which is a relatively new concept, has been examined.

## 3 Results

### 3.1 Neurological Basis of Executive Functions

According to research performed, executive functions are anatomically associated with the frontal lobe region. The frontal lobe is the largest lobe in the front of the brain. The highest level human functions such as thinking, creativity, and communication are located in this region of the brain. The frontal cortex consists of three parts: the motor, premotor, and prefrontal cortex (Milner & Petrides, 1984).

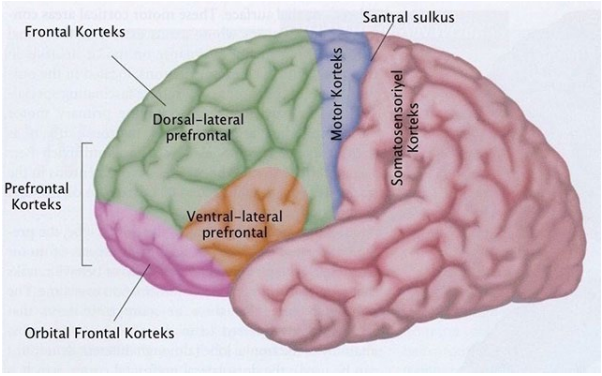


**Figure 1: Frontal Cortex and Prefrontal Cortex Anatomy.**
Source: Arıkan, 2022.

The prefrontal cortex is the axis of executive functions, working memory, social behavior, and attention. It is the region where functions such as planning and reasoning, implementation, social communication, and language are located. This

cortex is divided into three parts: the dorsolateral, ventromedial, and orbitofrontal cortex. The dorsolateral cortex is responsible for executive functions and the ventromedial cortex for motivation and attention; the orbitofrontal cortex, on the other hand, is responsible for the regulation of impulses and emotions (Powell & Voeller, 2004). Zelazo and Müller (2010) explained executive functions according to their functional changes. Executive functions are divided into two separate classes: hot and cold executive functions. They defined executive functions that evaluate the dorsolateral prefrontal cortex and have cognitive aspects related to attention as cold executive functions. They defined executive functions that evaluate the orbitofrontal prefrontal cortex and have aspects related to emotion as warm executive functions. The ability to make decisions about the future and think about the consequences (impulsivity) has been associated with warm executive functions.

Although the frontal lobe involves many important elements of executive functions, some studies indicate that executive functions are not limited to the functions of the prefrontal cortex. The prefrontal cortex is also associated with other cortical areas, cerebellum, subcortical regions such as the basal ganglia and amygdala, and the limbic system (Strauss et al., 2006).

### 3.2 Components of Executive Functions

Many views have been expressed that executive functions consist of different interrelated components. It is agreed that the basic components of executive functions are working memory, inhibitory control (inhibition), and cognitive flexibility (Meuwissen & Zelazo, 2014; Carlson et al., 2013; Diamond, 2013; Hughes, 2011; Blair & Diamond, 2008; Garon et al., 2008, Miyake et al., 2000).

#### 3.2.1 Working Memory

Working memory is expressed as a cognitive system that can access and maintain the information necessary for high-level cognitive tasks (Baddeley, 1992). Although it is a multi-component system, it has the ability to actively protect information in situations such as current processing or concentration dispersion. Active conservation represents the harmony of multiple processes (Storbeck & Maswood, 2016). Working memory has an active role in establishing the relationship between old information and new information, understanding expressions, and establishing uncertain connections (Diamond, 2013). It is a capacity system that allows the

individual to temporarily process, store, and manage information with conscious awareness in order to solve a problem related to the purpose. A solid working memory is critical to high-level tasks such as planning and decision making, as it allows an individual to regularly review incoming information. Moreover, working memory appears in various areas of daily life such as making plans, solving problems, communicating, and reading books (Roussel et al., 2012). It is thought that working memory has a significant effect on all high-level cognitive functions.

The ability to control attention and the ability to keep information in the short-term memory begins to develop at around the age of 2. During the kindergarten years, these skills develop rapidly and turn into working memory. Working memory provides support to children in terms of keeping the acquired information in their memory for a short time and completing a task with this information or giving appropriate reactions to a situation. As this structure develops, children can use more complex executive function skills. Thus, they can perform different tasks including complex and multi-step ones and remember and apply the rules in their memory (Baddeley, 1992; Garon et al., 2008). The ability of children in early childhood to follow and apply various instructions, making plans during the day, and chatting about them is an example of working memory skills.

### 3.2.2 Inhibitory Control (Inhibition)

Inhibitory control, also known as inhibition, is the deliberate inhibition of an overriding answer or response. It is the suppressing of a natural orientation and replacing it with another response that is not so dominant. The ability to inhibit is partially dependent on the development of attention control and working memory. With the development of this skill, individuals can engage in more controlled behaviors (Barkley, 2012). Inhibition is used to master impulses and thoughts, to filter them out, to resist distractions, and to stop and think before acting. It includes the ability to prevent unnecessary behaviors or thoughts that prevent the completion of tasks. Thus, it results in focus on the task and prevents inappropriate automatic responses (Diamond, 2013).

Inhibition skill enables the individual to make better plans, organize, solve problems, and stop and think before acting. It is of critical importance for individuals to control their behavior in daily life. It develops from early childhood and is seen primarily as the control of motor responses at around 1 year of age. Inhibition begins to be used

for the purpose of controlling behavior, emotions, and thoughts when children begin to notice and understand the limitations imposed by their families (Barkley, 2012). While performing complex tasks for inhibition, especially when the tasks have contradictory rules, children display the expected behaviors by using working memory. It starts during the early period and shows great development during the preschool period and beyond, but slows down from the age of 11 to adulthood (Fuster, 2008; Romine & Reynolds, 2005; Tregay et al., 2009). The ability of children in early childhood to delay gratification and to comply with classroom rules when they do not want to is an example of inhibition skill.

### 3.2.3 Cognitive Flexibility

Cognitive flexibility includes adapting to priorities, changing demands, and various views and being able to evaluate a situation from a different or new perspective. It also includes knowing that the rules differ according to the differences in the environments, switching between perspectives, and thinking abstractly (Nguyen & Duncan, 2019; Neitzel, 2018). Therefore, Diamond (2013) expressed cognitive flexibility as the third component of executive functions. Cognitive flexibility requires attentional control. It is the last component of executive function, built on working memory and inhibitory control (Garon et al., 2008). Multidimensional thinking about an open situation occurs thanks to cognitive flexibility (Zelazo, 2015). Cognitive flexibility is the individual's adaptation to various situations, willingness to be flexible, awareness of alternative options, believing that they have the ability to think flexibly, and feeling self-confident (Martin & Anderson, 1998).

Cognitive flexibility has a significant impact on unusual tasks and problem-solving skills in daily life. It develops from early childhood and it is seen that children fulfill their cognitive flexibility tasks from the age of one and a half. These skills develop with age (Stahl & Pry, 2005). The development of cognitive flexibility skills increases rapidly from the age of three to the age of eight, but slows down from the age of eight to adulthood (Anderson, 2002). The ability of children in early childhood to change their behavior to adapt to changing rules is an example of cognitive flexibility.

### 3.3 Development of Executive Functions

Executive functions begin to appear in infancy, develop rapidly from early childhood, mature in late adolescence, and regress in late adulthood (Diamond, 2013). Developments in the structuring of the brain show parallelism with the development of executive functions. Accordingly, myelination, synapse formation, and pruning of nerves progress during childhood and adolescence, and developmental stages are observed in the frontal lobe subregions during certain periods. These changes result in changes observed in the information processing capacity and speed of the brain and the interactions of its various regions (Anderson et al., 2002).

Executive functions develop in three basic stages. The first stage covers the period from 18 months to 5 years. During this stage, working memory, impulse control, and basic cognitive flexibility skills are seen in tasks based on motor responses. Young children around the age of 2 exhibit emotional breakdowns, disorganization, and impulsive behaviors due to the lack of development of executive function skills. Children between the ages of 3 and 5 show significant progress in the development of goal-related behaviors. Significant changes are observed in the neuronal density of the prefrontal cortex during this process (Diamond, 2013). As a result of this rapid growth in executive functions in this age range, children regulate their thoughts and behaviors with increasing flexibility. They also engage in self-regulated behaviors (Garon et al., 2008). The second stage covers the period from 5 years to 10 years. Metacognition, emotion control, impulse control, and simplified planning skills are seen during this stage, when executive function development is the fastest. However, at the end of this period, adult performance levels cannot be achieved in various executive function tasks. The third stage covers the period from 10 years to 14 years. During this stage, the development in working memory, impulse control, and cognitive flexibility continues and matures (Welsh et al., 2006).

Executive functions begin to emerge during infancy; they develop from childhood to adolescence and play an effective role in children's cognitive functions, behaviors, emotional control, and social interactions (Anderson, 2002). With the increase in life experiences and the maturation of the brain during early childhood, executive function skills develop significantly (Harris, 2016). Knowing how these skills develop during this period is important for understanding what children in different age groups can do and how much they can control themselves. In this way, it can be

predicted how much support children should receive and how from adults during their education life (Dawson & Guare, 2010). Since early childhood is a period of high plasticity of the brain, it is of critical importance in this regard (Blair & Raver, 2012; Diamond, 2013; Harris, 2016; McClelland et al., 2007; Welsh et al., 2010).

The components of executive function skills show varying developmental progression in different age groups. The development processes of executive function skills are given in Table 1.

**Table 1: Development of Executive Function Skills**

| Working Memory | Inhibitory Control (Inhibition) | Cognitive Flexibility |
|---|---|---|
| Adulthood: Can recall multiple tasks, rules, and strategies that vary from situation to situation. | Adulthood: Develops consistent self-control. Responds appropriately to situations (e.g., may resist saying something socially inappropriate) | Adulthood: Can reexamine actions and plans in differing circumstances. |
| | Ages 10-18: Can be self-controlled to flexibly switch between stimuli that require attention (like driving a bike/car) or non-attention (e.g., pedestrians-billboards, passing houses). | Ages 13-18: Develops skills to change focus and adapt to changing rules. |
| Ages 5-16: Can search for objects that have moved, remember where they are, and then develop skills to explore other places (e.g., play focus games or find the penny hidden under one of the three trophies) | 7 years old: May be close to performing at adult levels in learning to ignore irrelevant stimuli (like a dot at the edge of the screen) and focusing on the central stimulus (like the picture in the middle of the screen). | Ages 10-12: Successfully adapts to changing rules even in more than one dimension (like shouting in the playground, not shouting at school, sometimes shouting at a theater rehearsal) |
| Ages 4-5: Realizes that appearance is not always the same as reality (e.g., a sponge that looks like a rock) | Ages 4-5: The ability to produce alternative solutions develops when the first attempt is not successful. Considers an arbitrary rule (can sort cards by shape rather than color) | |
| 3 years old: Can remember two rules (e.g., reds will be placed here, blues will be placed there) and act according to the rules. | | Ages 2-5: Shows success in rules that vary according to different activities (e.g., can take off shoes at home, wear them at school, wear boots when it rains) |
| 9-10 months: Can execute simple goal-related tasks and two-step plans. | 9-11 months: Looks like a toy on the other side of the window but can thwart the urge to reach straight for an inaccessible reward. The dominant response is delayed to explore the barrier around it. | 9-11 months: When unable to reach an object directly, the ability to find various ways to retrieve the object develops. |
| 7-9 months: Object permanence develops. Combines two activities sequentially (Can take off the cloth, hold the toy). | 8-10 months: Begins to maintain focus despite being distracted by short delays in the task. | |
| | 6 months: Begins to inhibit the dominant response (may not touch the thing instructed not to touch) | |

Center on the Developing Child at Harvard University (2011)

Executive function skills develop gradually and each component builds on existing skills (Garon et al., 2008). Similarly, in Table 1, it is seen that working memory, preventive control, and cognitive flexibility, which are components of executive function skills, emerged during infancy and developed in a cumulative manner.

### 3.4 Executive Functions in Early Childhood

Executive functions are high-level cognitive skills that include behavior regulation and goal-directed activities of individuals (McCloskey et al., 2009). There are periods of high plasticity in which certain parts of the human brain, which is flexible by nature and can adapt to the environment, and their corresponding functions are sensitive to environmental influences (Zelazo et al., 2016). The prefrontal cortex is sensitive to environmental influences and its long-term development continues into adulthood. The rapid development of executive functions in early childhood shows the importance of experiences gained during this period and that this period of brain flexibility is the most critical time for intervention (Zelazo & Carlson, 2012).

Executive functions and behaviors begin to appear in infancy, but do not fully mature until young adulthood (Diamond & Lee, 2011). Executive functions at an early age predict executive function potential later in life (Eigsti et al., 2006; Friedman et al., 2007; Moffitt et al., 2011; Shoda et al., 1990). One of the most important and challenging tasks in early childhood is to acquire the early building blocks of executive function skills. The development of these skills in early childhood has a significant impact on healthy development in the later years of an individual's life (Center on the Developing Child at Harvard University, 2014). It is thought that adults should support the development of executive functions of children from an early age. Brain development is easily affected by the environment in the first years of life, especially in the 0-5 age range. When environments and interactions that support the development of executive function skills are created by adults, positive differences are observed in the actions and outcomes of young children at school, at home, and in their lives (Bryck & Fisher, 2012; Diamond & Lee, 2011; McCloskey et al., 2009; Wass et al., 2011).

A sample of executive functions (Dawson & Guare, 2009) and skills is presented in Table 2 with an explanation of how these skills are used by young children. Three components of executive function skills in early childhood are explained. Additional skills related to each component are also included. Here, it is considered important

that educators and adults realize that executive functions control behavior and that by understanding these functions they can help young children enhance these skills.

**Table 2: Executive Function in Early Childhood**

| Executive Function | Executive Skills | Older Toddlers (ages 2-3) | Preschoolers (ages 3-5) |
|---|---|---|---|
| **Cognitive Flexibility:** Mental ability to switch between different concepts; thinking about more than one concept at the same time. | – Creativity.<br>– Flexibility. | – Appropriately responds to differences in routines/structures with close adult support.<br>– Engages in new activities. | – Adapts to changes in plans or routines with some alerts.<br>– Begins to connect concepts that are not directly related, based on personal experience. |
| **Inhibitory Control:** The capacity to think before acting—the ability to resist the urge to say or do something. | – To wait.<br>– To think first. | – May stop responding for a few seconds if watched closely by an adult.<br>– Responds to "before, after" presentation of tasks when supported by an adult. | – Asks before taking anything.<br>– Waits in line at group events. |
| **Working Memory:** Ability to retain information in memory while performing complex tasks. It includes the ability to draw on past learning or experience to apply to the situation at hand or project it into the future. | – Remembe r and use. | – Follows instructions given by an adult. | – Can follow the steps of a routine with a single command.<br>– Can complete an easy task. |

National Center for Pyramid Model Innovations (NCPMI) (2019)

Executive function skills are critical for school readiness and academic performance. School success, which develops from early childhood through these skills, affects academic performance in the following years (Diamond, 2013; McClelland et al., 2007; Morrison et al., 2010). As a result of various training given for a certain period, it was determined that children with good executive function skills learned more permanently and were able to retain more information in their memory than their peers with worse executive function skills (Benson et al., 2013). Executive function skills are seen by teachers as one of the most important determinants of success in the classroom (McClelland et al., 2007). These skills are essential for meeting the demands of the classroom environment and performing daily life tasks. In this way, children can be aware of the situations in which they need to sit, apply them, pay

attention, remember and obey the rules, and gain flexibility to adapt to new perspectives. In addition, as an indirect effect of executive function skills, children who come to the educational institution with these skills do not experience much difficulty with the learning process; they can love school and be more motivated (Zelazo et al., 2016).

Executive function skills have a significant impact on academic achievement, as well as on the development of social competence and social skills, and the reduction of destructive actions (Hughes & Ensor, 2011). Children with higher executive function skills exhibit less behavioral problems and have stronger emotion regulation (Cole et al., 1993; Jahromi & Stifter, 2008). In addition, in a longitudinal study in the literature, children with better inhibitory control in the 3-11 age range had better physical and mental health after 30 years and obeyed the laws more than children with lower inhibitory control (Moffit et al., 2011).

## 4 Discussion and Conclusions

Executive function skills develop significantly in early childhood. These skills have a significant impact on all areas of development, especially mental development. They do not lose their importance in the life of the individual during adulthood. Support of these skills in the early years leads to the strengthening of children's school readiness, academic performance, and social competencies for primary school. For this reason, it is thought that it is important for adults who interact with the child to know about the development process and support of executive function skills in early childhood. In particular, it is considered important that educators have information about executive function skills, implement strategies that support these skills in classroom environments, and regularly monitor behaviors. Parents, with whom children spends most of their time, should likewise be able to help children develop these skills by understanding executive functions skills. Researchers should develop measurement tools for executive function skills and perform further studies on the subject. Thus, important information resources will be obtained in practice and theoretical dimensions in the development of executive function skills in young children. There is a need to expand studies on this subject.

**References**


Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychol. 8*(2), 71-82. doi: 10.1076/chin.8.2.71.8724.

Anderson, V. (1998). Assessing executive functions in children: Biological, psychological, and developmental considerations. *Neuropsychological Rehabilitation, 8*(3), 319-349.

Anderson, V., Levin, H. S., & Jacobs, R. (2002). Executive functions after frontal lobe injury: A developmental perspective. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 504–527). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195134971.003.0030

Archibald, S. J., & Kerns, K. A. (1999). Identification and description of new tests of executive functioning in children. *Child Neuropsychology, 5*(2), 115-129.

Arıkan, K. (2022). *Neuneuropsychological assessment and associated fields – I.* https://www.kemalarikan.com/en/neuneuropsychological-assessment-and-associated-fields-i.html

Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556-559.

Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation, 8,* 47-89. http://dx.doi.org/10.1016/S0079-7421(08)60452-1

Banich, M. T. (2009). Executive function: The search for an integrated account. *Current Directions in Psychological Science, 18*(2), 89-94.

Barkley, R. (2012). *Executive Functions: What They Are, How They Work and Why They Evolved.* Guilford Press.

Benson, J. E., Sabbagh, M. A., Carlson, S. M., & Zelazo, P. D. (2013). Individual differences in executive functioning predict preschoolers' improvement from theory-of-mind training. *Developmental Psychology, 49*(9), 1615–1627. https://doi.org/10.1037/a0031056

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology*, *20*(3), 899-911.

Blair, C., & Raver, C. C. (2012). Child development in the context of adversity: experiential canalization of brain and behavior. *American Psychologist, 67*(4), 309.

Bryck, R. L., & Fisher, P. A. (2012). Training the brain: Practical applications of neural plasticity from the intersection of cognitive neuroscience, developmental psychology, and prevention science. *American Psychologist, 67*(2), 87–100. https://doi.org/10.1037/a0024657

Carlson, S. M., Zelazo, P. D., & Faja, S. (2013). Executive function. In P. D. Zelazo (Ed.), *The Oxford handbook of developmental psychology (Vol. 1): Body and mind* (pp. 706–743). Oxford University Press.

Center on the Developing Child at Harvard University (2011). *Building the Brain's "Air Traffic Control" System: How Early Experiences Shape the Development of Executive Function: Working Paper No. 11.* www.developingchild.harvard.edu

Center on the Developing Child at Harvard University (2014). *Enhancing and Practicing Executive Function Skills with Children from Infancy to Adolescence.* www.developingchild.harvard.edu

Cole, P. M., Usher, B. A., & Cargo, A. P. (1993). Cognitive risk and its association with risk for disruptive behavior disorder in preschoolers. *Journal of Clinical Child Psychology, 22*(2), 154–164. https://doi.org/10.1207/s15374424jccp2202_3

Dawson, D., & Guare, P. (2010). *Executive Skills in Children and Adolescents: A Practical Guide to Assessment and Intervention.* Guildford.

Dawson, P., & Guare, R. (2009). *Smart but Scattered: The Revolutionary "Executive Skills" Approach to Helping Kids Reach their Potential.* Guilford Press.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–168. doi: 10.1146/annurev-psych-113011-143750.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-64. doi: 10.1126/science.1204529.

Eigsti, I.-M., Zayas, V., Mischel, W., Shoda, Y., Ayduk, O., Dadlani, M. B., Davidson, M. C., Aber, J. L., & Casey, B. J. (2006). Predicting cognitive control from preschool to late adolescence and

young adulthood. *Psychological Science, 17*(6), 478–484. https://doi.org/10.1111/j.1467-9280.2006.01732.x

Friedman, N. P., Haberstick, B. C., Willcutt, E. G., Miyake, A., Young, S. E., Corley, R. P., & Hewitt, J. K. (2007). Greater attention problems during childhood predict poorer executive functioning in late adolescence. *Psychological Science, 18*(10), 893–900. https://doi.org/10.1111/j.1467-9280.2007.01997.x

Fuster, J. M. (2008). *The Prefrontal Cortex.* Academic Press.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological Bulletin*, *134*(1), 31.

Harris, K. I. (2016). Supporting executive function skills in early childhood: Using a peer buddy approach for community, confidence, and citizenship. *Journal of Education and Training*, *3*(1), 158-175.

Hughes, C. (2011). Changes and challenges in 20 years of research into the development of executive functions. *Infant and Child Development*, *20*(3), 251-271.

Hughes, C., & Ensor, R. (2011). Individual differences in growth in executive function across the transition to school predict externalizing and internalizing behaviors and self-perceived academic success at 6 years of age. *Journal of Experimental Child Psychology, 108*(3), 663–676. https://doi.org/10.1016/j.jecp.2010.06.005

Jahromi, L. B., & Stifter, C. A. (2008). Individual differences in preschoolers' self-regulation and theory of mind. *Merrill-Palmer Quarterly, 54*(1), 125–150. https://doi.org/10.1353/mpq.2008.0007

Jurado, M.B., & Rosselli, M. (2007). The elusive nature of executive functions: a review of our current understanding. *Neuropsychol Rev*, *17*(3), 213-33. doi: 10.1007/s11065-007-9040-z

Lezak, M.D. (1983). *Neuropsychological Assessment.* Oxford University Press.

Martin, M. M., & Anderson, C. M. (1998). The cognitive flexibility scale: Three validity studies. *Communication Reports*, *11*(1), 1-9.

McClelland, M. M., Cameron, C. E., Wanless, S. B., & Murray, A. (2007). Executive function, behavioral self-regulation, and social-emotional competence. *Contemporary Perspectives on Social Learning in Early Childhood Education*, *1*, 113-137.

McCloskey, G., Perkins, L. A., & Van Divner, B. (2009). *Assessment and Intervention for Executive Function Difficulties.* Routledge/Taylor & Francis Group.

Meuwissen, A. S., & Zelazo, P. D. (2014). Hot and cool executive function: Foundations for learning and healthy development. *Zero to Three, 35*(2), 18-23.

Milner, B., & Petrides, M. (1984). Behavioural effects of frontal-lobe lesions in man. *Trends in Neurosciences, 7*(11), 403–407. https://doi.org/10.1016/S0166-2236(84)80143-5

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49-100.

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Morrison, F. J., Ponitz, C. C., & McClelland, M. M. (2010). Self-regulation and academic achievement in the transition to school. In S. D. Calkins & M. A. Bell (Eds.), *Child development at the intersection of emotion and cognition* (pp. 203–224). American Psychological Association. https://doi.org/10.1037/12059-011

National Center for Pyramid Model Innovations (NCPMI) (2019). *A Practice Guide for Teaching Executive Function Skills to Preschoolers through the Pyramid Model.* https://challengingbehavior.cbcs.usf.edu/docs/Executive-Function_Practice-Guide.pdf

Neitzel, J. (2018). What measures of program quality tell us about the importance of executive function: implications for teacher education and preparation. *Journal of Early Childhood Teacher Education, 39*(3), 181-192. doi: 10.1080/10901027.2018.1457580.

Nguyen, T., & Duncan, G. J. (2019). Kindergarten components of executive function and third grade achievement: A national study. *Early Childhood Research Quarterly, 46,* 49–61. https://doi.org/10.1016/j.ecresq.2018.05.006

Powell, K. B., & Voeller, K. K. S. (2004). Prefrontal executive function syndromes in children. *Journal of Child Neurology, 19*(10), 785–797.

Pribram, K. H. (1973). The primate frontal cortex - executive of the brain. In K.H. Pribram and A.R. Luria (Eds.), *Psychophysiology of the Frontal Lobes*, (pp. 293-314). Academic Press.

Ratiu, P., Talos, I.F., Haker, S., Lieberman, D., & Everett P. (2004). The tale of Phineas Gage, digitally remastered. *J Neurotrauma, 21*(5),637-43. doi: 10.1089/089771504774129964

Romine, C. B., & Reynolds, C. R. (2005). A model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology, 12*(4), 190-201.

Roussel, M., Dujardin, K., Hénon, H., & Godefroy, O. (2012). Is the frontal dysexecutive syndrome due to a working memory defcit? Evidence from patients with stroke. *Brain, 135,* 2192– 2201. https://doi.org/10.1093/brain/aws132

Shoda, Y., Mischel, W., & Peake, P. K. (1990). Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: Identifying diagnostic conditions. *Developmental Psychology, 26*(6), 978–986. https://doi.org/10.1037/0012-1649.26.6.978

Shutterstock (2022). https://www.shutterstock.com/tr/

Stahl, L., & Pry, R. (2005). Attentional flexibility and perseveration: Developmental aspects in young children. *Child Neuropsychology, 11*, 175-189.

Storbeck, J., & Maswood, R. (2016). Happiness increases verbal and spatial working memory capacity where sadness does not: Emotion, working memory and executive control. *Cognition and Emotion*, *30*(5), 925-938.

Strauss, E., Sherman, E. M., & Spreen, O. (2006). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary.* American Chemical Society.

Tregay, J., Gilmour, J., & Charman, T. (2009). Childhood rituals and executive functions. *British Journal of Developmental Psychology*, *27*(2), 283-296.

Wass, S. V., Porayska-Pomsta, K., & Johnson, M. H. (2011). Training attentional control in infancy. *Current Biology, 21,* 1543–1547.

Welsh, J. A., Nix, R. L., Blair, C., Bierman, K. L., & Nelson, K. E. (2010). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology, 102*(1), 43-53.

Welsh, M. C., Friedman, S. L., & Spieker, S. J. (2006). Executive Functions in Developing Children: Current Conceptualizations and Questions for the Future. In K. McCartney & D. Phillips (Eds.), *Blackwell handbook of early childhood development* (pp. 167–187). Blackwell Publishing. https://doi.org/10.1002/9780470757703.ch9

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology, 7*(2), 131–149. https://doi.org/10.1080/87565649109540483

Yıldırım, A., & Şimsek, H. (2006). *Research Methods in Social Sciences.* Seçkin Publications.

Zelazo, P. D. (2015). Executive function: Reflection, iterative reprocessing, complexity, and the developing brain. *Developmental Review, 38,* 55–68. https://doi.org/10.1016/j.dr.2015.07.001

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives, 6*(4), 354–360. https://doi.org/10.1111/j.1750-8606.2012.00246.x

Zelazo, P. D., & Müller, U. (2010). Executive Function in Typical and Atypical Development. In *The Wiley-Blackwell Handbook of Childhood Cognitive Development,* (pp. 574-603). Wiley-Blackwell. https://doi.org/10.1002/9781444325485.ch22

Zelazo, P. D., Blair, C. B., & Willoughby, M. T. (2016). *Executive function: Implications for education. U.S. Department of Education* (pp. 1–148). https://ies.ed.gov/ncer/pubs/20172000/pdf/20172000.pdf