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Academic achievement and socio-economic status: a review within context-specific models of executive function

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Executive function (EF) has traditionally been conceptualized as domain-general cognitive processes that support goal-directed thought and behavior. However, recent Context-Specific models suggest that EF emerges through goal-directed assemblies of processes (e.g., beliefs, language, and content knowledge) and emphasize training EF within the same contexts it is used in applied settings. This framework also provides novel insights on the impacts of environmental factors, including socio-economic status, on EF, related academic skills, and other developmental outcomes. The present narrative review examines context-specific associations among EF, socio-economic status, and academic achievement, detailing how these theories account for the mediating role of EF among these variables. Further, I review interventions informed by these models, discussing implications for students and teachers within low-income districts.

KEYWORDS

executive function, socio-economic status, academic achievement, education, cognitive development

Introduction

Executive function (EF) has traditionally been defined as domain-general processes that exert top-down control over cognition and behavior across contexts (e.g., Zelazo and Carlson, 2023). Empirical work under these models has largely emphasized relatively decontextualized laboratory measures (e.g., sorting pictures; see Carlson, 2005, for review), composite scores of which are often used to estimate overall EF or its core components (i.e., inhibition, shifting, and updating; Miyake et al., 2000; Miyake and Friedman, 2012). Research consistently highlights the importance of understanding EF and its development. For instance, a variety of environmental factors (e.g., stressful events) have been linked to the development of the neural substrates that support EF (e.g., DePasquale et al., 2021), which in turn predicts a myriad of academic and socio-emotional outcomes (Kitil et al., 2025; Munakata and Michaelson, 2021; Stucke and Doebel, 2024). These findings emphasize the value of conceptualizing EF within an appropriate theoretical framework that can properly account for how environmental factors contribute to EF's development, informing effective interventions to support these processes and related outcomes.

Contemporary models increasingly reconceptualize EF as the context-specific activation of processes (e.g., skills, beliefs, content knowledge) rather than domain-general skills that permeate somewhat uniformly across contexts (Doebel, 2020; Perone et al., 2021). Consider, for instance, a child who is regularly inattentive during class—whereas traditional "Domain-General" perspectives would posit that this child has overall difficulties with inhibition, emerging "Context-Specific" views suggest that this child's thoughts and behaviors are shaped by a culmination of beliefs (e.g., whether attending to the lesson is likely to result in learning), values (e.g., whether those learning outcomes are desirable), interests, and a multitude of other processes. Context-Specific perspectives emphasize that the "assembly" of these processes (Perone et al., 2021) is informed by children's past experiences and socio-cultural contexts (Munakata and Michaelson, 2021), while also varying across settings and goals. For instance, successful completion of laboratory EF assessments (e.g., sorting pictures; Zelazo, 2006) requires a different set of processes (e.g., knowledge of color and shape; Perone et al., 2015, 2021) than those needed to stay on-task in school. Within these models, EF maturation is re-framed as the development of these and other processes, and in turn the efficiency with which children can activate appropriate processes given a certain goal or context (Doebel, 2020). While these perspectives vary in terms of their respective emphases (e.g., the role of goals and cultural background in informing/triggering the activation of these processes; Doebel, 2020; Munakata and Michaelson, 2021), these models together frame EF as "deeply influenced by context" (Doebel and Müller, 2023, p. 165) and therefore invoked differentially across settings (e.g., laboratory vs. school). Given this context-dependency, these models also prioritize ecologically-valid EF assessments over traditional, decontextualized measures (Doebel, 2020; Gaskins and Alcalá, 2023).

Despite their rising popularity, Context-Specific approaches have not been universally accepted. Skeptics caution against these models' broad definition of EF and their emphasis on contextualized measurements, which may obfuscate and de-standardize operationalizations of these constructs. Further, laboratory assessments established within "Domain-General" frameworks are argued to yield relatively consistent results across populations and contexts, and predict long-term developmental outcomes (see Zelazo and Carlson, 2023, for review). By contrast, advocates for Context-Specific perspectives point out that performance on these assessments, even those targeting the same process (e.g., inhibition), do not reliably correlate with one another (e.g., Gärtner and Strobel, 2021). Further, these measures may underestimate the capabilities of minoritized children who are less likely to be familiar with these task demands or testing environments (Miller-Cotto et al., 2022; Munakata and Michaelson, 2021); on the other hand, EF tasks tailored to children's unique socio-cultural contexts may better capture their ability to control their thoughts and behaviors (Gaskins and Alcalá, 2023).

The perspective of the present review is not that these frameworks are mutually exclusive. Rather, Context-Specific models' renewed emphasis on EF's integration with context and other processes provides numerous avenues for future research while also warranting an updated interpretation of previous findings. For example, it is well-known that socio-economic status (SES) and academic achievement are intricately linked throughout development (e.g., Liu et al., 2022), with studies identifying EF as a mediator among these variables (e.g., Waters et al., 2021). While these associations have been examined at-length within Domain-General frameworks, Context-Specific models have unique explanatory power and provide novel insights into these established relationships. The purpose of this narrative review is therefore to re-evaluate these associations among early EF, SES, and academic achievement through a Context-Specific lens, supplementing knowledge previously derived from Domain-General frameworks.

EF and socio-economic status

SES is a multifaceted construct encompassing a family's access to both economic and social resources, and has been examined across various indices, including income/income-to-needs ratio, parental occupational prestige/education, and composites of these and other variables that exhibit differential associations with child cognition (Mousavi et al., 2024; Vrantsidis et al., 2020). SES is associated with an array of critical life experiences that are in turn affiliated with cognitive development (e.g., food insecurity, stressful events; see Jensen et al., 2017, for review), and children of lower SES often score lower on a range of EF assessments than their more affluent peers (Lawson et al., 2018). As will be discussed in the following paragraphs, Domain-General and Context-Specific perspectives provide alternative accounts for how SES contributes to EF—however, given understandable challenges in subjecting SES to experimental manipulation (but see Noble et al., 2021, for an intervention of family income), it should be noted that most studies on SES and related outcomes are inherently correlational.

Traditional Domain-General perspectives often consider associations among SES and EF through deficit lens (see Miller-Cotto et al., 2022, for discussion). These emphasize, for instance, that stressors more frequently experienced within low-SES households are associated with elevated cortisol, which impacts maturation and function of brain regions supporting EF (DePasquale et al., 2021; Vliegenthart et al., 2016; Vogel et al., 2016); notably, low-SES preschoolers show reduced activation in these areas during executive processing than their higher-SES peers (Moriguchi and Shinohara, 2019). By contrast, Context-Specific perspectives suggest that children's experiences and socio-cultural backgrounds are associated with the types of processes that they may engage when exercising control. For instance, variations in children's exposure to conceptual knowledge (e.g., shape, color) may mediate associations among SES and children's performance on laboratory EF assessments that involve these dimensions (e.g., Dimensional Change Card Sort; Perone et al., 2015). Further, the unpredictable circumstances often experienced by children of low SES may also inform a belief that use of control is unlikely to be beneficial, potentially encouraging children to seek immediate rewards over long-term gains (Kidd et al., 2013; Michaelson and Munakata, 2016). These beliefs may be especially influential in novel contexts, such as in a laboratory or with an unfamiliar researcher (Moffett et al., 2020), causing measurements to underestimate children's capacities for control, or undermining the potential benefits of EF interventions (Miller-Cotto et al., 2022). Further, children's perceptions about the predictability of their environments may remain somewhat constant over time, potentially contributing to EF's developmental stability (Michaelson and Munakata, 2016).

Thus, rather than framing SES-based differences in EF as deficits, Context-Specific perspectives more closely align with asset-based approaches, suggesting that these patterns reflect adapted responses to children's socio-cultural contexts. These perspectives are consistent with recent "Hidden Talents" approaches, which posit that adversity strengthens specific cognitive abilities that are especially beneficial in volatile environments (e.g., identifying angry faces; Frankenhuis et al., 2020), and are only revealed in relevant contexts. For example, youth with long-term exposure to adversity (e.g., violence, poverty) tend to perform lower on abstract updating tasks than their non-exposed peers; however, modifying these assessments with ecologically relevant stimuli (e.g., images of emotional faces or money) effectively closes these performance gaps (Young et al., 2022). Such findings offer a valuable reframing of the aforementioned role of SES in cortical development, suggesting that neural connections are developed to suit children's survival needs and other context-specific functions.

EF and academic achievement

As discussed previously, early EF is associated with a variety of cognitive and socio-emotional outcomes (Stucke and Doebel, 2024). EF's associations with numerous facets of academic success (e.g., school readiness, reading/mathematics; see Zelazo et al., 2016, for review), including long-term academic outcomes (Robson et al., 2020), are of particular interest in this review. Many interpret these correlations to imply mechanistic and bidirectional associations among EF and academics, with EF supporting schooling and vice versa (Miller-Cotto and Byrnes, 2020; Peng and Kievit, 2020). Consistent with this perspective, examinations of children of similar ages (5–6 years) but in different grades found that children with one more year of schooling exhibited heightened EF and activation of associated neural substrates relative to their similar-aged peers in lower grades (Brod et al., 2017).

The models highlighted in this review offer different explanations for associations among EF and academic achievement. For example, Domain-General perspectives suggest that schooling provides children with a variety of activities (e.g., circle time; McClelland et al., 2019) that support their broad executive capabilities. These in turn may support a variety of academic tasks, such as paying attention, following instructions, and shifting between activities, perspectives, or strategies (e.g., Chan and Scalise, 2022; Zelazo et al., 2016). Contrasting with generalized approaches, however, various executive processes exhibit differential associations with elements of academic success. For instance, performance on a verbal inhibition task (phonemic Continuous Performance Task) more strongly predicted kindergarteners' early reading than an equivalent non-verbal measure (Foy and Mann, 2013; see also Peng et al., 2024, for similar patterns with elementary school children).

While Domain-General theories may attribute these discrepancies to task impurity, Context-Specific accounts view them as meaningful, suggesting that children engage different processes depending on the specific demands of each academic task. As Context-Specific models characterize EF development as involving the maturation of its constituent processes (e.g., content knowledge; Doebel, 2020), they posit that education directly supports EF by bolstering children's academic skills (Perone et al., 2015). In this view, schooling also provides children with opportunities to practice control pursuant to academic goals (e.g., updating textual information in memory), enhancing their EF in similar educational contexts.

While the theories contrasted in this review offer different explanations for the relationship between EF and academic achievement, both present at least somewhat causal accounts. As with the previously discussed associations among SES and EF, however, most evidence connecting EF and academic achievement is correlational. EF interventions may therefore be especially valuable in elucidating the nature of these processes' associations with academic and other outcomes (Prager et al., 2023).

EF as a context-specific mediator

Numerous studies have linked SES to academic success (Liu et al., 2022), and these associations play out through multiple pathways. For instance, children's socio-economic backgrounds are often directly tied to their school environments; as public schools largely rely on local property taxes for funding, schools within low-SES neighborhoods tend to have limited access to educational resources and offer salaries that are less likely to attract and retain experienced educators (American Psychological Association, 2017; García and Han, 2022). Associations among SES and academic achievement are also mediated by various characteristics of children's home environments, such as familial values regarding education, parental involvement in their children's schooling, and access to educational resources (Bischoff and Owens, 2019; Davis-Kean et al., 2021; Doepke et al., 2019). Of particular interest to this review, associations among SES and academic achievement are partially mediated by EF across the school years (e.g., Lawson and Farah, 2017; Waters et al., 2021).

Given that EF is among many variables linking SES to academic success, it is perhaps unsurprising that the effect sizes of these mediations are often quite modest (e.g., Lawson et al., 2018). However, Context-Specific models are particularly well-suited to account for many of these additional mediating factors. For instance, access to educational resources supports the development of the content knowledge and skills frequently highlighted within these models (e.g., Doebel, 2020; Perone et al., 2021). Similarly, social factors such as familial, peer, and cultural attitudes toward education may also inform students' own values and motivation to succeed academically, which in turn contribute to whether and how students invoke control in academic settings (Miller-Cotto et al., 2022). Rather than viewing these and other mediators as extraneous, Context-Specific models are designed to integrate these variables into a more cohesive theoretical framework. The subsections below discuss the role of several of these factors within Context-Specific models in greater detail.

Academic knowledge and skills

SES-related gaps in school readiness suggest that differences in key Context-Specific processes emerge well before formal schooling begins. For example, children from families on welfare hear an estimated 30 million fewer words by their 3rd birthdays than their more affluent peers (Hart and Risley, 1995; Ellwood-Lowe et al., 2022; cf. Sperry et al., 2019), with early language gaps predicting later academic success (Lurie et al., 2021). Longitudinal work has documented similar associations among SES and 3-year-olds' mathematical abilities that are primarily mediated by mothers' support of their children's numerical skills (Lombardi and Dearing, 2021). As Context-Specific perspectives frame EF as the assembly of task-specific processes, these views suggest that early gaps in academic skills inherently limit control in contexts where those components are needed (Perone et al., 2021). For instance, children's reading comprehension involves updating textual information in memory, but also foundational skills (e.g., decoding) and content knowledge (e.g., the meaning of words; Artuso and Palladino, 2022) that may vary across socio-economic strata.

These issues may be especially relevant in mathematics, which relies on a wide variety of skills and content knowledge (e.g., number symbols, magnitudes, equations). As the appropriateness of these processes vary considerably across problems, children must assemble the needed processes while inhibiting irrelevant knowledge and strategies (Medrano and Prather, 2023)—thus, basic numerical skills bridge the connection between early EF and mathematical achievement. Associations among Head Start students' EF and performance on a standardized math test were mediated by basic numerical abilities; when all numeracy skills were tested simultaneously, these associations were mediated by a broader range of skills in kindergarteners (set counting, number line estimation, number identification and comparison) than in preschoolers (Chan and Scalise, 2022). Consistent with Context-Specific models' conceptualization of EF development, these findings may suggest that schooling expands and strengthens children's repertoires of numeric and verbal skills, which students may call upon when invoking EF pursuant to academic goals. Whereas these skills are often viewed as sources of statistical noise in Domain-General perspectives, Context-Specific models posit that EF is, in part, the *activation* of these and other goal-relevant processes (Doebel, 2020).

Social influences and the "cost of control"

In addition to goal-specific skills and knowledge, Context-Specific perspectives also emphasize how EF is shaped by socio-contextual factors, such as group norms and expectations. Within this framework, EF is viewed as being informed by children's understanding of what behaviors are expected or valued within their social context, rather than as relatively context-independent traits (Miller-Cotto et al., 2022; Munakata and Michaelson, 2021). In line with this view, preschool-aged children arbitrarily assigned to peer groups (e.g., the "green group") waited significantly longer on a delay-of-gratification assessment when they believed that other members of their group had been successful at this task (Doebel and Munakata, 2018; Munakata et al., 2020).

These findings have significant implications for children's EF in real-world settings, where their beliefs about their in-groups reflect long-term interactions with their peers and authority figures. Group norms are especially relevant in the classroom given that children of similar SES tend to attend the same schools (Mijs and Roe, 2021). As a result, schools serving low-income districts tend to have higher concentrations of students facing challenges with EF and academics (Bottiani et al., 2019), informing students' collective expectations for their peers' self-regulation and achievement. Teachers also play a significant role in developing classroom norms, and therefore teacher biases (e.g., based on familial income, race) may reinforce or establish maladaptive expectations; research has found that interventions to facilitate positive student-teacher interactions benefit preschoolers' and primary school students' EF (Sankalaite et al., 2021). Context-Specific approaches posit that children's interactions with their peers and teachers inform their internalized beliefs about their own capacities for regulation, and whether attempts at regulation will lead to desirable outcomes (e.g., Doebel, 2020).

Given the effort required for successful control (Diamond, 2020), these beliefs are theorized to factor into a cost-benefit analysis in which children weigh the expenditure of cognitive resources against the likelihood that their efforts will be sufficiently rewarded (e.g., peer approval, good grades). As noted earlier, this decision-making process is particularly relevant among children who often face unpredictable circumstances, and may therefore be especially unsure of whether their control will yield long-term benefits (Kidd et al., 2013; Michaelson and Munakata, 2016; Moffett et al., 2020). This uncertainty or unfamiliarity may contribute to a misalignment among children's context-informed goals (e.g., maximizing immediate rewards) and those of a given situation (e.g., delaying gratification; Frick and Chevalier, 2023). This mismatch may lead to what may be perceived as "poor" EF in both classroom and laboratory settings, potentially causing assessments to underestimate children's capabilities. This is especially relevant for children whose cultural values de-emphasize elements that are often central to standardized EF measures (e.g., obedience to adults, following verbal instructions; Gaskins and Alcalá, 2023). In other words, apparent "failures" of EF may instead reflect adapted responses shaped by children's environments and past experiences (Miller-Cotto et al., 2022).

Context-Specific models therefore frame "successful" EF as the appropriate assembly of cognitive processes given a particular setting or goal, rather than one's generalized use of control. Supporting this view, humans, rodents, and birds reared in unpredictable environments have heightened cognitive skills that are especially beneficial in similarly volatile contexts (e.g., faster attentional shifting to threatening stimuli; see Ellis et al., 2017, for review). Further, for low-SES kindergarteners of color, positive classroom behaviors and performance on a non-delay EF assessment (Head-Toes-Knees-Shoulders) were associated with the tendency to seek *immediate* gratification on a choice delay task (Duran and Grissmer, 2020). While the authors acknowledged

TABLE 1 Overview of context-specific EF interventions.

References	Age in years (SD)	Clinical risk	Context-specific EF training	# Sessions (duration)	Training group size	Comparison conditions	Main findings
Dyson et al. (2017)	5–7 years[a]	Older children were only included if they had "weak reading skills"	"Set for variability" intervention: shifting between pronunciations of vowel sounds embedded within words	8 (20 min) over 4 weeks	≤8	EF training ($n = 42$) and passive control ($n = 39$)	Intervention improved children's ability to read and define irregular trained words and untrained words of equivalent difficulty
Goodrich et al. (2023)	$M = 4.4$ (0.5)	Dual language learners with low language/literacy performance; primarily low-SES	Early literacy instruction embedded with EF training. For example, remembering increasing spans of letters/words, performing opposite actions based on rhymes (e.g., point to ear for words rhyming with "nose"), and shifting between saying word onsets and rimes	28 (25 min) over 7 weeks	≤4[b]	EF + early literacy instruction, early literacy instruction only, and passive control ($ns = 23$)	Both training conditions yielded improvements over the control condition on two (syntax and receptive vocabulary) of six literacy measures of interest. There were no significant differences between the training conditions
Kroesbergen et al. (2012; study 2)	$M = 5.8$ (0.3)	Low math performance	Embed number words of increasing magnitude within sentences, track numbers thrown on a die during a board game, and remember/sort cards based on number	8 (30 min) over 4 weeks	5	EF training, counting training, and passive control ($ns = 15$)	Both training conditions improved children's counting skills
Kroesbergen et al. (2014)	$M = 5.9$ (0.3)	Low math performance	See Kroesbergen et al. (2012)		5	Context-specific EF training, equivalent domain-general EF training ($ns = 15$), and passive control ($n = 21$)	Both training conditions led to significant improvements on a number comparison task. Only the Context-Specific group showed significantly greater gains than the control group on the counting test; however, there was no significant difference between the two training conditions
Kyttälä et al.'s (2015)	$M = 5.9$ (0.7)	N/A	See Kroesbergen et al. (2012)		4–7	EF training ($n = 23$), counting training ($n = 21$), and passive control ($n = 17$)	Counting training, but not EF training, improved children's counting skills
McClelland et al. (2019)	$M = 4.3$ (0.5)	Low-SES (head start)	Modified *"Red Light, Purple Light!"* intervention embedded with math and literacy content. For example, responding to cues related to print knowledge, phonological awareness, and early numeracy	16 (15–20 min) over 8 weeks	Class-wide ($M = 12$ participants per class)	Context-specific EF training ($n = 61$), equivalent domain-general EF training ($n = 59$), and passive control ($n = 37$)	Children in both training conditions had greater mathematical (but not literacy) gains over the school year than the control group. Results were "somewhat stronger" for the context-specific intervention, but differences among training conditions were statistically insignificant

(Continued)

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TABLE 1 (Continued)

References	Age in years (SD)	Clinical risk	Context-specific EF training	# Sessions (duration)	Training group size	Comparison conditions	Main findings
Prager et al. (2023)	*M* = 4.0 (5.5)	N/A	EF + Number training: shifting between counting item shapes based on color and shape (adapted Dimensional Change Card Sort)	3 (15 min)[c]	N/A[d]	EF + Number training, number-only training (*ns* = 27), EF-only training, and active storybook control (*ns* = 25)	Both EF training conditions yielded improvements in numerical skills compared to control group, but only EF + Number training improved general mathematical skills. However, differences in math outcomes between EF interventions were not statistically significant. Surprisingly, number-only training lead to non-significant and marginally significant improvements in numeracy and general mathematics, respectively
Siu et al. (2018)	*M* = 7.5 (0.4)	N/A	Repeat forwards and backwards increasingly long spans of Cantonese and English syllables to form strings of words	4 (30 min) and 1 (60 min) over 8 weeks	N/A[d]	EF training (*n* = 10), metalinguistic training (*n* = 13), and passive control (*n* = 12)	Both training conditions improved children's word reading fluency. Only metalinguistic training improved children's phonological skills

Overview of context-specific EF intervention of early academic achievement. [a]M and SD not provided. [b]Intervention was a mix of group and one-on-one training sessions. [c]Training span not provided; duration between pre-test and protest was M = 12.34 days (SD = 4.05). [d]Training was carried out in one-on-one sessions.

that children's choices may be shaped by other factors that are also linked to SES (e.g., task comprehension, familiarity with "waiting" games; see also Bailey et al., 2021 for further critiques), these findings non-etheless lend support to notion that children's engagement with these tasks are shaped by their socio-cultural contexts.

Context-specific EF interventions of academic achievement

Though mostly correlational, the findings discussed above point to EF training as a potential means to address SES-based achievement gaps (Lawson and Farah, 2017). EF has vital implications for children's academic skills, as they must, for instance, continually update representations of textual and numerical information in memory. However, although early EF can be trained to an extent, these benefits have unreliably transferred to academic outcomes and other untrained skills (Birtwistle et al., 2025; Melby-Lervåg and Hulme, 2013; Peng and Swanson, 2022; Scionti et al., 2020; Takacs and Kassai, 2019).

Context-Specific models offer insights that may help strengthen the efficacy of EF-based academic interventions. In particular, these perspectives suggest that this lack of transfer is due to a contextual mismatch between the training conditions and their intended outcomes. For instance, training 4-year-old children on traditional EF tasks (e.g., Flanker, Go/No-Go) does not improve their mathematical ability (Blakey et al., 2020), likely because the processes involved in completing these tasks differ significantly from those used in mathematics. These models propose that interventions that train children's EF within specific academic contexts (e.g., training children to update numerical information; Kroesbergen et al., 2012) may be more effective. Consistent with this perspective, a recent meta-analysis on reading interventions in 1st grade and beyond demonstrated that reading-specific EF training programs yielded greater academic improvements than domain-general ones. However, the authors noted that the current pool of studies on context-specific interventions was "underdeveloped," warranting further research on the effectiveness of these programs (Cartwright and Palian, 2024).

Table 1 overviews studies examining context-specific training programs, focusing on relatively small-scale early childhood interventions targeting academic outcomes—though several large-scale EF interventions (e.g., *Tools of the Mind*) have yielded impressive academic benefits, they require significant curricular overhaul (and therefore extensive professional development; Diamond et al., 2019) that may be inaccessible to low-SES districts. Consistent with Cartwright and Palian's (2024) assessment, the literature examining context-specific early childhood interventions is also quite limited. The implications of these studies and directions for future research in this area are discussed below.

As seen in the table, a common context-specific intervention strategy is to embed academic content (e.g., numbers, letters) into EF training (or vice versa). This method theoretically benefits academics by having children practice control in similar ways they would use it toward academic pursuits. For example, in a numeracy-modified Dimensional Change Card Sort task, children shifted between counting items based on shape and color (e.g., "how many blue ones are there?"). This training yielded significant improvements in preschoolers' numeracy and general mathematical abilities (Prager et al., 2023). Similarly, training children to flexibly shift between vowel pronunciations bolstered their ability to read and define irregular words (Dyson et al., 2017). While these training interventions generally (but not always; e.g., Kyttälä et al.'s, 2015) improved children's academic outcomes, studies including active control groups demonstrated limited benefits of these programs above and beyond the effects of simply training academic skills in isolation (e.g., Kroesbergen et al., 2012). Further, the few early childhood studies directly comparing context-specific interventions with otherwise equivalent domain-general ones found only small differences in their effects on academic outcomes, though these typically favored context-specific approaches (Kroesbergen et al., 2014; McClelland et al., 2019).

It is entirely possible that EF interventions of any kind will have limited impacts on young children's academic skills. At the same time, these mixed findings suggest that context-specific interventions have potential, and future work can examine modifications of these programs that may boost their effectiveness. For instance, existing interventions can be adjusted to be more explicitly "context-specific"—though often framed as a dichotomy, context-specificity truly exists on a spectrum, with some interventions and measures being more context-specific than others. For example, studies using Kroesbergen et al. (2012) training procedures were included in this review of context-specific interventions because they incorporated numeracy content. However, these may be less context-specific than, for instance, the counting-only training provided to Kyttälä et al. (2015) comparison group. It is likely for this reason that studies using this numbers-based EF training have varied in their classification of this intervention, with one labeling it as "domain-specific" (Kroesbergen et al., 2014), and another as "domain-general" (Kyttälä et al.'s, 2015).

In other words, while these studies included academic content in EF training (and were therefore classified as "context-specific" in this review), there may still be a significant mismatch among training and testing conditions. For instance, these interventions were presented as games, whereas outcomes were often assessed via standardized math and literacy tests (Kroesbergen et al., 2014; McClelland et al., 2019). Though gamification has significant practical benefits for children's engagement and enjoyment of these tasks (Eng et al., 2024), Context-Specific models may caution that this can hinder the contextual alignment between interventions and intended outcomes. Role-playing games in which children apply academic and control skills in semi-realistic scenarios could strike a balance between ecological validity and child engagement. This may help explain the success of programs like *Tools of the Mind* (e.g., Diamond et al., 2019), though further research is needed to determine whether this approach can be effectively implemented on a smaller, more accessible scale.

In addition to modifying training conditions, this work may also opt for more ecologically valid assessments of academic outcomes in addition to standardized testing. These measures may better capture the effects of context-specific interventions, while also better aligning with these theoretical models. Future studies should also continue to include active control conditions with the goal of developing interventions that substantially benefit academic skills beyond the effects of simply training domain-general EF or academic skills independently.

This line of inquiry could inform interventions to better support EF and academic achievement across a broad range of socio-economic strata. Many of the interventions highlighted in this section may already be relatively accessible to a wide variety of school districts. Most of these studies utilized group training sessions, which may be more easily adapted for a classroom than one-on-one interventions. These training sessions are also relatively short, involve few material resources, and require brief training for faculty/staff planning to implement the intervention (e.g., less than a day; McClelland et al., 2019)—especially compared to more extensive programs, like *Tools of the Mind,* which requires several days of teacher training (Diamond et al., 2019). At the same time, it is important to note that the faculty/staff, particularly those serving low-SES districts, may already be stretched thin (Farahmandpour and Voelkel, 2025) and *any* interventions, no matter how "budget-friendly," may be difficult to implement due to their need for teacher time and cognitive resources—optimizing the academic impact of these interventions will inherently enhance their resource-effectiveness. As discussed above, Context-Specific perspectives may offer a valuable framework for maximizing these programs' benefits.

Discussion

Limitations and future directions

Context-Specific models broaden our understanding of EF by emphasizing its integration with other cognitive and affective processes, as well as their highly context-dependent nature (Doebel, 2020; Munakata and Michaelson, 2021; Perone et al., 2021). These perspectives are therefore well-suited to provide meaningful insights on how children's environments, including socio-economic factors, shape EF development and related outcomes. As SES is an exceptionally broad construct (Lawson et al., 2018), its linkages with EF and academic outcomes are multi-directional and nearly limitless. Therefore, rather than providing an exhaustive account for these associations, the goal of this review was to provide a conceptual framework that supports future research in exploring SES-related factors not thoroughly addressed here (e.g., food insecurity) and potential interventions to support children's EF and their academic achievement. Further, given that these models underscore the importance of *context* on EF and related outcomes, additional research may also expand this line of inquiry to the many other interacting systems within children's environments (Bronfenbrenner, 1977). For instance, child cognitive outcomes also reflect dynamics within their households (Davis-Kean et al., 2021), which interact with larger exo- and chrono-system level influences (e.g., systemic racism).

As highlighted previously, a further limitation of this review is that most work on SES and related risk factors/outcomes is inherently correlational, making some of the theorized connections among SES, EF, and academic achievement somewhat speculative. While the academic benefits of the aforementioned EF training paradigms (e.g., Prager et al., 2023) suggest at least somewhat causal associations among these variables, this literature has produced limited findings that warrant further examinations on the effectiveness of these programs. Longitudinal work would also be valuable in examining the long-term effects of these interventions, while also capturing potential developmental shifts in EF's contributions to academic achievement (and vice versa) throughout the school years.

Reconciling context-specificity and domain-generality

As stated in the introduction, the goal of this review was to examine how Context-Specific models provide insights on associations among academic achievement, EF, and SES that complement those gained from traditional Domain-General accounts. This focus was due to the novelty of Context-Specific perspectives as compared to their Domain-General counterparts, rather than superiority of one model over another. Indeed, Context-Specific perspectives have several inherent limitations. Some have suggested that these models are too broad in scope, and theories in which "everything matters" are not especially informative ways to study development (Zelazo and Carlson, 2023; see also Perone et al., 2021, for discussion). While these models offer valuable insights into the context-dependency of EF, their breadth may come at the expense of focus and conceptual clarity. Further, Context-Specific models' emphasis on ecologically valid measures over traditional laboratory assessments has raised concerns over likely inconsistent operationalizations of EF across contexts and studies, with this lack of standardization hindering the integration of work within this framework into a cohesive literature (Zelazo and Carlson, 2023).

I am therefore not suggesting that we "throw out the proverbial (domain-general) baby with the bathwater" (Cartwright and Palian, 2024, p. 276). Rather, these views' respective strengths and weaknesses warrant a reconciliation (Zelazo and Carlson, 2023) that characterizes EF's development both within and across contexts. A hybrid model that integrates these perspectives is especially appropriate given that the neural substrates underlying EF are known to show both generalized and task-specific properties (Lemire-Rodger et al., 2019; Wilkey, 2023). One such reconciliation includes the proposal that children generalize across multiple instances of using EF across a range of contexts to build abstract executive processes, with children more easily able to generalize use of control across relatively similar goals (e.g., not kicking someone vs. not eating a marshmallow) than less similar ones (e.g., paying attention to a conversation). Here, EF maturation is not just seen as the development of its constituent processes, but also the ongoing collection of diverse experiences and their abstraction into schemas of control (Ibbotson, 2023).

Critically, hybridized models account for children's use of *both* generalized and context-specific processes, as well as intermediary functions (e.g., perspective taking) that assemble relevant processes (e.g., valuing others' views, switching flexibly between perspectives) while also applying to a broad range of settings (e.g., cooperative play, prosocial behavior). This perspective can guide future research examining how children's experiences in one context (e.g., home) translate to use of control others (e.g., school). This line of inquiry may therefore be especially informative in the development of EF training interventions; in particular, these hybridized perspectives suggest that training intermediary executive processes would be especially likely to transfer to a variety of real-world skills, including but not limited to those used in academic contexts (Zelazo et al., 2024).

Conclusion

In sum, Context-Specific models provide valuable insights on the interplays among children's environments and cognitive outcomes. This renewed focus is particularly relevant amid widening income disparities (Bischoff and Owens, 2019; Mijs and Roe, 2021)—particularly in the United States, where potential educational reforms may further disadvantage children and teachers within low-income districts. Traditional and emerging models each contribute to our understanding of how EF and its constituent processes can be supported in low-SES and other at-risk children (Doebel, 2020; Ibbotson, 2023; Zelazo and Carlson, 2023). This work is especially important given that a recent meta-analysis noted a severe lack of attention to SES in the developmental sciences (Singh and Rajendra, 2024). Continued efforts in this area will not only advance our scientific understanding of EF and its development, but also support vital cognitive and academic outcomes.

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References

American Psychological Association (2017). *Education and Socio-economic Status*. Available online at: https://www.apa.org/pi/ses/resources/publications/education (Accessed March 31, 2025).

Artuso, C., and Palladino, P. (2022). Working memory, vocabulary breadth and depth in reading comprehension: a study with third graders. *Discourse Processes* 59, 685–701. doi: 10.1080/0163853X.2022.2116263

Bailey, A. J., Romeu, R. J., and Finn, P. R. (2021). The problems with delay discounting: a critical review of current practices and clinical applications. *Psychol. Med.* 51, 1799–1806. doi: 10.1017/S0033291721002282

Birtwistle, E., Chernikova, O., Wünsch, M., and Niklas, F. (2025). Training of executive functions in children: a meta-analysis of cognitive training interventions. *SAGE Open* 15, 1–18. doi: 10.1177/21582440241311060

Bischoff, K., and Owens, A. (2019). The segregation of opportunity: social and financial resources in the educational contexts of lower-and higher-income children, 1990–2014. *Demography* 56, 1635–1664. doi: 10.1007/s13524-019-00817-y

Blakey, E., Matthews, D., Cragg, L., Buck, J., Cameron, D., Higgins, B., et al. (2020). The role of executive functions in socioeconomic attainment gaps: results from a randomized controlled trial. *Child Dev.* 91, 1594–1614. doi: 10.1111/cdev.13358

Bottiani, J. H., Duran, C. A., Pas, E. T., and Bradshaw, C. P. (2019). Teacher stress and burnout in urban middle schools: associations with job demands, resources, and effective classroom practices. *J. School Psychol.* 77, 36–51. doi: 10.1016/j.jsp.2019.10.002

Brod, G., Bunge, S. A., and Shing, Y. L. (2017). Does one year of schooling improve children's cognitive control and alter associated brain activation? *Psychol. Sci.* 28, 967–978. doi: 10.1177/0956797617699838

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *Am. Psychol.* 32, 513–531. doi: 10.1037/0003-066X.32.7.513

Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Dev. Neuropsychol.* 28, 595–616. doi: 10.1207/s15326942dn2802_3

Cartwright, K. B., and Palian, S. R. (2024). Considering roles of executive functions in the science of reading: a meta-analysis highlighting promises and challenges of reading-specific executive functions. *Educ. Psychol.* 59, 263–290. doi: 10.1080/00461520.2024.2418392

Chan, J. Y. C., and Scalise, N. R. (2022). Numeracy skills mediate the relation between executive function and mathematics achievement in early childhood. *Cogn. Dev.* 62:101154. doi: 10.1016/j.cogdev.2022.101154

Davis-Kean, P. E., Tighe, L. A., and Waters, N. E. (2021). The role of parent educational attainment in parenting and children's development. *Curr. Direct. Psychol. Sci.* 30, 186–192. doi: 10.1177/0963721421993116

DePasquale, C. E., Tyrell, F. A., Kalstabakken, A. W., Labella, M. H., Thibodeau, E. L., Masten, A. S., et al. (2021). Lifetime stressors, hair cortisol, and executive function: age-related associations in childhood. *Dev. Psychobiol.* 63, 1043–1052. doi: 10.1002/dev.22076

Diamond, A. (2020). "Executive functions," in *Handbook of Clinical Psychology, Vol. 173*, eds. A. Gallagher, C. Bulteau, D. Cohen, and J. L. Michaud, 225—240. doi: 10.1016/B978-0-444-64150-2.00020-4

Diamond, A., Lee, C., Senften, P., Lam, A., and Abbott, D. (2019). Randomized control trial of tools of the mind: marked benefits to kindergarten children and their teachers. *PLoS ONE* 14:e0222447. doi: 10.1371/journal.pone.0222447

Doebel, S. (2020). Rethinking executive function and its development. *Perspect. Psychol. Sci.* 15, 942–956. doi: 10.1177/1745691620904771

Doebel, S., and Müller, U. (2023). The future of research on executive function and its development: an introduction to the special issue. *J. Cogn. Dev.* 24, 161–171. doi: 10.1080/15248372.2023.2188946

Doebel, S., and Munakata, Y. (2018). Group influences on engaging self-control: children delay gratification and value it more when their in-group delays and their out-group doesn't. *Psychol. Sci.* 29, 738–748. doi: 10.1177/0956797617747367

Doepke, M., Sorrenti, G., and Zilibotti, F. (2019). The economics of parenting. *Annu. Rev. Econ.* 11, 55–84. doi: 10.1146/annurev-economics-080218-030156

Duran, C. A., and Grissmer, D. W. (2020). Choosing immediate over delayed gratification correlates with better school-related outcomes in a sample of children of color from low-income families. *Dev. Psychol.* 56, 1107–1120. doi: 10.1037/dev0000920

Dyson, H., Best, W., Solity, J., and Hulme, C. (2017). Training mispronunciation correction and word meanings improves children's ability to learn to read words. *Sci. Stud. Read.* 21, 392–407. doi: 10.1080/10888438.2017.1315424

Ellis, B. J., Bianchi, J., Griskevicius, V., and Frankenhuis, W. E. (2017). Beyond risk and protective factors: an adaptation-based approach to resilience. *Perspect. Psychol. Sci.* 12, 561–587. doi: 10.1177/1745691617693054

Ellwood-Lowe, M. E., Foushee, R., and Srinivasan, M. (2022). What causes the word gap? Financial concerns may systematically suppress child-directed speech. *Dev. Sci.* 25:e13151. doi: 10.1111/desc.13151

Eng, C. M., Tsegai-Moore, A., and Fisher, A. V. (2024). Incorporating evidence-based gamification and machine learning to assess preschool executive function: a feasibility study. *Brain Sci.* 14:451. doi: 10.3390/brainsci14050451

Farahmandpour, Z., and Voelkel, R. (2025). Teacher turnover factors and school-level influences: a meta-analysis of the literature. *Educ. Sci.* 15:219. doi: 10.3390/educsci15020219

Foy, J. G., and Mann, V. A. (2013). Executive function and early reading skills. *Read. Writing* 26, 453–472. doi: 10.1007/s11145-012-9376-5

Frankenhuis, W. E., Young, E. S., and Ellis, B. J. (2020). The hidden talents approach: theoretical and methodological challenges. *Trends Cogn. Sci.* 24, 569–581. doi: 10.1016/j.tics.2020.03.007

Frick, A., and Chevalier, N. (2023). A first theoretical model of self-directed cognitive control development. *J. Cogn. Dev.* 24, 191–204. doi: 10.1080/15248372.2022.2160720

García, E., and Han, E. S. (2022). Teachers' base salary and districts' academic performance: evidence from national data. *SAGE Open* 12, 1–17. doi: 10.1177/21582440221082138

Gärtner, A., and Strobel, A. (2021). Individual differences in inhibitory control: a latent variable analysis. *J. Cogn.* 4, 1–18. doi: 10.5334/joc.150

Gaskins, S., and Alcalá, L. (2023). Studying executive function in culturally meaningful ways. *J. Cogn. Dev.* 24, 260–279. doi: 10.1080/15248372.2022.2160722

Goodrich, J. M., Peng, P., Bohaty, J., Leiva, S., and Thayer, L. (2023). Embedding executive function training into early literacy instruction for dual language learners: a pilot study. *J. Speech Lang. Hearing Res.* 66, 573–588. doi: 10.1044/2022_JSLHR-22-00253

Hart, B., and Risley, T. R. (1995). *Meaningful Differences in the Everyday Experience of Young American Children*. Baltimore, MD: Brookes.

Ibbotson, P. (2023). The development of executive function: mechanisms of change and functional pressures. *J. Cogn. Dev.* 24, 172–190. doi: 10.1080/15248372.2022.2160719

Jensen, S. K., Berens, A. E., and Nelson, C. A. (2017). Effects of poverty on interacting biological systems underlying child development. *Lancet Child Adolescent Health* 1, 225–239. doi: 10.1016/S2352-4642(17)30024-X

Kidd, C., Palmeri, H., and Aslin, R. N. (2013). Rational snacking: young children's decision-making on the marshmallow task is moderated by beliefs about environmental reliability. *Cognition* 126, 109–114. doi: 10.1016/j.cognition.2012.08.004

Kitil, M. J., Diamond, A., Guhn, M., and Schonert-Reichl, K. A. (2025). Longitudinal relations of executive functions to academic achievement and wellbeing in adolescence. *Front. Educ.* 10:1573107. doi: 10.3389/feduc.2025.1573107

Kroesbergen, E. H., van't Noordende, J. E., and Kolkman, M. E. (2012). "Number sense in low-performing kindergarten children: effects of a working memory and an early math training," in *Reading, Writing, Mathematics and the Developing Brain: Listening to Many Voices*, Vol. 6, eds. Z. Breznitz, O. Rubinsten, V.J. Molfese, and D. Molfese (New York, NY: Springer), 295–313. doi: 10.1007/978-94-007-4086-0_16

Kroesbergen, E. H., van't Noordende, J. E., and Kolkman, M. E. (2014). Training working memory in kindergarten children: effects on working memory and early numeracy. *Child Neuropsychol.* 20, 23–37. doi: 10.1080/09297049.2012.736483

Kyttälä, M., Kanerva, K., and Kroesbergen, E. (2015). Training counting skills and working memory in preschool. *Scand. J. Psychol.* 56, 363–370. doi: 10.1111/sjop.12221

Lawson, G. M., and Farah, M. J. (2017). Executive function as a mediator between SES and academic achievement throughout childhood. *Int. J. Behav. Dev.* 41, 94–104. doi: 10.1177/0165025415603489

Lawson, G. M., Hook, C. J., and Farah, M. J. (2018). A meta-analysis of the relationship between socioeconomic status and executive function performance among children. *Dev. Sci.* 21:e12529. doi: 10.1111/desc.12529

Lemire-Rodger, S., Lam, J., Viviano, J. D., Stevens, W. D., Spreng, R. N., and Turner, G. R. (2019). Inhibit, switch, and update: a within-subject fMRI investigation of executive control. *Neuropsychologia* 132:107134. doi: 10.1016/j.neuropsychologia.2019.107134

Liu, J., Peng, P., Zhao, B., and Luo, L. (2022). Socioeconomic status and academic achievement in primary and secondary education: a meta-analytic review. *Educ. Psychol. Rev.* 34, 2867–2896. doi: 10.1007/s10648-022-09689-y

Lombardi, C. M., and Dearing, E. (2021). Maternal support of children's math learning in associations between family income and math school readiness. *Child Dev.* 92, e39–e55. doi: 10.1111/cdev.13436

Lurie, L. A., Hagen, M. P., McLaughlin, K. A., Sheridan, M. A., Meltzoff, A. N., and Rosen, M. L. (2021). Mechanisms linking socioeconomic status and academic achievement in early childhood: cognitive stimulation and language. *Cogn. Dev.* 58:101045. doi: 10.1016/j.cogdev.2021.101045

McClelland, M. M., Tominey, S. L., Schmitt, S. A., Hatfield, B. E., Purpura, D. J., Gonzales, C. R., et al. (2019). Red light, purple light! Results of an intervention to promote school readiness for children from low-income backgrounds. *Front. Psychol.* 10:2365. doi: 10.3389/fpsyg.2019.02365

Medrano, J., and Prather, R. W. (2023). Rethinking executive functions in mathematical cognition. *J. Cogn. Dev.* 24, 280–295. doi: 10.1080/15248372.2023.2172414

Melby-Lervåg, M., and Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Dev. Psychol.* 49:270. doi: 10.1037/a0028228

Michaelson, L. E., and Munakata, Y. (2016). Trust matters: seeing how an adult treats another person influences preschoolers' willingness to delay gratification. *Dev. Sci.* 19, 1011–1019. doi: 10.1111/desc.12388

Mijs, J. J., and Roe, E. L. (2021). Is America coming apart? Socioeconomic segregation in neighborhoods, schools, workplaces, and social networks, 1970–2020. *Sociol. Compass* 15:e12884. doi: 10.1111/soc4.12884

Miller-Cotto, D., and Byrnes, J. P. (2020). What's the best way to characterize the relationship between working memory and achievement? An initial examination of competing theories. *J. Educ. Psychol.* 112:1074. doi: 10.1037/edu0000395

Miller-Cotto, D., Smith, L. V., Wang, A. H., and Ribner, A. D. (2022). Changing the conversation: a culturally responsive perspective on executive functions, minoritized children and their families. *Infant Child Dev.* 31:e2286. doi: 10.1002/icd.2286

Miyake, A., and Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: four general conclusions. *Curr. Direct. Psychol. Sci.* 21, 8–14. doi: 10.1177/0963721411429458

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., and Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: a latent variable analysis. *Cogn. Psychol.* 41, 49–100. doi: 10.1006/cogp.1999.0734

Moffett, L., Flannagan, C., and Shah, P. (2020). The influence of environmental reliability in the marshmallow task: an extension study. *J. Exp. Child Psychol.* 194:104821. doi: 10.1016/j.jecp.2020.104821

Moriguchi, Y., and Shinohara, I. (2019). Socioeconomic disparity in prefrontal development during early childhood. *Sci. Rep.* 9:2585. doi: 10.1038/s41598-019-39255-6

Mousavi, S. Z., Farhadi, N., and Gharibzadeh, S. (2024). Socioeconomic status and childhood executive function: differing conceptualizations, diverse assessments, and decontextualized investigations. *Integr. Psychol. Behav. Sci.* 58, 1284–1299. doi: 10.1007/s12124-022-09680-w

Munakata, Y., and Michaelson, L. E. (2021). Executive functions in social context: implications for conceptualizing, measuring, and supporting developmental trajectories. *Annu. Rev. Dev. Psychol.* 3, 139–163. doi: 10.1146/annurev-devpsych-121318-085005

Munakata, Y., Yanaoka, K., Doebel, S., Guild, R. M., Michaelson, L. E., and Saito, S. (2020). Group influences on children's delay of gratification: testing the roles of culture and personal connections. *Collabra Psychol.* 6:1. doi: 10.1525/collabra.265

Noble, K. G., Magnuson, K., Gennetian, L. A., Duncan, G. J., Yoshikawa, H., Fox, N. A., et al. (2021). Baby's first years: design of a randomized controlled trial of poverty reduction in the United States. *Pediatrics* 148:e2020049702. doi: 10.1542/peds.2020-049702

Peng, P., and Kievit, R. A. (2020). The development of academic achievement and cognitive abilities: a bidirectional perspective. *Child Dev. Perspect.* 14, 15–20. doi: 10.1111/cdep.12352

Peng, P., Liu, Y., Cartwright, K., Goodrich, M., Koziol, N., Ma, C., et al. (2024). The role of domain-general, behavioral, and reading-specific executive function in reading comprehension: does context-specific executive function matter? *Sci. Stud. Read.* 28, 713–736. doi: 10.1080/10888438.2024.2409635

Peng, P., and Swanson, H. L. (2022). The domain-specific approach of working memory training. *Developmental Review* 65, 101035. doi: 10.1016/j.dr.2022.101035

Perone, S., Molitor, S. J., Buss, A. T., Spencer, J. P., and Samuelson, L. K. (2015). Enhancing the executive functions of 3-year-olds in the dimensional change card sort task. *Child Dev.* 86, 812–827. doi: 10.1111/cdev.12330

Perone, S., Simmering, V. R., and Buss, A. T. (2021). A dynamical reconceptualization of executive-function development. *Perspect. Psychol. Sci.* 16, 1198–1208. doi: 10.1177/1745691620966792

Prager, E. O., Ernst, J. R., Mazzocco, M. M., and Carlson, S. M. (2023). Executive function and mathematics in preschool children: training and transfer effects. *J. Exp. Child Psychol.* 232:105663. doi: 10.1016/j.jecp.2023.105663

Robson, D. A., Allen, M. S., and Howard, S. J. (2020). Self-regulation in childhood as a predictor of future outcomes: a meta-analytic review. *Psychol. Bull.* 146, 324–354. doi: 10.1037/bul0000227

Sankalaite, S., Huizinga, M., Dewandeleer, J., Xu, C., De Vries, N., Hens, E., et al. (2021). Strengthening executive function and self-regulation through teacher-student interaction in preschool and primary school children: a systematic review. *Front. Psychol.* 12:718262. doi: 10.3389/fpsyg.2021.718262

Scionti, N., Cavallero, M., Zogmaister, C., and Marzocchi, G. M. (2020). Is cognitive training effective for improving executive functions in preschoolers? A systematic review and meta-analysis. *Front. Psychol.* 10:2812. doi: 10.3389/fpsyg.2019.02812

Singh, L., and Rajendra, S. J. (2024). Greater attention to socioeconomic status in developmental research can improve the external validity, generalizability, and replicability of developmental science. *Dev. Sci.* 27:e13521. doi: 10.1111/desc.13521

Siu, T. S. C., McBride, C., Tse, C. S., Tong, X., and Maurer, U. (2018). Evaluating the effects of metalinguistic and working memory training on reading fluency in Chinese and English: a randomized controlled trial. *Front. Psychol.* 9:2510. doi: 10.3389/fpsyg.2018.02510

Sperry, D. E., Sperry, L. L., and Miller, P. J. (2019). Language does matter: but there is more to language than vocabulary and directed speech. *Child Dev.* 90, 993–997. doi: 10.1111/cdev.13125

Stucke, N. J., and Doebel, S. (2024). Early childhood executive function predicts concurrent and later social and behavioral outcomes: a review and meta-analysis. *Psychol. Bull.* 150:1178. doi: 10.1037/bul0000445

Takacs, Z. K., and Kassai, R. (2019). The efficacy of different interventions to foster children's executive function skills: a series of meta-analyses. *Psychol. Bull.* 145, 653–697. doi: 10.1037/bul0000195

Vliegenthart, J., Noppe, G., van Rossum, E. F., Koper, J. W., Raat, H., and van den Akker, E. L. (2016). Socioeconomic status in children is associated with hair cortisol levels as a biological measure of chronic stress. *Psychoneuroendocrinology* 65, 9–14. doi: 10.1016/j.psyneuen.2015.11.022

Vogel, S., Fernández, G., Joëls, M., and Schwabe, L. (2016). Cognitive adaptation under stress: a case for the mineralocorticoid receptor. *Trends Cogn. Sci.* 20, 192–203. doi: 10.1016/j.tics.2015.12.003

Vrantsidis, D. M., Clark, C. A., Chevalier, N., Espy, K. A., and Wiebe, S. A. (2020). Socioeconomic status and executive function in early childhood: exploring proximal mechanisms. *Dev. Sci.* 23:e12917. doi: 10.1111/desc.12917

Waters, N. E., Ahmed, S. F., Tang, S., Morrison, F. J., and Davis-Kean, P. E. (2021). Pathways from socioeconomic status to early academic achievement: the role of specific executive functions. *Early Childhood Res. Q.* 54, 321–331. doi: 10.1016/j.ecresq.2020.09.008

Wilkey, E. D. (2023). The domain-specificity of domain-generality: attention, executive function, and academic skills. *Mind Brain Educ.* 17, 349–361. doi: 10.1111/mbe.12373

Young, E. S., Frankenhuis, W. E., DelPriore, D. J., and Ellis, B. J. (2022). Hidden talents in context: cognitive performance with abstract versus ecological stimuli among adversity-exposed youth. *Child Dev.* 93, 1493–1510. doi: 10.1111/cdev.13766

Zelazo, P. D. (2006). The dimensional change card sort (DCCS): a method of assessing executive function in children. *Nat. Protoc.* 1, 297–301. doi: 10.1038/nprot.2006.46

Zelazo, P. D., Blair, C. B., and Willoughby, M. T. (2016). *Executive Function: Implications for Education. NCER 2017-2000.* National Center for Education Research. Washington, DC: U.S. Department of Education.

Zelazo, P. D., Calma-Birling, D., and Galinsky, E. (2024). Fostering executive-function skills and promoting far transfer to real-world outcomes: the importance of life skills and civic science. *Curr. Direct. Psychol. Sci.* 33, 121–127. doi: 10.1177/09637214241229664

Zelazo, P. D., and Carlson, S. M. (2023). Reconciling the context-dependency and domain-generality of executive function skills from a developmental systems perspective. *J. Cogn. Dev.* 24, 205–222. doi: 10.1080/15248372.2022.2156515