Chapter

A View from the Start: A Review of Inhibitory Control Training in Early Childhood

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Abstract

Young children's capacity to monitor and control their thoughts and behaviors is influenced largely by inhibitory control, which grows rapidly during this age due to brain maturation. This capacity has important implications for children's development, including academic and social outcomes, and has been shown to be influenced by culture and exposure to adverse life events such as poverty. Research suggests that this capacity, importantly, may be largely trainable, with appropriate training programs.

Keywords: early childhood, executive function, cross-cultural, low-income

1. Introduction

During the childhood years and into adolescence, the brain grows tremendously, causing a significant change in cognitive capacities. In later years of childhood and adolescence, many of the neurological changes correspond with advancements in perspective taking and reasoning; however, evidence from the early childhood years suggests that these changes more closely align with advancements in inhibitory control and executive functions more broadly [1, 2]. However, there are distinct developmental changes which inform our understanding of inhibitory control and which merit further discussion. Regardless, these developmental changes have profound impacts on children's development overall, including academic and social outcomes. It is important to recognize, however, that children's capacities to inhibit a prepotent response have been shown to vary by culture, as well as exposure to early adverse life events, and therefore a consideration of environment should be included when attempting to conduct research in this area or when making important policy or curriculum decisions. Nevertheless, research which utilizes inhibitory control (IC) training specifically within the early childhood ages demonstrates positive results, with more intensive training yielding more promising results.

2. Nature of inhibitory control during the early childhood years

Research has consistently demonstrated that the preschool years are a developmental time during which children experience profound growth in their ability to inhibit an unwanted response [3]. Younger preschool-age children are more likely to perseverate in their errors across multiple trials [4] by repeating a maladaptive behavior—for instance, a child who continues to shout out in class instead of raising their hand—whereas this pattern declines markedly by age 4. Similarly, 3-year-old children demonstrate an ability to inhibit an automatic prepotent response on a Simon Says task (e.g., Go/NoGo task [5]: children are trained to respond to one stimulus and are trained not to respond to a similar stimulus; see **Table 1**) for roughly one in four trials, in comparison to 4-year-old children who were successful on roughly 9 out of 10 trials [6]. Moreover, the impacts of inhibitory control on children's cognitive capacities also seem to change as a function of age. For instance, younger preschool-age children's inhibitory control capacities strongly predict their problem-solving strategy use and performance; however, older preschool-age children's problem solving is better explained by their working memory capacities (see **Table 1**) rather than their inhibitory control abilities [7]. Relatedly, the development patterns of IC growth may not be limited to simply greater accuracy on relatively straightforward tasks. Older preschool-age children perform with greater success on more complicated tasks of IC than their younger peers [1], which may indicate that using multiple, progressive tasks when assessing IC may reveal important developmental patterns not captured by using a single task or by using

Key terms	Definitions
Executive functions (EF)	The constellation of foundation cognitive capacities, such as inhibitory control, working memory, and attention, which allow for later emergence of reasoning and problem solving
Inhibitory control (IC)	The cognitive capacity to inhibit a prepotent, automatic behavioral response
Working memory	A cognitive system for temporarily storing and managing information that is necessary for undertaking complex cognitive tasks
Theory of mind (ToM)	The understanding that others have mental states such as beliefs, desires, etc., which can vary from person to person or within one person over time
Go/NoGo task	Children are trained to respond to one stimulus (e.g., "Go" stimuli) and are trained not to respond to a similar stimulus ("NoGo" stimuli). This task measures behavioral inhibition
Day/Night Stroop task	Children are trained and must complete trials in which they say the word "night" when presented with an image of a sun on a white background and say "day" when presented with an image of a moon on a dark background. This task involves both behavioral inhibition and cognitive interference
Cognitive interference/interference control	It refers to attempts to suppress interference from competing stimuli. The response time of an IC task is usually considered as a measure of cognitive interference
Behavioral inhibition	It requires suppressing a behavioral response for a more optimal response. Cognitive interference and behavioral inhibition are two aspects of IC
Electroencephalogram (EEG)	A neurological testing that allows researchers to precisely measure brain activity during the behavioral tasks, which provides for a more complete examination and consideration of IC as a cognitive capacity
Inhibitory control training	A designed intervention that includes a training process which aimed at improving IC

Table 1.
A summary of definitions of the major concepts and techniques.

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multiple similar tasks. Overall, the findings on early childhood IC show robust and dramatic growth, particularly during the childhood years.

Although researchers agree on the tremendous growth of IC during this developmental age, there persists disagreement as to the specific nature of IC, and executive functions, during this time. Executive functions (EF) refer to the constellation of foundational cognitive capacities, such as inhibitory control, working memory, and attention [1], which allow for later emergence of reasoning and problem solving. In middle childhood and beyond, these executive function capacities can be considered as increasingly discrete processing mechanisms; however, during early childhood, these patterns remain more nebulous, and studies using confirmatory factor analysis have shown developmental differences in factor emergence and persistent factor unification into the childhood years. For instance, during the preschool years (broadly, ages 3 years to 6 years), studies using multiple assessments of inhibitory control, attention, and working memory yield a single unitary construct of executive function or inhibition generally [8–12], whereas studies of middle childhood have discerned multiple discrete factors, including working memory and attention shifting [13], and this trend continues and expands into later childhood and adolescence (see [14]).

The prevailing argument is that tasks of IC during the early childhood years necessitate activation of multiple other components of EF. take, for instance, the Day/Night Stroop task (see [15]; **Table 1**) in which a child is trained and must complete trials in which they say the word "night" when presented with an image of a sun on a white background and say "day" when presented with an image of a moon on a dark background. In this task, IC is typically measured by accuracy, with measurements of response time frequently included as well. This task clearly requires the child to inhibit the automatic response of verbalizing the association they have made between the sun and it being daytime, or between the moon being present during nighttime, and thus is inarguably a task of IC. However, some argue that this task measures additional facets of EF simply by the nature of the task. For instance, a child must have sustained attention throughout the assessment, and if the child loses focus for even a moment, the measurement of response time could be conflated, leading some scholars to argue that the attentional component of EF predicts IC [3, 16]. Similarly, the child must work to keep the rules of the moon/day and sun/night matching in the forefront of their mind during the assessment, and if they do not, then the accuracy measure could be conflated with working memory. Many researchers have argued, therefore, that the various EF components are highly integrated during the early childhood years and that these components emerge as more distinct with age and experience [1, 14].

As shown by the previous example, it is difficult for researchers to disentangle the various components of EF, from a measurement perspective, in early childhood. Researchers' understanding and measurement of inhibitory control during the early childhood years should therefore be sensitive to the developmental nature of such phenomena and should perhaps consider using indices of a variety of executive function capacities. However, as described previously [14], a common conceptualization of EF in the early childhood literature seems to imply that EF and IC are analogous at this development time (e.g., [17]) or that IC developmentally precedes other domains of EF (e.g., [16]). Although IC contributes largely to early childhood EF, as demonstrated in the previous example, it may be problematic to consider these as synonymous. One argument in support of this claim is that children's task performance on EF tasks most closely replicates issues of IC—that is, a child will persist in making prepotent errors, a classic demonstration of immature IC, while also activating other areas of EF, such as attention, working memory, etc. Although several arguments have been proposed to counter the position of equivocating EF with IC, most pertinent to the current chapter may be that IC itself may be multidimensional. Referring again to the aforementioned example, many researchers consider response time in the Day-Night Stroop task to be a measure of *cognitive interference* (sometimes referred to as interference control), which refers to attempts to suppress interference from competing stimuli, in contrast to *behavioral inhibition* which requires suppressing a behavioral response for a more optimal response [18, 19]. That is, the construct of inhibitory control as it pertains to developmental changes during the early childhood years requires both the cognitive power to limit attention to distractor stimuli and the behavioral power to engage an appropriate response.

Turning to developing an appreciation for the role of IC for holistic development, the capacity for IC has important implications in terms of development across a number of domains [20]. For instance, although IC has been shown to predict children's academic achievement generally throughout the childhood years [21], strong IC consistently predicts more proficient mathematical knowledge [16, 22–24] and numerical strategy use [25]. Moreover, IC has been implicated in children's emergent literacy proficiency [16, 24] and language development [26]. The development of IC during the early childhood years additionally has profound implications for children's social and emotional development [27], such as the emergence and development of social perspective taking [28], problem solving and emotional control [27], and suppressing disruptive behaviors and aggression [11]. As such, IC should be considered by researchers and practitioners alike for the implications this capacity may hold across areas of maladaptive academic and social development.

Research methodologies employed for assessing IC during the early childhood years can vary considerably, and each assessment offers a wealth of strengths yet, as mentioned previously, may be incomplete on its own. Therefore, much of the research studies in this area use more than one type of assessment or multiple assessments with considerable methodological overlap. An important consideration in measurement of IC, indeed of any cognitive faculty, during the early childhood years is the developmental appropriateness of the task (see [8], for review). For instance, children in this age range are often concurrently experiencing emerging literacy skills and are often not yet proficient readers; therefore, it would be inappropriate to use a task which requires even low reading requirements, as such a task would likely require a cognitive load too great to allow for successful task completion. Moreover, such a task when used with an emerging reader would result in contaminated measurement in that task performance may indicate a lack of understanding the rules of the task, the lack of proficiency in reading, or inhibitory control. Similarly, tasks to be used on a study of early childhood should be rather straightforward, without overly complicated instructions or numerous steps. Therefore, much of the research studies in the area of inhibitory control that focus on early child development utilize tasks or games which require no reading, with simple instructions provided to the child verbally and repeated if necessary, and these tasks typically include a generous training time to ensure that the child understands and can perform the task.

Many of the commonly employed tasks resemble that of the Day/Night Stroop task [15, 29] and the Go/NoGo task [1, 5, 19, 30], both of which were described in the previous paragraphs. Importantly, these two tasks differ in terms of cognitive interference with regard to the expectations for children's behavioral responses. Specifically, the Day/Night Stroop task involves embedded rule use, thus requires children to produce a verbal response to multiple stimuli, and therefore requires that the children process and act on multiple rules (i.e., if moon, then "day," but if sun, then "night"), whereas the Go/NoGo task only requires a behavioral response to a single stimulus (e.g., if "Simon Says," then response; if not, then no response).

This distinction has led some to argue that the Day/Night Stroop task may be more complex particularly for younger children than other tasks, and therefore performance on this and similar tasks may be indicative of greater IC capacities compared with Go/NoGo tasks (see, e.g., [31, 32]).

Consistent with the recommendation noted previously regarding the need to use multiple indices of IC when attempting to correctly assess children's capacities, many researchers employ the use of neurological testing, such as an electroencephalogram (EEG), in concert with a behavioral task, such as the Go/NoGo task (e.g., [30]). Using neurological measurement, such as EEG, allows researchers to precisely measure brain activity during the behavioral tasks, which provides for a more complete examination and consideration of IC as a cognitive capacity particularly from a developmental perspective. That is, as the brain is experiencing tremendous growth during the early childhood years, it is important to capture how such physical growth corresponds with cognitive growth, and this is perhaps best done by measuring neural activity during a cognitive task.

Overall, EF generally, and inhibitory control specifically, undergoes dramatic growth during the preschool years, which has important implications for their development overall [1, 2]. Although EF is discernable as more discrete constructs in later ages of development, this has not been consistently demonstrated during the early childhood years [8–12], and thus researchers should consider possibly utilizing multiple tasks, including neurological assessments if possible [30], to provide a more comprehensive understanding of IC during the early childhood years.

2.1 Impacts of culture and environment on young children's inhibitory control development

Consistent with other cross-cultural research which shows variation in the timing and emergence of children's cognitive capacities (e.g., [33]), evidence of IC development from non-Western societies is not entirely consistent with that of Western societies, suggesting that children's inhibitory control may be impacted by cultural and environmental factors [34]. For instance, a variety of studies comparing Chinese samples to Western samples may suggest that preschool-age children reared in Chinese cultures outperform their US counterparts on tasks of IC [34, 35], which has also been found in other non-Western cultures (e.g., Japan [36]). Importantly, comparing samples of non-Western cultures from African and Latin American communities [37] as well as cultures which share both Western and Eastern ideals (i.e., Turkey [38]) to Western has not yielded differences by culture. Overall, the cross-cultural research on IC development in early childhood may indicate that although there is a large universality in terms of IC development, cultural and societal mores may cause differences in children's IC and development more broadly.

Moreover, in terms of implications of the cross-cultural research for child development more broadly, in Western cultures IC has been consistently shown to predict theory of mind (i.e., the understanding that others have mental states such as beliefs, desires, etc., which can vary from person to person or within one person over time [39]) particularly during the early childhood years [31], which holds implications for children's social competence during early childhood and beyond; however, this predictive relation between IC and theory of mind has not consistently been demonstrated in cross-cultural samples to the same degree as in Western samples [40]. For example, a recent meta-analysis discussed that although IC and EF generally did predict theory of mind and mental state understanding across cultures, the strength of this prediction was weaker among studies assessing East Asian samples than several Western samples, including the USA, Canada, and Europe [31].

Other environmental factors, such as exposure to poverty or low socioeconomic opportunity, have also been shown to impact children's cognitive development, including the development of EF during the early childhood years, with children from low-income families generally underperforming their more affluent peers [41, 42]; however, the recent work has turned to focus on the adaptive strengths of children raised in environments with higher rates of adversity [43]. For example, although children from low-income families have demonstrated less accuracy on a Go/NoGo task, they did not perform more slowly on the task [44]. Moreover, children from low-income families performed less accurately on a simple working memory task than with peers, but these group differences were eliminated when the task was made to be more complex [44]. A similar finding has been shown for children who have experienced familial trauma, and this may be true even when considering the impacts of poverty exposure. Children who have been reported as experiencing family trauma, as assessed by indices of post-traumatic stress disorder (PTSD), showed poorer global EF than non-traumatized children [45]; however, the effect size was weaker for IC task performance than other types of EF, such as working memory and processing speed. This may suggest that children who experience familial trauma may develop adaptive responses to their environments which allow them to inhibit prepotent responses as indicated by the IC task performance.

Similar to the pattern of IC mediating the impact of culture on early childhood competence, it may be that environmental exposure to poverty and adversity may additionally impact other areas of children's development. Academic achievement and behavioral regulatory faculties are more strongly predicted by IC task performance for children from more affluent family backgrounds, for example, than their less affluent peers [46]. Additionally, among children attending a federally funded educational program for low-income families and their children, children with stronger IC performance were rated by their teachers as having better socio-emotional faculties and showed fewer internalizing behaviors (e.g., indications of anxiety and depression) than their low-income peers who performed less well on IC tasks [47, 48]. Children who experience other types of environmental adversity, such as children who experience violence or maltreatment at home, show similar patterns of poorer academic achievement and school adjustment, yet this relation is additionally explained by children's IC [49]. In sum, although children who experience adverse early life events, or are raised in low-income families and neighborhoods, have shown to differ from more traditional samples in terms of academic achievement and socio-emotional competencies, these discrepancies may be explained by young children's emerging IC faculties. Therefore, these children may show marked improvements in EF capacities, as well as other positive outcomes such as improved academic achievement, with IC training.

2.2 Inhibitory control training in early childhood and implications for development

Efforts in establishing inhibitory control as an effective tool for cognitive improvements have proven successful across the life span [50]. Moreover, as the early childhood years are an important time for the development of EF generally, and IC specifically, as previously discussed, this developmental age range is ideal for examining the possible power of IC training. Several studies have examined the impacts of IC training on child outcomes, and these studies consistently yield positive findings [19, 21, 50–56].

Importantly, the outcomes of IC training have been shown to vary considerably based on the types of training. Studies have shown, for example, the training of more global EF capacities rather than IC specifically (e.g., [53, 55]) may be successful in expanding cognitive performance across a wide range of tasks. This aligns with the aforementioned discussion of the entanglement of multiple components of EF during early childhood (i.e., that many factor analytic studies have shown that in the early childhood years the distinct components of EF, such as working memory and IC, may not be as separately discernable as evidenced during the later years of development [8–12]). To test this, some researchers have attempted to gauge the effectiveness of IC training compared with training in other areas of EF, such as working memory; for instance, children who received 5 weeks of computerized IC training, compared with a group who received a parallel program of working memory training, showed improvements in task performance for the task on which they received training; however these improvements did not transfer to other tasks of EF [55]. Limited transfer effects have been reported elsewhere as well, such as children showing increased performance on methodologically and structurally similar tasks as to the training task, but not other tasks [51], although this increase in performance was sustained over many months. However, other research has shown considerable transfer effects, such as children showing enhanced reasoning abilities after training on a Go/NoGo task [19] and children, adolescents, and adults showing enhanced perspective-taking capacities after receiving IC training [50].

Other types of training have also shown to be successful in improving EF performance. Having children engage in reflective metacognition regarding their performance on difficult cognitive tasks, such as their performance in the Day/Night Stroop task, has shown to be effective in enhancing their performance on that task even compared with more traditional training procedures, such as practice and corrective feedback [54]. Additionally, training on language skills can have a positive impact on children's IC, as such trainings require engaging in multiple components of EF (e.g., sustained attention), as well as IC specifically [57] such as by requiring the child to use the correct term for a specific item within a larger category of items. This aligns with the espoused conceptualization of early childhood IC as profoundly entangled within EF and is consistent with other research on EF trainings more broadly. For instance, children who received 12 sessions over 4 weeks of training that included working memory, IC, and cognitive flexibility showed significant improvements across a range of EF capacities, and these effects transferred to other areas of children's cognition as well [58].

Additionally, outcomes of IC training may yield important changes at the level of neuronal and brain activity [54], which may not necessarily correspond with immediate changes in behavior. For instance, studies have shown that children who received an 8-week program of training which targeted children's IC, working memory, and planning ability found that, for children who received the training, neural activity levels changed in the corresponding brain regions as expected; however children's task performance after the training did not differ significantly from their pre-training performance [30]. Other studies have found that a single training session of metacognitive reflection about controlling impulsive behaviors may lead to decreased activation of the brain region responsible for processing conflicting information, which may indicate a lessened likelihood to process the information as conflicting, and therefore possibly indicating better adaptation in integrating new rule schemes [54].

Moreover, the positive impacts of receiving EF training have been found effective for children from low-income families as well. For instance, one study showed that when classrooms serving low-income families implemented a full year of an EF training that included a broad range of EF skills deeply integrated into the classroom curriculum, compared with classrooms that had no such program, children who received the training outperformed children in the control group on both simple and advanced tasks [52]. Indeed, children in the control group showed a decline in task performance for the more advanced tasks, which was not found for children who received the training. What's more, the program was so successful that the control condition was not allowed to repeat, by request of the school, as the teachers and parents noted such profound change in terms of academics and student behavior that the school refused to continue the project without full implementation of the program in all classrooms. In concert with findings from more traditional samples which included less intensive training, these outcomes would indicate that children from low-income families might be an especially important area for future research, given the overwhelming strength of the results.

Although studies using IC training with children of incarcerated parents, or children who have experienced abuse or neglect, were not revealed during the current literature search, the previously discussed research of IC training during early childhood could be extended to these populations [45]. For instance, research on treatment approaches for anxiety and depression (common outcomes of trauma) with adults has shown that training individuals to develop better self-regulatory executive processes, such as attention, have shown promising results (see [45] for discussion). Given that children's EF faculties are more nebulous and entangled than adults, it stands to reason that such approaches would yield additionally promising results during the early childhood years.

Moreover, such intervention approaches might be promising for researchers working in clinical settings. For instance, mindfulness training approaches that capitalize on EF processes, such as attentional focus, for children with anxiety have proven effective in reducing anxiety symptomology [59]. Such training has proven effective for children from low-income families as well [60], with positive effects extending beyond advanced EF development to include positive socio-emotional and behavioral changes as well. However, much of the research in this area has been conducted with older children, and examinations of the promise of mindfulness training during the early childhood years may not yet exist. This may be an important area for future research, as the implications for positive outcomes may be more robust with earlier intervention.

Overall, findings with regard to improving child outcomes during the early childhood years as they relate to IC training suggest that IC training may be effective to varying degrees. Although a few studies showed limited transfer effects, the most promising findings come from studies which implemented a broader EF training program rather than those which utilized specific IC training. Additionally, research studies with longer training programs, such as the 1-year program discussed above, yield stronger effects in terms of global child outcomes than did shorter programs. Studies involving brain imaging have also shown positive outcomes in terms of changes in brain activity, indicating that such training may be important for effecting long-term change.

3. Conclusions

The cognitive capacity to inhibit a prepotent, automatic response grows tremendously during the early childhood years corresponding with and as a function of profound brain development taking place at this time [1, 2]. At later ages, this cognitive ability is rather distinct from other foundational cognitive capacities, such as attention and working memory; however, considerable research suggests that during early childhood these distinctions are less clear, leading many researchers to consider and research EF as a more global function at this age [8–14].

Research which focuses on IC during the early childhood years typically utilizes simple, game-like tasks which require brief or no verbal response, and researchers typically utilize a variety of tasks which may assess various areas of EF, including the Day/Night Stroop task [15, 29] and the Go/NoGo task [1, 5, 19, 30]. Importantly, and with regard for the important growth occurring at this age in specific brain

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regions, many researchers use these tasks in combination with brain imaging [30], providing important insights into developmental changes taking place in brain and neuronal activity.

Importantly, the current chapter includes much literature on EF broadly rather than focusing specifically on IC and IC training. Although this is consistent with the current conceptualization of IC during this developmental time within the literature, this may have resulted in certain findings and trainings being included in the current discussion with which some researchers may disagree. Additionally, the current chapter focuses narrowly on a specific developmental window and thus is not representative of the research on IC across childhood.

For transparency, the literature review for the current chapter used the following databases: Google Scholar, ScienceDirect, and Web of Science. The keywords were executive function, inhibitory control (training), working memory, sustained attention, cognitive development, self-regulation, preschoolers, early childhood, children, cross-cultural, and risk population. Specifically, inhibitory control is a broad term in the research procedure, which has been expanded and is not limited to the executive function and cognitive development [61]. For ease of understanding, an at-risk population was defined as any potential risk factors (i.e., poverty or low income, neighborhood violence, family violence, family maltreatment, low social status, low education background, rural area). However, and as is the case with many reviews, the current chapter does not include findings from unpublished works, and thus the positive support for IC training as discussed here may be an artifact of publication bias.

Nevertheless, in creating IC training programs, much of the research has shown positive outcomes across a variety of training programs; however, as is to be expected, more promising and profound results accompany programs with more intensive training with longer durations [50–58]. Such training programs have proven effective across cultures and changes in the environment [52], including children from low-income backgrounds and children who have experienced profound early adverse life events. Although little research to date has examined IC training during early childhood in clinical samples, extending from the work discussed in this chapter, it would follow that IC training broadly, and perhaps mindfulness training specifically, may yield positive outcomes across domains.

Conflict of interest

The authors declare there is no conflict of interest.

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References

[1] Anderson PJ, Reidy N. Assessing executive function in preschoolers. Neuropsychology Review. 2012;**22**(4): 345-360

[2] Munakata Y, Herd SA, Chatham CH, Depue BE, Banich MT, O'Reilly RC. A unified framework for inhibitory control. Trends in Cognitive Sciences. 2011;**15**(10):453-459

[3] Reck SG, Hund AM. Sustained attention and age predict inhibitory control during early childhood. Journal of Experimental Child Psychology. 2011;**108**(3):504-512

[4] Diamond A, Taylor C. Development of an aspect of executive control: Development of the abilities to remember what I said and to "Do as I say, not as I do". Developmental Psychobiology. 1996;**29**(4):315-334

[5] Luria AR. Higher Cortical Functions in Man. Berlin: Springer Science & Business Media; 2012

[6] Jones LB, Rothbart MK, Posner MI. Development of executive attention in preschool children. Developmental Science. 2003;**6**(5):498-504

[7] Senn TE, Espy KA, Kaufmann PM. Using path analysis to understand executive function organization in preschool children. Developmental Neuropsychology. 2004;**26**(1):445-464

[8] Garon N, Bryson SE, Smith IM. Executive function in preschoolers: a review using an integrative framework. Psychological Bulletin. 2008;**134**(1):31

[9] Hughes C, Ensor R, Wilson A, Graham A. Tracking executive function across the transition to school: A latent variable approach. Developmental Neuropsychology. 2009;**35**(1):20-36

[10] Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. Cognitive Psychology. 2000;**41**(1):49-100

[11] Raaijmakers MA, Smidts DP, Sergeant JA, Maassen GH, Posthumus JA, Van Engeland H, et al. Executive functions in preschool children with aggressive behavior: Impairments in inhibitory control. Journal of Abnormal Child Psychology. 2008;**36**(7):1097

[12] Wiebe SA, Espy KA, Charak D. Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. Developmental Psychology. 2008;**44**(2):575

[13] van der Sluis S, de Jong PF, van der Leij A. Executive functioning in children, and its relations with reasoning, reading, and arithmetic. Intelligence. 2007;**35**(5):427-449

[14] Zelazo PD, Müller U. Executive function in typical and atypical development. In: Blackwell Handbook of Childhood Cognitive Development. Oxford, England: Blackwell Publishers; 2008. pp. 445-469

[15] Gerstadt CL, Hong YJ, Diamond A. The relationship between cognition and action: performance of children 312-7 years old on a stroop-like day-night test. Cognition. 1994;**53**(2):129-153

[16] Blair C, Razza RP. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. Child Development. 2007;**78**(2):647-663

[17] Kirkham NZ, Cruess L, Diamond A. Helping children apply their knowledge to their behavior on a

dimension-switching task. Developmental Science. 2003;**6**(5):449-467

[18] Friedman NP, Miyake A. The relations among inhibition and interference control functions: a latent-variable analysis. Journal of Experimental Psychology. General. 2004;**133**(1):101

[19] Liu Q, Zhu X, Ziegler A, Shi J. The effects of inhibitory control training for preschoolers on reasoning ability and neural activity. Scientific Reports. 2015;**5**:14200

[20] Carlson SM. Developmentally sensitive measures of executive function in preschool children. Developmental Neuropsychology. 2005;**28**(2):595-616

[21] Allan NP, Hume LE, Allan DM, Farrington AL, Lonigan CJ. Relations between inhibitory control and the development of academic skills in preschool and kindergarten: A meta-analysis. Developmental Psychology. 2014;**50**(10):2368

[22] Bull R, Scerif G. Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. Developmental Neuropsychology. 2001;**19**(3):273-293

[23] Espy KA, McDiarmid MM, Cwik MF, Stalets MM, Hamby A, Senn TE. The contribution of executive functions to emergent mathematic skills in preschool children. Developmental Neuropsychology. 2004;**26**(1):465-486

[24] McClelland MM, Cameron CE, Connor CM, Farris CL, Jewkes AM, Morrison FJ. Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. Developmental Psychology. 2007;**43**(4):947

[25] Fuhs MW, McNeil NM. ANS acuity and mathematics ability in preschoolers from low-income homes: Contributions of inhibitory control. Developmental Science. 2013;**16**(1):136-148

[26] Barac R, Bialystok E. Bilingual effects on cognitive and linguistic development: Role of language, cultural background, and education. Child Development. 2012;**83**(2):413-422

[27] Fishburn FA, Hlutkowsky CO, Bemis LM, Huppert TJ, Wakschlag LS, Perlman SB. Irritability uniquely predicts prefrontal cortex activation during preschool inhibitory control among all temperament domains: A LASSO approach. NeuroImage. 2019;**184**:68-77

[28] Carlson SM, Moses LJ, Hix HR. The role of inhibitory processes in young children's difficulties with deception and false belief. Child Development. 1998;**69**(3):672-691

[29] Baker ER, Jensen CJ, Tisak MS. A closer examination of aggressive subtypes in early childhood: contributions of executive function and single-parent status. Early Child Development and Care. 2019;**189**(5):733-746

[30] Pietto ML, Giovannetti F, Segretin MS, Belloli LM, Lopez-Rosenfeld M, Goldin AP, et al. Enhancement of inhibitory control in a sample of preschoolers from poor homes after cognitive training in a kindergarten setting: Cognitive and ERP evidence. Trends in Neuroscience and Education. 2018;**13**:34-42

[31] Devine RT, Hughes C. Relations between false belief understanding and executive function in early childhood: A meta-analysis. Child Development. 2014;**85**(5):1777-1794

[32] Zelazo PD, Jacques S. Children's rule use: Representation, reflection, and cognitive control. Annals of Child Development. 1997;**12**:119-176

[33] Shahaeian A. Sibling, family, and social influences on children's theory of mind understanding: New evidence from diverse intracultural samples. Journal of Cross-Cultural Psychology. 2015;**46**(6):805-820

[34] Sabbagh MA, Xu F, Carlson SM, Moses LJ, Lee K. The development of executive functioning and theory of mind: A comparison of Chinese and US preschoolers. Psychological Science. 2006;**17**(1):74-81

[35] Lan X, Legare CH, Ponitz CC, Li S, Morrison FJ. Investigating the links between the subcomponents of executive function and academic achievement: A cross-cultural analysis of Chinese and American preschoolers. Journal of Experimental Child Psychology. 2011;**108**(3):677-692

[36] Kuwabara M, Smith LB. Cross-cultural differences in cognitive development: Attention to relations and objects. Journal of Experimental Child Psychology. 2012;**113**(1):20-35

[37] Chasiotis A, Kiessling F, Hofer J, Campos D. Theory of mind and inhibitory control in three cultures: Conflict inhibition predicts false belief understanding in Germany, Costa Rica and Cameroon. International Journal of Behavioral Development. 2006;**30**(3):249-260

[38] Orta IM, Corapci F, Yagmurlu B, Aksan N. The mediational role of effortful control and emotional dysregulation in the link between maternal responsiveness and Turkish preschoolers' social competency and externalizing symptoms. Infant and Child Development. 2013;**22**(5):459-479

[39] Baker ER, Jensen CJ, Moeyaert M, Bordoff S. Socioeconomic status and early childhood aggression: moderation by theory of mind for relational, but not physical, aggression. Early Child Development and Care. 2018:1-5

[40] Duh S, Paik JH, Miller PH, Gluck SC, Li H, Himelfarb I. Theory of mind and executive function in Chinese preschool children. Developmental Psychology. 2016;**52**(4):582

[41] Farah MJ, Shera DM, Savage JH, Betancourt L, Giannetta JM, Brodsky NL, et al. Childhood poverty: Specific associations with neuro-cognitive development. Brain Research. 2006;**1110**(1):166-174

[42] Molzhon A. Exploring the influence of socioeconomic status on the executive function and theory of mind skills of preschoolers [dissertation]. Richmond, VA: Virginia Commonwealth University; 2016

[43] Ellis BJ. Toward an adaptation-based approach to resilience. In: The Biology of Early Life Stress. Berlin: Springer; 2018. pp. 31-43

[44] St. John AM, Kibbe M, Tarullo AR. A systematic assessment of socioeconomic status and executive functioning in early childhood. Journal of Experimental Child Psychology. 2019;**178**:352-368

[45] DePrince AP, Weinzierl KM, Combs MD. Executive function performance and trauma exposure in a community sample of children. Child Abuse and Neglect. 2009;**33**(6):353-361

[46] Duncan RJ, McClelland MM, Acock AC. Relations between executive function, behavioral regulation, and achievement: Moderation by family income. Journal of Applied Developmental Psychology. 2017;**49**: 21-30

[47] Liew J, Chen Q, Hughes JN. Child effortful control, teacher–student relationships, and achievement in academically at-risk children: Additive and interactive effects. Early Child Research Quarterly. 2010;**25**(1):51-64

[48] Rhoades BL, Greenberg MT, Domitrovich CE. The contribution of inhibitory control to preschoolers' social–emotional competence. Journal of Applied Developmental Psychology. 2009;**30**(3):310-320

[49] Pears KC, Fisher PA, Bruce J, Kim HK, Yoerger K. Early elementary school adjustment of maltreated children in foster care: The roles of inhibitory control and caregiver involvement. Child Development. 2010;**81**(5):1550-1564

[50] Karbach J, Kray J. How useful is executive control training? Age differences in near and far transfer of task-switching training. Developmental Science. 2009;**12**(6):978-990

[51] Blakey E, Carroll DJ. A short executive function training program improves preschoolers' working memory. Frontiers in Psychology. 2015;**6**:1827

[52] Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. Science. 2007;**318**(5855):1387-1388

[53] Dowsett SM, Livesey DJ. The development of inhibitory control in preschool children: Effects of "executive skills" training. Developmental Psychobiology: The Journal of the International Society for Developmental Psychobiology. 2000;**36**(2):161-174

[54] Espinet SD, Anderson JE, Zelazo PD. N2 amplitude as a neural marker of executive function in young children: an ERP study of children who switch versus perseverate on the dimensional change card sort. Developmental Cognitive Neuroscience. 2012;**2**:S49-S58

[55] Thorell LB, Lindqvist S, Bergman Nutley S, Bohlin G, Klingberg T. Training and transfer effects of executive functions in preschool children. Developmental Science. 2009;**12**(1): 106-113

[56] Viterbori P, Usai MC, Traverso L, De Franchis V. How preschool executive functioning predicts several aspects of math achievement in Grades 1 and 3: A longitudinal study. Journal of Experimental Child Psychology. 2015;**140**:38-55

[57] Kray J, Ferdinand NK. How to improve cognitive control in development during childhood: potentials and limits of cognitive interventions. Child Development Perspectives. 2013;**7**(2):121-125

[58] Traverso L, Viterbori P, Usai MC. Improving executive function in childhood: evaluation of a training intervention for 5-year-old children. Frontiers in Psychology. 2015;**6**:525

[59] Semple RJ, Reid EF, Miller L. Treating anxiety with mindfulness: An open trial of mindfulness training for anxious children. Journal of Cognitive Psychotherapy. 2005;**19**(4):379

[60] Semple RJ, Lee J, Rosa D, Miller LF. A randomized trial of mindfulness-based cognitive therapy for children: Promoting mindful attention to enhance social-emotional resiliency in children. Journal of Child and Family Studies. 2010;**19**(2):218-229

[61] Beveridge M, Jarrold C, Pettit E. An experimental approach to executive fingerprinting in young children. Infant and Child Development: An International Journal of Research and Practice. 2002;**11**(2):107-123