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The Efficacy of Different Interventions to Foster Children's Executive Function Skills: A Series of Meta-Analyses

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In the present meta-analysis all available evidence regarding the efficacy of different behavioral interventions for children's executive function skills were synthesized. After a systematic search we included experimental studies aiming to enhance children's (up to 12 years of age) executive functioning with neurodevelopmental tests as outcome measures. The results of 100 independent effect sizes in 90 studies including data of 8,925 children confirmed that it is possible to foster these skills in childhood (Diamond & Lee, 2011). We did not find convincing evidence, however, for the benefits to remain on follow-up assessment. Different approaches were effective for typically and nontypically developing samples. For nontypically developing children (including children with neurodevelopmental disorders or behavior problems) acquiring new strategies of self-regulation including biofeedback-enhanced relaxation and strategy teaching programs were the most effective. For typically developing children we found evidence for the moderate beneficial effects of mindfulness practices. Although small to moderate effects of explicit training with tasks loading on executive function skills in the form of computerized and noncomputer training were found, these effects were consistently weaker for nontypically developing children who might actually be more in need of such training. Thus, atypically developing children seem to profit more from acquiring new strategies of self-regulation as compared with practice with executive function tasks. We propose that explicit training does not seem to be meaningful as the approaches that implicitly foster executive functions are similarly or more effective, and these activities are more enjoyable and can be more easily embedded in children's everyday activities.

Public Significance Statement
The present meta-analysis evidences the efficacy of implicit approaches to fostering children's executive function skills over explicit training, highlighting specifically the benefits of interventions that provide children with strategies of self-regulation. More specifically, the evidence points to the potential of mindfulness practices for typically developing samples and that of biofeedback-enhanced relaxation and strategy teaching programs for atypically developing children.

Keywords: executive functions, children, intervention, meta-analysis, review

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Executive functions (EFs) are a set of cognitive skills that are responsible for planning, organizing, and executing our conscious and goal-directed actions especially in new or unexpected circumstances when schematic reactions are not appropriate. These top-down control processes also play a major role in both cognitive and emotional aspects of our self-regulation. EFs show continuous development well into young adulthood (Diamond, 2013). That is because EFs rely on the prefrontal cortex, which is the last area to develop in the brain (Jurado & Rosselli, 2007; Stuss, 1992). Childhood is a highly sensitive period regarding the development of these basic cognitive skills (Garon, Bryson, & Smith, 2008).

Executive function skills are considered to be a unitary construct with three dissociable skills in adults: working memory, inhibitory control, and cognitive flexibility (Miyake et al., 2000). These basic skills of holding information in mind and manipulating it, being able to ignore a distractor and inhibit automatic responses, and the

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ability to flexibly shift between different rules and mind sets enable higher order skills like problem solving, creativity and planning (Diamond & Lee, 2011). There is evidence that these skills at school entry are more predictive of school achievement than intelligence (Blair & Razza, 2007) and also strongly related to social-emotional well-being (Denham, Bassett, Sirotkin, Brown, & Morris, 2015; Liew, 2012; Rhoades, Greenberg, & Domitrovich, 2009; Riggs, Jahromi, Razza, Dillworth-Bart, & Mueller, 2006).

There is evidence for the key role of environmental risk factors like stress, poor parenting, or low socioeconomic status (Blair et al., 2011; Hackman & Farah, 2009). Certain neurodevelopmental disorders like autism spectrum disorder (ASD) or attention deficit hyperactivity disorder (ADHD) are characterized by a deficit in EF skills (e.g., flexible shifting or inhibitory control; Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009; Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004; Pennington & Ozonoff, 1996). In sum, there is large heterogeneity between children regarding these fundamental cognitive skills.

Considering the importance of EFs in childhood, the possibility of training these skills has received considerable attention and several approaches have been tested. In their seminal literature review Diamond and Lee (2011) summarized the evidence and outlined the major intervention approaches. They concluded that executive function skills in childhood are possible to be enhanced. They discussed the different interventions in the literature: computerized training, hybrid of computer and noncomputer games, aerobic exercise, martial arts and mindfulness practices, classroom curricula, and add-ons to classroom curricula. From the different approaches they highlighted the efficacy of (a) physical exercise (e.g., aerobics, martial arts, and yoga); and (b) classroom curricula that are specifically developed to foster EF skills. They hypothesized that in contrast to computer-based training programs that only target certain EF skills, interventions that also consider children's socioemotional and physical development are more beneficial. In the same vein, Blair (2017) emphasized that interventions that are applied in the context of children's everyday activities have more ecological validity than computer trainings. In a more recent review Diamond and Ling (2016; in press) confirmed earlier conclusions and added that aerobic exercise without a cognitive component does not seem to be as effective as physical activity that includes some cognitive challenge such as taekwondo or yoga. Additionally, the authors note that there is some evidence that benefits of these interventions are sustained over time but it remains a crucial issue in this line of research.

The goal of the present meta-analytic investigation was to synthesize all available empirical evidence on the efficacy of the different interventions to foster children's EF skills. Although there are meta-analytic reviews regarding different intervention approaches (on computerized working memory trainings see Melby-Lervag & Hulme, 2013; on physical activity see Álvarez-Bueno et al., 2017; Verburgh, Königs, Scherder, & Oosterlaan, 2014; on mindfulness meditation see Mak, Whittingham, Cunnington, & Boyd, 2017; Zenner, Herrnleben-Kurz, & Walach, 2014; Zoogman, Goldberg, Hoyt, & Miller, 2015), the present study, to our knowledge, is the first to systematically investigate the evidence regarding all behavioral interventions to train children's EF skills in a quantitative synthesis. Furthermore, we aimed to assess whether benefits are sustained over time, that is, whether these interventions have an effect on not only posttest but also on follow-up assessment. Such an evaluation of the existing empirical evidence regarding the most effective approaches to fostering EF skills is of high importance as these skills are crucial for school readiness and academic achievement in addition to social-emotional development (Denham et al., 2015; Liew, 2012; Rhoades et al., 2009; Riggs, Greenberg, Kusché, & Pentz, 2006). Accordingly, there is a call for early intervention to prevent school failure (Blair & Diamond, 2008). Thus, the evidence regarding the best practices has to be investigated in order to assist parents, teachers, and policymakers. Finally, different interventions might be more effective for children showing atypical development such as exhibiting behavior problems or living with neuropsychological disorders like ADHD or ASD. The present meta-analysis also aimed to investigate the efficacy of the different interventions for typically and nontypically developing samples as this is crucial information for the educational and clinical practice in order to select the most effective intervention programs with the individual differences in mind.

A widespread approach to fostering children's executive function skills is computerized training programs such as CogMed in which children can practice working memory tasks similar to span tasks in both the verbal and visuospatial domains or Braingame Brian targeting inhibitory control and cognitive flexibility. Although it might be logical to directly train executive function skills in case children are behind regarding these abilities, the evidence so far shows that it might be effective in improving the skill that is practiced, however, this effect does not seem to transfer to untrained domains (Blair & Razza, 2007; Diamond, 2012; Diamond & Lee, 2011; Diamond & Ling, 2016, in press), not even to other untrained executive function skills (Kassai, Futo, Demetrovics, & Takacs, 2019). Moreover, it is questionable whether children can apply the skills they gain by practicing the aforementioned paradigms without a meaningful context in real-world situations (Blair, 2017). Melby-Lervag & Hulme, 2013 and Melby-Lervåg, Redick, & Hulme, 2016, found in two meta-analyses that computerized working memory training had a significant effect on young children's verbal and visuospatial working memory skills. Melby-Lervåg and colleagues (2016) also found that participants with a learning disorder benefit more from these trainings than nondisordered samples. However, working memory training did not affect children's inhibitory skills (measured by the Stroop paradigm; Melby-Lervag & Hulme, 2013). Furthermore, Melby-Lervåg et al. (2016) did not find evidence for long-term benefits on verbal working memory but a significant effect on follow-up on visuospatial working memory although the authors note that these tasks were quite similar to the one practiced during the interventions. It has to be noted that a limited number of studies was available to be synthesized in these meta-analyses.

Similar to computerized training of specific EF skills, there is some evidence for the efficacy of explicitly training EF skills in a noncomputer environment. For instance, circle time games intended to practice inhibitory skills, such as freezing when the music stops or acting on a certain stimulus and not acting on another, were found to enhance inhibition but only of those preschoolers' who entered the study with lower inhibitory control (Tominey & McClelland, 2011).

Another line of research shows that chronic physical activity might enhance children's executive function skills (for reviews see Best & Miller, 2010; Ng, Ho, Chan, Yong, & Yeo, 2017; Tomporowski, Davis, Miller, & Naglieri, 2008). Several possible mechanisms for such an effect have been suggested. According to Best and Miller (2010) at least three possible pathways are plausible: (a) the cognitive demands of certain kinds of physical activity like team sports and ball games that require strategic and adaptive behavior makes children practice skills that are related to executive functions; (b) complex motor activity facilitates brain regions that are interrelated with the prefrontal cortex that is associated with executive functioning; and (c) there is an immediate physiological response to physical activity (increased blood flow, oxygen, and BDNF in the brain) and changes in the brain due to exercise that facilitates cognitive performance and learning. Especially cognitively challenging physical activity such as team sports and ball games evidence benefits to children's executive function skills as compared to nonengaging aerobic exercise (Best & Miller, 2010; Diamond, 2015). This might be due to multiple mechanisms activated during cognitively challenging physical activity: These games themselves pose cognitive challenges such as flexibly adapting one's behavior to the changing environment that are closely related to executive functions (Best & Miller, 2010). In contrast, aerobic exercise like running requires less cognitive processing because automated movements suffice.

Verburgh, Königs, Scherder, and Oosterlaan (2014) conducted a meta-analysis of the available evidence and found, based on two studies, a significant moderate acute effect of physical activity on children's inhibitory skills. However, based on four studies they found no significant chronic effects on children's executive function skills. It is important to note that the authors did not make a difference between cognitively challenging and nonengaging forms of physical activity and the included studies utilized a nonengaging form of physical activity in most cases. In contrasts, in a recent meta-analysis Álvarez-Bueno et al. (2017) found significant effects of physical activity interventions on children's EF skills. In the present meta-analysis, the overall effects of chronic physical activity interventions on children's executive function skills in addition to the differential effects of cognitively challenging forms of physical activity and nonengaging aerobic exercise were tested.

According to Diamond and Lee (2011), one of the most promising intervention approaches is curricula designed specifically to promote EF skills like Tools of the Mind and Montessori. They highlight that the strength of these approaches is that activities developed to foster EF (e.g., pretend play, waiting for your turn for a certain material) are built in children's daily practice. Practicing these skills during everyday activities probably helps to generalize the learnt abilities and apply them in other contexts. Additionally, these programs do not require any special material, they are feasible in the classroom setting led by regular teachers and they can be relatively easily given to large numbers of children.

In addition to these intervention approaches outlined by Diamond and colleagues (2011, 2016, in press), Diamond (2012) suggested that theater, orchestra, and choir might be potentially effective approaches to training children's executive function skills. There is some evidence regarding different art activities including music training (Chacona, 2007) and drama or pretend play (Schellenberg, 2004; Thibodeau, Gilpin, Brown, & Meyer, 2016) to foster children's EF skills. Protzko (2017) found in a meta-analysis that music training significantly increases children's IQ. Results regarding drama and pretend play were merged in the present meta-analysis because both require children to stay in role and inhibit their own behavior, and it is plausible that this fosters children's executive function skills.

Another approach that has been proposed to foster children's executive function skills is providing them strategies of self-regulation. In some studies the intervention program explicitly teaches children such strategies. For instance, they teach children about executive function-related skills (e.g., switching, inhibiting, focusing, emotion- or self-regulating) and practice the manner they can apply them during academic tasks (e.g., reading in Garcia-Madruga et al., 2013 or arithmetic's in Deano, Alfonso, & Das, 2015), and teach children strategies for self-regulation like planning before acting (e.g., Hannesdottir, Ingvarsdottir, & Bjornsson, 2017; Nash et al., 2015) or self-instruction (Meichenbaum & Goodman, 1971).

Another widespread intervention approach during which children acquire strategies of self-regulation is mindfulness meditation. During mindfulness practices meditators observe sensations and thoughts without judging them thus detecting inner happenings with sustained and focused attention, and actively directing their attention back to the present moment in case their thoughts would wander (Zelazo & Lyons, 2012). Therefore, meditators need to be in control of their attention on a moment-to-moment basis and practice self-control. Zelazo and Lyons (2012) suggests that mindfulness meditation is an ideal approach to fostering children's self-regulation because it is hypothesized to work both through top-down and bottom-up processes. That is, the purposeful regulation of attention that is central to mindfulness meditation probably trains children's attention and executive skills and, additionally, it likely reduces stress and anxiety. Thus, the authors argue, mindfulness meditation works on both the cognitive and emotional levels toward fostering children's self-regulation.

In a meta-analysis Zenner, Herrnleben-Kurz, and Walach (2014) found a large effect of mindfulness-based school interventions on children's and adolescents' cognitive performance including tests of attention, creativity, mind wandering, and grades. A recent meta-analytic review shows preliminary results for the potential of mindfulness-based interventions to foster children's executive function (Mak et al., 2017). Out of the 13 studies with samples under 18 years of age, five revealed a significant effect of mindfulness meditation on at least one measure of children's attention or executive functions. Finally, Zoogman, Goldberg, Hoyt, and Miller (2015) found a small but significant effect of mindfulness interventions with youth on measures of attention and mindfulness.

Finally, biofeedback-enhanced relaxation training utilizing electroencephalography (EEG) and electromyography (EMG) signal also appears in the literature as an intervention to reduce ADHD symptoms. In fact, these trainings teach children strategies for having control over their physiological reactions (Niv, 2013). However, so far the evidence does not support its efficacy to reduce these symptoms (Sonuga-Barke et al., 2013).

In sum, the following hypotheses were investigated in the present meta-analysis:

Hypothesis 1: We hypothesized that it is possible to train children's EF skills (Blair, 2017; Diamond, 2012; Diamond & Lee, 2011; Diamond & Ling, 2016, in press).

Hypothesis 2: We expected smaller but significant effects on follow-up assessment (Diamond & Ling, 2016, in press; Melby-Lervåg et al., 2016).

Hypothesis 3: Larger effects were expected for children showing atypical development (showing behavior problems or having a clinical diagnosis; Melby-Lervåg et al., 2016). It is also plausible that different interventions are more suitable for typically and atypically developing children.

Hypothesis 4: Not all intervention approaches were expected to be effective.

4a. Explicit practice with EF tasks was expected to be effective. More specifically, computer training has been found to foster children's EF skills (Diamond & Lee, 2011; Diamond & Ling, 2016, in press). Noncomputer training seems to have an effect on inhibitory control skills (Diamond & Lee, 2011).

4b. Cognitively challenging physical activity was expected to be effective, while nonengaging aerobic exercise was not (Best & Miller, 2010). EF-specific curricula were hypothesized to be especially effective (Blair & Diamond, 2008; Diamond & Lee, 2011).

4c. We had no hypothesis regarding the effects of art activities, however, music was found to have a positive effect on IQ in a previous meta-analysis (Protzko, 2017).

4d. We expected significant gains from interventions that teach children strategies for self-regulation. More specifically, mindfulness meditation was hypothesized to significantly foster children's EF skills based on previous meta-analytic results (Mak et al., 2017; Zenner et al., 2014; Zoogman et al., 2015). Based on a previous meta-analysis demonstrating no effect of biofeedback on children's ADHD symptoms (Sonuga-Barke et al., 2013), however, we expected biofeedback interventions to be ineffective for fostering children's EF skills. We had no prior expectations regarding the efficacy of strategy teaching interventions although the results of the primary studies are promising (e.g., Dias & Seabra, 2015a).

Method

Operational Definitions

The aim of the present meta-analysis was to synthesize all available evidence regarding any intervention targeting children (instead of via their parents or teachers, e.g., Connor et al., 2010) to foster their EF skills. Accordingly, we considered a wide range of intervention approaches that has been outlined in previous reviews (Diamond & Lee, 2011; Diamond & Ling, 2016, in press) including computerized and noncomputer training, cognitively engaging physical activity and aerobic exercise, mindfulness meditation and curricula that is focused on EF skills, but also other intervention methods we identified in the literature such as art activities, biofeedback-enhanced relaxation and strategy teaching interventions. We grouped these interventions according to how they approach facilitation of EF skills. First, computer and noncomputer training interventions use explicit practice of EF skills. During these explicit trainings children are not provided new strategies but have to apply their existing set of strategies when practicing tasks that load heavily on EF skills. In contrast, strategy learning programs, mindfulness and biofeedback-enhanced relaxation interventions teach children new strategies of self-regulation instead of practicing EF tasks. Full-time curricula such as Tools of the Mind, Montessori, and the Intervention Program for Self-Regulation and Executive Functions (PIAFEx)—that teach children strategies of self-regulation, apply pretend play and other art activities, and might contain explicit practice of EF tasks—were considered too complex to categorize into these intervention approaches. In a full-time curriculum program promotion of EF skills is built into a plethora of different everyday activities. Physical activity including cognitively engaging and aerobic exercise have to been proposed to enhance executive functions through several possible mechanisms like physiological, neurological, and behavioral processes thus it was also considered as another intervention approach. Finally, art activities included music training and pretend play/drama.

Regarding the EF outcome measures in the primary studies, we categorized them according to which component of EF skills it assessed. Instead of relying on the interpretation of the primary studies' authors of the tests, we categorized which component the task loaded on according to previous considerations in the literature (Diamond, 2013; Friedman & Miyake, 2004; Garon et al., 2008; Miyake et al., 2000). For instance, counting span (e.g., Holmes, Gathercole, & Dunning, 2009) and backward digit, word, or spatial (e.g., Corsi block test) span tasks (e.g., Chacko et al., 2014) were coded as measures of working memory. It is important to note that forward span tests were considered to reflect short-term memory (STM) because they require no manipulation of the information kept in mind (Alloway, Gathercole, & Pickering, 2006; Diamond, 2013) and were thus excluded in the present study. In case a measure including both forward and backward span tasks was reported in a study it was still included as a measure of working memory (e.g., Dovis, Van der Oord, Wiers, & Prins, 2015). Additionally, we decided to combine results over verbal and visuospatial working memory because evidence shows that working memory is a domain-general capacity (Alloway et al., 2006).

Go/no-go (Dowsett & Livesey, 2000), flanker (e.g., Röthlisberger et al., 2011), and Stroop-like tests (e.g., Wimmer, Bellingrath, & von Stockhausen, 2016) were considered to reflect inhibition skills just like different tasks using the delay of gratification paradigm like the toy wait test (e.g., Razza, Bergen-Cico, & Raymond, 2015) based on Diamond (2013). Card sorting tasks such as the Dimensional Card Sorting Test (e.g., Howard, Powell, Vasseleu, Johnstone, & Melhuish, 2016; Schmitt, 2013) and the Trail Making Test Part B (e.g., Dias & Seabra, 2015a) that require the ability of rule switching in addition to the Tower of London test (e.g., Goldin et al., 2014), which is associated with planning and problem solving skills (Allport, 1997; Nitschke, Köstering, Finkel, Weiller, & Kaller, 2017) were categorized as indicators of cognitive flexibility.

Search Strategy

We conducted a systematic search in the literature in order to locate all available evidence regarding the efficacy of any interventions aimed at fostering children's executive function skills measured by neurocognitive tests. The literature search was conducted in two steps. First, we ran a search string (see Appendix A) in the databases of PsycINFO, Web of Science, PsycARTICLES, and ERIC. As shown in Appendix B, this search resulted in 7,287 hits after removing duplicates. These hits were screened by pairs of research assistants based on the title and the abstract for eligibility. In a secondary search we screened the reference lists of all included studies and other relevant literature reviews and meta-analyses. We aimed to synthesize all evidence regardless whether it was published or not so we included unpublished dissertations as well (e.g., Lomas, 2001).

Inclusion Criteria

We utilized similar inclusion criteria as Diamond and colleagues in previous literature reviews (Diamond & Lee, 2011; Diamond & Ling, 2016, in press). Important points were (a) the use of an experimental design (because correlational results do not necessarily reflect the results of an intervention but might be biased by participants' characteristics and interest); (b) the inclusion of a control group (in order to rule out effects of maturation and testing); (c) interventions longer than a single session were considered in order to assess chronic effects instead of acute outcomes; and (d) outcome measures other than the tasks practiced during the training were included.

The included studies had to meet the following criteria:

- A randomized controlled experimental or a quasiexperimental (children were not randomly assigned to the conditions on an individual but on a group basis (e.g., classroom) design was utilized.
- An intervention condition that was aimed at enhancing children's executive function skills, either explicitly training them (e.g., a working memory computer training) or implicitly fostering them (e.g., physical activity).
- The results of the intervention group were compared with a passive (no treatment) or an active (an activity that was not intended to foster EF skills) control group.
- The age of the sample was no more than 12 years at the beginning of the study.
- Reported the results on at least one outcome measure that used a neurocognitive test of executive functions on posttest.
- The article was written in English.

As shown in Table 1, from the studies that reported on the results of more than one intervention or control conditions that met our inclusion criteria we included more contrasts and treated them as nonindependent contrasts in the analyses. If there were two or more suitable intervention conditions, all of them were included as compared to the control group (e.g., a mindfulness meditation and a concentration training condition in Wimmer et al., 2016). The same strategy was used when a study contained more control conditions like an active and a passive control (e.g., Kyttälä, Kanerva, & Kroesbergen, 2015; for a similar procedure, see Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003). In case the results were reported separately for two groups of the sample like younger and older children (Dowsett & Livesey, 2000), we included the results for both groups as long as they fit our inclusion criteria.

Exclusion Criteria

First of all, we excluded correlational studies (e.g., Oberle, Schonert-Reichl, Lawlor, & Thomson, 2012) and case studies (e.g., Gooch, 2010). Furthermore, when we discovered that two studies reported data on the same experiment with the same sample we chose one of them to be included in the analyses. For example, we chose to include results of Hillman et al. (2014) on the FitKids trial over the studies of Chaddock-Heyman et al. (2013) and Kamijo et al. (2011) because the latter two reported results of subsamples.

As outcome measures we only included neurocognitive tests of executive function conducted with the children. Accordingly, other kinds of instruments were excluded: We did not include teacher-, parent-, or self-reported assessment of executive functions like the Behavior Rating Inventory of Executive Function (e.g., de Vries, Prins, Schmand, & Geurts, 2015). Finally, it is important to note that we did not include measures that were the same as a task the children practiced during the intervention. For instance, children practiced a go/no-go apparatus in the study of Dowsett and Livesey (1999) and were tested on the same machine afterward. In a similar vein, Dovis, Van der Oord, Wiers, and Prins (2015) used a stop task on posttest that was also very similar to an inhibition task used in the intervention. Also, Markomichali (2015) applied a cookie delay task both as an outcome measure and the central task of the intervention. As these tasks were explicitly practiced during the intervention, we excluded them from the analyses in order not to overestimate effects of the interventions. Tasks had to use different stimuli other than the ones used in the same paradigm during the intervention, for the very least, in order to be included.

Finally, results had to be excluded in case we could not locate the full text in English (e.g., Aghababaei, Malekpour, & Abedi, 2012) or if we did not have sufficient statistics to calculate an effect size even after contacting the authors (e.g., St. Clair-Thompson & Holmes, 2008).

Coding

During the coding process every article was coded by two research assistants according to a predefined coding schema regarding the following information: (a) descriptive information (e.g., title, author(s), year of publication, and the continent where the data was collected); (b) sample characteristics (e.g., the number of the participants in the intervention and control groups, the mean age of the sample, and whether they were typically or nontypically developing children including the reason for the nontypical categorization: clinical diagnosis, behavior problems reported, or low executive function skills); (c) study design (e.g., experimental or quasiexperimental, passive, or active control); (d) characteristics of the intervention (e.g., the kind of intervention applied and the length of the intervention, whether some information regarding intervention fidelity was reported; e.g., attempts to monitor adherence to intervention protocol, report of children's attendance or a manipulation check); (e) the kind of outcome measure (e.g., working memory, inhibitory control, or cognitive flexibility).

It has to be noted that as an estimate of the length of the interventions we calculated the number of intervention sessions in all intervention categories except for the EF-specific curricula. In case of these studies we did not have enough information to code

Table 1
Overview of the Studies That Assessed the Effects of Computer Trainings Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Alloway	2013	USA, North America	$M = 10.76$	Atypical: diagnosed with learning impairments	Computer training: "Jungle Memory WMT high" ($n = 24$)	Active control: "Jungle Memory WMT low" ($n = 32$)	Working memory (2 measures):			
Contrast 1							1. Mix of backward digit recall and processing letter recall	No	Yes (−.38)	Yes (1.35)
							2. Shape recall	No	Yes (−.03)	Yes (.82)
Alloway	2013	USA North America	$M = 10.76$	Atypical: diagnosed with learning impairments	Computer training: "Jungle Memory WMT high" ($n = 24$)	Passive control ($n = 32$)	Working memory (2 measures):			
Contrast 2							1. Mix of backward digit recall and processing letter recall	No	Yes (.58)	Yes (.76)
							2. Shape recall	No	Yes (.40)	Yes (1.59)
Bennett	2013	United Kingdom, Europe	7–12	Atypical: diagnosed with Down syndrome	Computer training: "Cogmed Working Memory Training: RoboMemo" ($n = 10$)	Passive control ($n = 11$)	Working memory (2 measures):			
							1. Counting recall	No	Yes (.24)	No
							2. Odd one out	No	Yes (.20)	No
Bergman-Nutley	2011	Sweden, Europe	4	Typically developing	Computer training: "Cogmed Working Memory Training: RoboMemo (WT)" ($n = 25$)	Active control: "Placebo (Nonadaptive CB training)" ($n = 25$)	Working memory (1 measure):			
Contrast 1							1. Odd one out	No	Yes (.55)	No
Bergman-Nutley	2011	Sweden, Europe	4	Typically developing	Computer training: "Nonverbal reasoning training (NV)" ($n = 24$)	Active control "Placebo (Nonadaptive CB training)" ($n = 25$)	Working memory (1 measure)			
Contrast 2							1. Odd one out	No	Yes (.51)	No
Bergman-Nutley	2011	Sweden, Europe	4	Typically developing	Computer training: "Cogmed Working Memory Training: RoboMemo + Nonverbal reasoning training (CB)" ($n = 27$)	Active control "Placebo (Nonadaptive CB training)" ($n = 25$)	Working memory (1 measure)			
Contrast 3							1. Odd one out	No	Yes (.66)	No
Bigorra	2016	Spain, Europe	7–12	Atypical: diagnosed with ADHD	Computer training: "Cogmed Working Memory Training: RoboMemo" ($n = 31$)	Active control (Nonadaptive CB training) ($n = 30$)	Working memory (2 measures):			
							1. Spatial recall	No	Yes (.71)	Yes (.20)
							2. Letter-number sequencing	No	Yes (.57)	Yes (.01)
							Inhibitory control (1 measure):			
							1. CPT II (commission errors)	No	Yes (.29)	Yes (.08)
							Cognitive flexibility (3 measures):			
							1. Tower of London	No	Yes (−.02)	Yes (.08)
							2. WCST (perseverative errors)	No	Yes (−.15)	Yes (.17)
							3. Trail making test B	No	Yes (−.46)	Yes (−.18)

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Blakey	2015	England, Europe	M = 4.33; SD = 3.58	Typically developing	Computer training: "Short executive function training program" (n = 26)	Active control: "Three simple perceptual judgment tasks" (n = 28)	Working memory (1 measure):			
							1. Backward word task	No	Yes (.52)	Yes (.87)
							Inhibitory control (1 measure):			
							1. Peg tapping	No	Yes (.70)	Yes (.39)
							Cognitive flexibility (2 measures):			
							1. FIST	No	Yes (.10)	Yes (.05)
							2. SWIFT mixed switch	No	Yes (.13)	Yes (.15)
Chacko	2014	USA, North America	7–11	Atypical: diagnosed with ADHD	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 44)	Active control: "CWMT Placebo (low level)" (n = 41)	Working memory (2 measures):			
							1. Listening recall	No	Yes (.07)	No
							2. Spatial recall	No	Yes (.29)	No
							Inhibitory control (1 measure):			
							1. CPT (commission errors)	No	Yes (−.02)	No
de Vries Contrast 1	2015	The Netherlands, Europe	8–12	Atypical: diagnosed with ASD	Computer training: "Braingame Brian–working memory training" (n = 31)	Active control: "Mock training (nonadaptive)" (n = 29)	Working memory (1 measure):			
							1. N-back test–2-back trials	Yes (.48)	Yes (.04)	Yes (.18)
							Inhibitory control (1 measure):			
							1. Stop-task	Yes (.08)	Yes (−.13)	Yes (−.20)
							Cognitive flexibility (2 measures):			
							1. Number-gnome switch	Yes (−.18)	Yes (.09)	Yes (.01)
							2. Gender-emotion switch	Yes (−.62)	Yes (−.18)	Yes (.07)
de Vries Contrast 2	2015	The Netherlands, Europe	8–12	Atypical: diagnosed with ASD	Computer training: "Braingame Brian–flexibility training" (n = 26)	Active control: "Mock training (nonadaptive)" (n = 29)	Working memory (1 measure):			
							1. N-back test–2-back trials	Yes (.24)	Yes (.06)	Yes (.33)
							Inhibitory control (1 measure):			
							1. Stop-task	Yes (−.01)	Yes (.09)	Yes (−.44)
							Cognitive flexibility (2 measures):			
							1. Number-gnome switch	Yes (−.11)	Yes (−.10)	Yes (−.21)
							2. Gender-emotion switch	Yes (−.41)	Yes (.10)	Yes (.06)

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Dongen-Boomsma	2014	The Netherlands, Europe	5–7	Atypical: diagnosed with ADHD	Computer training: "Cogmed Working Memory Training: RoboMemo" (*n* = 26)	Active control: "Nonadaptive training" (*n* = 21)	Working memory (2 measures):			
(Dissertation, Chapter VI)							1. Knox Cubes Leidse Diagnostische Test	No	Yes (.35)	No
							2. Digit Span (WISC) Backward	No	Yes (.52)	No
							Inhibitory control (3 measures):			
							1. Day/Night Stroop	Yes (.56)	Yes (.23)	No
							2. Shape school control red	Yes (−.23)	Yes (.00)	No
							3. Shape school control yellow	Yes (−.07)	Yes (.19)	No
							Cognitive flexibility (2 measures):			
							1. Shape school switch red	Yes (−.29)	Yes (.11)	No
							2. Shape school switch yellow	Yes (−.39)	Yes (.28)	No
Dovis	2015	The Netherlands, Europe	10	Atypical: diagnosed with ADHD	Computer training: "Braingame Brian" (Full active) (*n* = 31)	Active control: "Braingame Brian (Placebo-mode)" (*n* = 30)	Working memory (1 measure):			
Contrast 1							1. Digit Span (WISC)	No	Yes (.00)	Yes (.13)
							Cognitive flexibility (1 measure):			
							1. Trail Making Test (switch-cost)	No	Yes (.90)	Yes (.04)
							Inhibitory control (1 measure)			
							1. Stroop test	Yes (.11)	No	No
Dovis	2015	The Netherlands, Europe	10	Atypical: diagnosed with ADHD	Computer training: "Braingame Brian" (Partially active) (*n* = 28)	Active control: "Braingame Brian (Placebo-mode)" (*n* = 30)	Working memory (1 measure):			
Contrast 2							1. Digit Span (WISC)	No	Yes (.00)	Yes (.03)
							Cognitive flexibility (1 measure):			
							1. Trail Making Test (switch-cost)	No	Yes (.10)	Yes (−.13)
							Inhibitory control (1 measure)			
							1. Stroop test	Yes (.26)	No	No

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Dörrenbacher	2014	Germany, Europe	8–11	Typically developing	Computer training: "Task switching training" (high motivation) (n = 14)	Active control: "Single task training" (n = 13)	Working memory (2 measures):			
Contrast 1							1. Backward digit span	No	Yes (.05)	No
							2. Counting span	Yes (.35)	Yes (.16)	No
							Inhibitory control (3 measures):			No
							1. CPT AY	Yes (−.07)	Yes (−.37)	No
							2. CPT BX			No
							3. Stroop test	Yes (.55)	Yes (.21)	
							Cognitive flexibility (1 measure):			
							1. Task switching	Yes (.57)	Yes (−.14)	
							task	No	Yes (−.14)	
Dörrenbacher	2014	Germany, Europe	8–11	Typically developing	Computer training: "Task switching training" (low motivation) (n = 14)	Active control: "Single task training" (n = 14)	Working memory (2 measures):			
Contrast 2							1. Backward digit span	No	Yes (.41)	No
							2. Counting span	Yes (−.17)	Yes (−.34)	No
							Inhibitory control (3 measures):			
							1. CPT AY	Yes (−.19)	Yes (.86)	No
							2. CPT BX	Yes (.21)	Yes (.39)	No
							3. Stroop test	Yes (.00)	Yes (.82)	No
							Cognitive flexibility (1 measure):			
							1. Task switching task		Yes (.04)	No
Dunning	2013	United Kingdom, Europe	7–9	Atypical: "Low working memory"	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 34)	Passive control (n = 30)	Working memory (2 measures):			
Contrast 1							1. Mix of backward digit span and listening recall	No	Yes (1.04)	No
							2. Mix of Mr. X, Odd one out	No	Yes (.97)	No
							Inhibitory control (1 measure):			
							1. CPT (commission error)	No	Yes (.30)	No
Dunning	2013	United Kingdom, Europe	7–9	Atypical: "Low working memory"	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 34)	Active control: "Nonadaptive training" (n = 30)	Working memory (2 measures):			
Contrast 2							1. Mix of backward digit span and listening recall	No	Yes (.56)	No
							2. Mix of Mr. X, Odd one out	No	Yes (.46)	No
							Inhibitory control (1 measure):			
							1. CPT (commission error)	No	Yes (.40)	No

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Egeland	2013	Norway, Europe	10–12	Atypical: diagnosed with ADHD	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 33)	Passive control (n = 34)	Inhibitory control (2 measures):			
							1. Color word test	No	Yes–error rate and speed (.05)	Yes (−.10)
							2. CPT–Hyperactivity-Impulsivity	No	Yes (commission error and reaction time) (.36)	Yes (−.28)
							Cognitive flexibility (1 measure):			
							1. Trail Making Test–4	No	Yes (.12)	Yes (−.04)
Espinet Experiment 1		Canada, North America	2–4	Typically developing	Computer training: "Reflection training" (n = 15)	Active control: "Number-conservation training" (n = 14)	Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (.84)	No
Espinet Experiment 2		Canada, North America	2–4	Typically developing	Computer training: "Reflection training" (n = 14)	Active control "Number-conservation training" (n = 14)	Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (.86)	No
Espinet Experiment 3 Contrast 1		Canada, North America	2–4	Typically developing	Computer training: "Reflection training" (n = 20)	Active control: "Corrective feedback" (n = 16)	Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (1.00)	No
Espinet Experiment 3 Contrast 2		Canada, North America	2–4	Typically developing	Computer training: "Reflection training" (n = 20)	Active control "Mere practice" (n = 20)	Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (1.15)	No
Goldin	2014	Argentina, South America	6–7	Typically developing	Computer training: "Mate Marote" (n = 73)	Active control: "Three equally motivating games with similar motor requirement but less cognitive demand" (n = 38)	Inhibitory control (2 measures):			
							1. Child Attention Network Task–incongruent	Yes (.64)	Yes (.09)	No
							2. Hearts and Flowers–Fix incongruent	Yes (.20)	Yes (.02)	No
							Cognitive flexibility (3 measures):			
							1. Hearts and Flowers–Mix congruent	Yes (.37)	Yes (.17)	No
							2. Hearts and Flowers–Mix incongruent	Yes (.25)	Yes (.17)	No
							3. Tower of London	No	Yes (.37)	No
Holmes	2009	United Kingdom, Europe	8–11	Atypical: "Low working memory"	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 22)	Active control: "Nonadaptive training" (n = 20)	Working memory (2 measures):			
							1. Mix of Mr. X and Odd one out	No	Yes (.43)	No
							2. Counting recall	No	Yes (.72)	No

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Hovik	2013	Norway, Europe	10–12	Atypical: diagnosed with ADHD	Computer training: "Cogmed Working Memory Training: RoboMemo" ($n = 33$)	Passive control ($n = 34$)	Working memory (2 measures):			
							1. Leiter R forward and backward	No	Yes (.35)	Yes (.78)
							2. Mix of letter-number sequencing and sentence span	No	Yes (.13)	Yes (.53)
Karbach Contrast 1	2009	Germany, Europe	8.1–10.1	Typically developing	Computer training: "Task-switching training" ($n = 14$)	Active control: "Single task training" ($n = 15$)	Working memory (2 measures):			
							1. Mix of reading span and counting span	No	Yes (.35)	No
							2. Mix of symmetry span and navigation span	No	Yes (.16)	No
							Inhibitory control (1 measure):			
							1. Mix of color and number Stroop task	Yes (.26)	No	No
Karbach Contrast 2	2009	Germany, Europe	8.1–10.1	Typically developing	Computer training: "Task-switching training + verbal self-instructions" ($n = 14$)	Active control: "Single task training" ($n = 15$)	Working memory (2 measures):			
							1. Mix of reading span and counting span	No	Yes (.48)	No
							2. Mix of symmetry span and navigation span	No	Yes (.29)	No
							Inhibitory control (1 measure):			
							1. Mix of color and number Stroop task	Yes (.51)	No	No
Karbach Contrast 3	2009	Germany, Europe	8.1–10.1	Typically developing	Computer training: "Switch training + verbal instructions + variable training" ($n = 14$)	Active control: "Single task training" ($n = 15$)	Working memory (2 measures):			
							1. Mix of reading span and counting span	No	Yes (.30)	No
							2. Mix of symmetry span and navigation span	No	Yes (.23)	No
							Inhibitory control (1 measure):			
							1. Mix of color and number Stroop task	Yes (.67)	No	No
Klingberg	2005	Sweden, Europe	7–12	Atypical: diagnosed with ADHD	Computer training: "Cogmed Working Memory Training: RoboMemo" ($n = 20$)	Active control: "Nonadaptive training" ($n = 24$)	Working memory (1 measure):			
							1. Span board task	No	Yes (1.02)	Yes (1.00)
							Inhibitory control (1 measure):			
							1. Stroop test	Yes (.47)	Yes (.84)	Yes (.20)

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Lomas	2001	USA, North America	7–9	Atypical: diagnosed with ADHD	Computer training: "LocuTour Multimedia Cognitive Rehabilitation" (n = 16)	Passive control (n = 15)	Inhibitory control (1 measure):			
(Dissertation)							1. Continuous Performance Test	No	Yes–commission errors (.00)	No
							Cognitive flexibility (1 measure):			
							1. WCST	No	Yes (−.38)	No
Luo	2013	China, Asia	8–11	Atypical: diagnosed with Dyslexia	Computer training: "Working memory and central executive tasks" (n = 15)	Active control: "Nonadaptive training" (n = 15)	Working memory (2 measures):			
							1. Word span task backward	No	Yes (.68)	No
							2. Digit span backward	No	Yes (.53)	No
							Inhibitory control (1 measure):			
							1. Stroop	No	Yes (.00)	No
Rueda	2012	Spain, Europe	5	Typically developing	Computer training: "Computerized training of attention" (n = 19)	Active control: "Watching cartoon videos" (n = 18)	Inhibitory control (4 measures):			
							1. Delay of Gratification–Self	No	Yes (.61)	Yes (.43)
							2. Delay of Gratification–Other	No	Yes (.42)	Yes (.23)
							3. Child Gambling Task	No	Yes (.35)	Yes (.69)
							4. Child ANT	No	Yes-commission error (.20)	Yes (.32)
St. Clair-Thompson	2008	United Kingdom, Europe	6–7	Typical developing	Computer training: "Memory Booster" (n = 22)	Passive control (n = 22)	Working memory (2 measures):			
Study 1							1. Listening recall task	No	Yes (.75)	No
							2. Counting recall task	No	Yes (.61)	No
St. Clair-Thompson	2008	United Kingdom, Europe	6–7	Typically developing	Computer training: "Memory Booster" (n = 18)	Passive control (n = 18)	Working memory (2 measures):			
Study 2							1. Backwards digit recall task	No	Yes (1.72)	No
							2. Listening recall task	No	Yes (.89)	No
St. Clair-Thompson	2010	United Kingdom, Europe	5–8	Typically developing	Computer training: "Memory Booster" (n = 117)	Passive control (n = 137)	Working memory (1 measure):			
							1. Listening recall	No	Yes (1.15)	No

(*table continues*)

Table 1 (*continued*)

First author	Publication year	Place	Age (year)	Typically/atypically developing sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' g)	Accuracy (Hedges' g)	Follow-up assessment (Hedges' g)
Thorell	2009	Sweden, Europe	4–5	Typical developing	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 17)	Active control: "Computer games" (n = 14)	Working memory (2 measures):			
Contrast 1							1. Span Board Task (WAIS-R-NI)	No	Yes (.20)	No
							2. Word Span Task	No	Yes (.31)	No
							Inhibitory control (2 measures):			
							1. Day-Night Stroop Task	No	Yes (.42)	No
							2. Go/No-Go Task	No	Yes (commission error) (−.09)	No
Thorell	2009	Sweden, Europe	4–5	Typically developing	Computer training: "Cogmed Working Memory Training: RoboMemo" (n = 17)	Passive control (n = 16)	Working memory (2 measures):			
Contrast 2							1. Span Board Task (WAIS-R-NI)	No	Yes (.30)	No
							2. Word Span Task	No	Yes (.30)	No
							Inhibitory control (2 measures):			
							1. Day-Night Stroop Task	No	Yes (.33)	No
							2. Go/No-Go Task	No	Yes (commission error) (−.25)	No
Thorell	2009	Sweden, Europe	4–5	Typically developing	Computer training: "Cogmed Inhibition Training: RoboMemo" (n = 18)	Active control: "Computer games" (n = 14)	Working memory (2 measures):			
Contrast 3							1. Span Board Task (WAIS-R-NI)	No	Yes (−1.45)	No
							2. Word Span Task	No	Yes (−.51)	No
							Inhibitory control (2 measures):			
							1. Day-Night Stroop Task	No	Yes (.16)	No
							2. Go/No-Go Task	No	Yes (commission error) (.12)	No
Thorell	2009	Sweden, Europe	4–5	Typically developing	Computer training: "Cogmed Inhibition Training: RoboMemo" (n = 18)	Passive control (n = 16)	Working memory (2 measures):			
Contrast 4							1. Span Board Task (WAIS-R-NI)	No	Yes (−1.01)	No
							2. Word Span Task	No	Yes (−.52)	No
							Inhibitory control (2 measures):			
							1. Day-Night Stroop Task	No	Yes (.06)	No
							2. Go/No-Go Task	No	Yes (commission error) (−.27)	No
Wong	2014	China, Asia	6–12	Atypical: "Low working memory"	Computer training: "Computerized working memory training" (n = 26)	Passive control (n = 25)	Working memory (1 measure):			
							1. Span Board task	No	Yes (.56)	Yes (.23)
							Inhibitory control (1 measure):			
							1. Stroop task	Yes	Yes (−.30)	Yes (−.58)

the number of intervention sessions so instead, we coded the number of months children were enrolled in the program.

Interrater reliability ranged from 85% to 100% with the lowest values for the categorization of the intervention program and the outcome measures applied, which reflect excellent reliability.

Meta-Analytic Procedures

The standardized mean difference between the intervention and the control conditions on the posttest was the dependent variable in the present meta-analysis. We chose the effect size of Hedges' *g* over Cohen's *d* because it corrects for small sample sizes (Borenstein, Hedges, Higgins, & Rothstein, 2009). A positive effect size reflected the advantage of the intervention condition, while a negative effect suggested that the control condition outperformed the intervention group. For calculating the effect sizes, the raw means and standard deviations on the posttests were preferred but if they were not available we used the growth scores in the two conditions (the change from pre- to posttest), or other statistics as long as they reflected the difference between the intervention and the control condition on the posttest (e.g., adjusted means and standard deviations, *t*- or *F*-statistics, or Cohen's *d*). If standard error statistics were provided in the paper we calculated the standard deviations based on a formula ($SD = SE^{*}\sqrt{n}$). Because effect sizes based on growth or change scores might be different from effect sizes calculated from posttest scores in case of nonrandomized designs, we also checked if results changed when such growth score-based effect sizes were excluded from the analyses.

The primary outcome in the present meta-analysis was accuracy on the executive function tests. This included the number of correct trials, error rates, and latency (e.g., the time children waited in a delay of gratification paradigm or the time participants took to finish a test). Additionally, we coded effect sizes based on reaction time (RT) differences and conducted a separate meta-analysis regarding those data (for a similar procedure see Lim & Dinges, 2010) in order to assess whether RT results confirm the results of accuracy data. Finally, we coded effect sizes for the follow-up results if primary papers reported such in order to synthesize those results in another meta-analysis testing whether benefits of interventions are sustained over time.

When more than one appropriate outcome measure was reported in a study, we calculated effect sizes for all of those. We used the software Comprehensive Meta-Analysis (CMA), Version 3.0 (Borenstein, Hedges, Higgins, & Rothstein, 2005) to calculate the effect size for each contrast. The software takes the average of the effect sizes found on the different outcome measures per study before calculating the average effect size over the different studies. The results were scanned for outliers with a standardized residual exceeding ±3.29 (Tabachnik & Fidell, 2007).

We conducted three meta-analyses: one on the posttest accuracy results, one on the posttest RT data, and one on follow-up accuracy results. Because there was a wide range of different samples, interventions and outcome measures, we used the random-effects model to calculate the average effect sizes. The random-effects model allows for between-study variance beyond sampling error (Borenstein et al., 2009). Under this model the average effect size is calculated after weighting the contrasts by the inverse of the sampling error, thus studies with larger samples weigh more into the average. Further, the *Q*-statistics was utilized to calculate the heterogeneity of the average effect sizes. A significant *Q*-value indicates a heterogeneous effect.

In order to assess the effects of differences between the primary studies that might have an influence on the results we tested the effects of a priori defined variables: the year of publication and the continent the study was conducted in, the mean age of the sample, the length of the intervention, whether the study applied a randomized or a quasiexperimental design, and whether the study utilized an active or a passive control condition. Subgroup analyses were conducted to compare the contrasts based on categorical moderator variables (e.g., active or passive control condition), while metaregression was conducted in case of continuous variables (e.g., publication year) in all the meta-analyses. Categorical moderator variables had to have at least four contrasts in each category to suffice for testing statistical significance (Bakermans-Kranenburg et al., 2003).

Publication bias was inspected in all sets of studies because studies with significant results are more likely to be published thus significant findings can be overrepresented in a meta-analysis and this tendency may lead to an overestimation of the average effect size (Rothstein, Sutton, & Borenstein, 2006). Rosenthal's fail-safe *n* was calculated in case of significant average effect sizes, which is an estimate regarding how many missing studies with a null finding would be needed for the average effect size to turn insignificant. In case of a robust effect, this fail-safe number should exceed $5k + 10$ where k is the number of contrasts included (Rosenthal, 1979). Additionally, a funnel plot with the effect sizes of the included studies plotted against the standard errors was inspected. An asymmetrical distribution of the studies on the funnel plot suggests the possibility of missing studies and thus, publication bias. In case of an asymmetrical funnel plot, we used Duval and Tweedie's trim and fill procedure to calculate the adjusted effect (Borenstein et al., 2009).

Finally, we tested the average effect sizes in the different intervention categories too (explicit training including computerized and noncomputer training, physical activity programs including aerobic exercise and cognitively engaging physical activity, EF-specific curricula, art activities including music and drama/pretend play, and interventions that provide children new strategies of self-regulation including mindfulness practices, biofeedback-enhanced relaxation, and strategy teaching programs).

Additionally, we inspected the average effects of the different interventions on each EF component (working memory, inhibitory control, and cognitive flexibility) separately. Finally, in each meta-analysis we inspected the results separately for typically and nontypically developing samples in order to the test the hypothesis that different interventions might be effective for the two groups.

Results

Overall Effects

Funnel plots and forest plots are shown in the online supplementary material. The data files can be found on the following link: https://osf.io/at36x/.

Accuracy (posttest). There were two outliers (Kloo & Perner, 2003; Pan et al., 2016) that were excluded from the analyses. After excluding those, 100 effect sizes in 90 studies including data of 8,925 children were included in the meta-analysis on posttest accuracy measures of EF skills. As shown in Tables 1–9 the

Table 2
Effects Overall and Separately for the Different Types of Interventions on Accuracy Indicators on Posttest

Intervention type	Sample	Number of contrasts (*k*)	Average effect size (g^+)	Standard error	95% confidence interval	Significance (*p*)	Difference between nontypically and typically developing (*Q*)
Overall							
	Overall	100	.30	.02	[.23, .37]	<.001	
	Nontypical	41	.39	.07	[.25, .53]	<.001	*Q* (1) = 2.37, *p* = .12
	Typical	59	.26	.04	[.17, .34]	<.001	
Explicit practice							
	Overall	47	.38	.06	[.26, .49]	<.001	
	Nontypical	20	.24	.07	[.10, .38]	.001	*Q* (1) = 4.45, *p* = .04
	Typical	27	.46	.08	[.31, .61]	<.001	
Computer training							
	Overall	28	.42	.08	[.25, .58]	<.001	
	Nontypical	15	.25	.07	[.11, .39]	<.001	*Q* (1) = 5.14, *p* = .02
	Typical	13	.60	.14	[.33, .87]	<.001	
Noncomputer training							
	Overall	19	.30	.06	[.17, .42]	<.001	
	Nontypical	5	.22	.35	[−.47, .91]	.53	*Q* (1) = .07, *p* = .79
	Typical	14	.31	.07	[.18, .45]	<.001	
Physical activity							
	Overall	22	.16	.07	[.01, .30]	.03	
	Nontypical	10	.40	.19	[.02, .78]	.04	*Q* (1) = 3.40, *p* = .07
	Typical	12	.03	.05	[−.07, .13]	.59	
Aerobic exercise							
	Overall	8	.05	.14	[−.22, .32]	.72	
	Nontypical	3	.52	.24	[.05, .99]	.03	—
	Typical	5	−.15	.10	[−.35, .05]	.14	
Cognitively engaging exercise							
	Overall	17	.17	.08	[.002, .33]	.048	
	Nontypical	8	.29	.23	[−.17, .75]	.22	*Q* (1) = .72, *p* = .40
	Typical	9	.08	.06	[−.04, .21]	.20	
EF-specific curricula							
	Overall	7	.12	.07	[−.02, .27]	.09	
	Nontypical	—	—	—	—	—	—
	Typical	7	.12	.07	[−.02, .27]	.09	
Art activities							
	Overall	4	.07	.12	[−.16, .30]	.56	
	Nontypical	1	−.21	.26	[−.71, .29]	.41	—
	Typical	3	.14	.13	[−.12, .40]	.28	
Music							
	Overall	2	−.04	.18	[−.38, .31]	.84	
	Nontypical	1	−.21	.26	[−.71, .29]	.41	—
	Typical	1	.12	.24	[−.36, .60]	.62	
Drama/pretend play							
	Overall	3	.10	.13	[−.16, .36]	.44	
	Nontypical	—	—	—	—	—	—
	Typical	3	.10	.13	[−.16, .36]	.44	
Providing new strategies of self-regulation							
	Overall	20	.46	.09	[.28, .64]	<.001	
	Nontypical	10	.84	.13	[.60, 1.08]	<.001	*Q* (1) = 15.03, *p* < .001
	Typical	10	.24	.09	[.05, .42]	.01	
Mindfulness practices							
	Overall	6	.46	.11	[.26, .67]	<.001	—
	Nontypical	—	—	—	—	—	
	Typical	6	.46	.11	[.26, .67]	<.001	
Biofeedback-enhanced relaxation							
	Overall	5	.93	.18	[.58, 1.28]	<.001	
	Nontypical	5	.93	.18	[.58, 1.28]	<.001	—
	Typical	—	—	—	—	—	
Strategy teaching interventions							
	Overall	10	.30	.12	[.06, .53]	.01	
	Nontypical	5	.76	.17	[.42, 1.10]	<.001	*Q* (1) = 11.42, *p* = .001
	Typical	5	.08	.10	[−.12, .27]	.45	

Table 3
Overview of the Studies That Assessed the Effects of Noncomputer Games Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Caviola	2009	Italy, Europe	9	Typically developing	**Noncomputer training:** “Metacognitive visuospatial working memory training” (n = 22)	Active control: “Involved in general cognitive activities” (n = 24)	**Working memory (2 measures):**			
							1. Backward digit recall	No	Yes (.16)	No
							2. Corsi block test	No	Yes (.59)	No
Dowsett Sample 1	2000	Australia	3	Atypical: “Low inhibition”	**Noncomputer training: “**Training EF promoting tasks” (n = 7)	Passive control (n = 5)	**Inhibitory control (1 measure):**			
							1. Go/No-Go discrimination apparatus	No	Yes (−.49)	No
Dowsett Sample 2	2000	Australia	4–5	Atypical: “Low inhibition”	**Noncomputer training: “**Training EF promoting tasks” (n = 8)	Passive control (n = 4)	**Inhibitory control (1 measure):**			
							1. Go/No-Go discrimination apparatus	No	Yes (−.06)	No
Howard Study 1, Contrast 1	2016	Australia	4	Typically developing	**Noncomputer training:** “Shared book reading–Quincey Quokka’s Quest”–one-on-one reading (n = 22)	Active Control: “Dialogic reading” (n = 18)	**Working memory (1 measure):**			
							1. Mr. Ant	No	Yes (.77)	No
							Inhibitory control (1 measure):			
							1. Go/No-Go	No	Yes (.22)	No
							Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (.67)	No
Howard Study 1, Contrast 2	2016	Australia	4	Typically developing	**Noncomputer training:** “Shared book reading–Quincey Quokka’s Quest” (n = 25)–group reading	Active Control: “Dialogic reading” (n = 18)	**Working memory (1 measure):**			
							1. Mr. Ant	No	Yes (.10)	No
							Inhibitory control (1 measure):			
							1. Go/No-Go	No	Yes (.28)	No
							Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (.00)	No
Howard Study 2	2016	Australia	4	Typically developing	**Noncomputer training:** “Shared book reading–Quincey Quokka’s Quest”–one-on-one reading (n = 19)	Active control: “Dialogic reading” (n = 21)	**Working memory (1 measure):**			
							1. Mr. Ant	No	Yes (.70)	No
							Inhibitory control (1 measure):			
							1. Go/No-Go	No	Yes (−.07)	No
							Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (.62)	No

(*table continues*)

Table 3 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Howard	2016	Australia	4	Typically developing	**Noncomputer training:** "Shared book reading–Quincey Quokka's Quest"–one-on-one reading (n = 19)	Active control: "Dialogic reading" (n = 15)	**Working memory (1 measure):**			
Study 3							1. Mr. Ant	No	Yes (.83)	Yes (.45)
							Inhibitory control (1 measure):			
							1. Go/No-Go	No	Yes (.05)	Yes (.06)
							Cognitive flexibility (1 measure):			
							1. Dimensional Change Card Sort	No	Yes (.55)	Yes (.30)
*Kloo	2003	Austria, Europe	2–4	Typically developing	**Noncomputer training:** "Card Sorting" (n = 14)	Active control: "Number-conservation training, Relative-clause training" (n = 15)	**Cognitive flexibility (1 measure):**			
							1. Dimensional Change Card Sort	No	Yes (90.21)	No
Kroesbergen	2014	The Netherlands, Europe	5	Typically developing	**Noncomputer training: "**Domain general working memory training" (n = 15)	Passive control (n = 21)	**Working memory (2 measures):**			
Contrast 1							1. Word recall backward	No	Yes (.79)	No
							2. Odd one out	No	Yes (.81)	No
Kroesbergen	2014	The Netherlands, Europe	5	Typically developing	**Noncomputer training: "**Domain specific working memory training" (n = 15)	Passive control (n = 21)	**Working memory (2 measures):**			
Contrast 2							1. Word recall backward	No	Yes (.26)	No
							2. Odd one out	No	Yes (.86)	No
Kyttala	2015	Finland, Europe	5.9	Typically developing	**Noncomputer training: "**Working memory and counting training" (n = 23)	Active control: "Counting training)" (n = 23)	**Working memory (3 measures):**			
Contrast 1							1. Backward word span	No	Yes (.61)	No
							2. Backward digit span	No	Yes (−.47)	No
							3. Odd one out	No	Yes (.25)	No
Kyttala	2015	Finland, Europe	5.9	Typically developing	**Noncomputer training: "**Working memory and counting training" (n = 23)	Passive control (n = 17)	**Working memory (3 measures):**			
Contrast 2							1. Backward word span	No	Yes (.38)	No
							2. Backward digit span	No	Yes (.00)	No
							3. Odd one out	No	Yes (.28)	No
Markomichali	2015	USA, North America	4–5	Typically developing	**Noncomputer training:** "Waiting Game" (n = 12)	Active control "Low intensity training" (n = 13)	**Inhibitory control (1 measure):**			
(Dissertation, Chapter V) Contrast 1							1. The Teddies Task	No	Yes (.19)	No
Markomichali	2015	USA, North America	4–5	Typically developing	**Noncomputer training:** "Waiting Game" (n = 12)	Passive control (n = 13)	**Inhibitory control (1 measure):**			
(Dissertation, Chapter V) Contrast 2							1. The Teddies Task	No	Yes (−.20)	No
Markomichali	2015	USA, North America	4–6	Atypical: "Low inhibition"	**Noncomputer training:** "Waiting Game" (n = 19)	Passive control (n = 18)	**Inhibitory control (2 measures):**			
(Dissertation, Chapter VI)							1. The Teddies Task	No	Yes (.23)	No
							2. Bee Delay Task	No	Yes (−.34)	No

(*table continues*)

Table 3 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Re	2007	Italy, Europe	5	Atypical: diagnosed with ADHD	**Noncomputer training:** "Working Memory Control Training Program" (n = 5)	Passive control (n = 5)	**Working memory (1 measure):**			
							1. Dual Request Selective Task	No	Yes (2.46)	No
							Inhibitory control (1 measure):			
							1. Walk/Don't Walk	No	Yes (1.99)	No
Re Sample 1	2015	Italy, Europe	5	Atypical: "ADHD symptoms"	**Noncomputer training:** "Working Memory Control Training Program" (n = 13)	Active control: "Prereading and prewriting exercises" (n = 13)	**Working memory (1 measure):**			
							1. Dual Request Selective Task	No	Yes (−.32)	No
							Inhibitory control (1 measure):			
							1. Walk/Don't Walk	No	Yes (.65)	No
Re Sample 2	2015	Italy, Europe	5	Typically developing	**Noncomputer training:** "Working Memory Control Training Program" (n = 13)	Active control: "Prereading and prewriting exercises" (n = 13)	**Working memory (1 measure):**			
							1. Dual Request Selective Task	No	Yes (.34)	No
							Inhibitory control (1 measure):			
							1. Walk/Don't Walk	No	Yes (.64)	No
Rõthlisberger Sample 1	2011	Swiss, Europe	5	Typically developing	**Noncomputer training:** "EF promoting small group program" (n = 33)	Passive control (n = 38)	**Working memory (1 measure):**			
							1. Complex Span Task		Yes (.21)	No
							Inhibitory control (1 measure):			
							1. Simple Flanker Task	Yes–conflict RT (.79)	Yes (.13)	No
							Cognitive flexibility (1 measure):			
							1. Mixed Flanker Task	Yes (.97)	Yes (.65)	No
Rõthlisberger Sample 2	2011	Swiss, Europe	6	Typically developing	**Noncomputer training:** "EF promoting small group program" (n = 30)	Passive control (n = 34)	**Working memory (1 measure):**			
							1. Complex Span Task	No	Yes (.16)	No
							Inhibitory control (1 measure):			
							1. Simple Flanker Task	Yes–conflict RT (.99)	Yes (.41)	No
							Cognitive flexibility (1 measure):			
							1. Mixed Flanker Task	Yes (2.22)	Yes (.13)	No

(*table continues*)

Table 3 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Schmitt	2013 dissertation	USA, North America	3–5	Typically developing	**Noncomputer training:** "Self-regulation intervention" (n = 126)	Passive control (n = 150)	**Inhibitory control (1 measure):**			
							1. Head-Toes-Knees-Shoulders Task	No	Yes (.26)	No
							Cognitive flexibility (1 measure):			
							1. DCCS	No	Yes (.26)	No
Tominey	2011	USA, North America	3–5	Typically developing	**Noncomputer training:** "Circle Time Games" (n = 28)	Passive control (n = 37)	**Inhibitory control (1 measure):**			
							1. Head-Toes-Knees-Shoulders Task	No	Yes (.28)	No
Traverso	2015	Italy, Europe	5	Typically developing	**Noncomputer training:** "EF promoting small group program–Chicco and Nana" (n = 32)	Passive control (n = 43)	**Working memory (2 measures):**			
							1. Backward Word Span	No	Yes (.43)	No
							2. Keep Track	No	Yes (.65)	No
							Inhibitory control (5 measures):			
							1. Circle drawing task	No	Yes–latency (.35)	No
							2. Arrow flanker task	Yes–all trials (.60)	Yes− incongruent (.28)	No
							3. Gift wrap	No	Yes− latency (−.64)	No
							4. Delay task	No	Yes − peeks (.69)	No
							5. Matching Familiar Figures	No	Yes–errors (.45)	No
							Cognitive flexibility (2 measures):			
							1. Go/No-Go (shifting phase)	No	Yes (.15)	No
							2. Dots task	Yes (.14)	Yes (.60)	No

(*table continues*)

Table 3 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Volckaert	2015	Belgium, Europe	4–5	Typically developing	**Noncomputer training:** "Inhibition training" (n = 24)	Active control: "Handicraft sessions" (n = 23)	**Working memory (1 measure):**			
							1. Mix of Categospan, Words Span, Block tapping test (Working memory factor)	No	Yes (.24)	No
							Inhibitory control (1 measure):			
							1. Mix of Traffic lights, Cat-Dog-Fish, Monster Stroop, Head-Toes-Knees-Shoulders (Inhibition factor)	No	Yes (.43)	No
							Cognitive flexibility (1 measure):			
							1. Mix of Traffic lights Head-Toes-Knees-Shoulders Monster Stroop (Flexibility factor)	No	Yes (.55)	No

Note. The study marked by * was excluded from the analyses because it had an outlying effect size.

Table 4
Overview of the Studies That Assessed the Effects of Physical Activity Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Afshari	2012	Iran, Asia	7–12.5	Atypical: diagnosed with ASD	**Cognitively engaging physical activity:** Perceptual-motor training (n = 20)	Passive control (n = 20)	**Inhibition (1 measure):**			
							1. CPT	No	Yes–confidence index (1.45)	No
Chang	2014	Taiwan, Asia	5–10	Atypical: diagnosed with ADHD	**Aerobic exercise:** Aquatic Exercise Program (n = 14)	Passive control (n = 13)	**Inhibition (1 measure):**			
							1. Go/No-Go test: No-Go trials	No	Yes (.63)	No
Crova	2014	Italy, Europe	9–10	Typically developing (overweight)	**Cognitively engaging physical activity:** Tennis-based PE program (n = 37)	Passive control (n = 33)	**Working memory (1 measure):**			
							1. Random number generation	No	Yes–redundancy score (.40)	No
Davis Contrast 1	2011	USA, North America	7–11	Typically developing (overweight)	**Cognitively engaging physical activity:** High-dose aerobic exercises (e.g. running games, jump rope, and modified basketball and soccer) (n = 56)	Passive control (n = 60)	**Inhibition (1 measure):**			
							1. Cognitive Assessment System (CAS) Attention	No	Yes (.14)	No
							Cognitive flexibility (1 measure):			
							1. CAS Planning	No	Yes (.42)	No
Davis Contrast 2	2011	USA, North America	7–11	Typically developing (overweight)	**Cognitively engaging physical activity:** Low-dose aerobic exercises (running games, jump rope, and modified basketball and soccer) (n = 55)	Passive control (n = 60)	**Inhibition (1 measure):**			
							1. CAS Attention	No	Yes (−.08)	No
							Cognitive flexibility (1 measure):			
							1. CAS Planning	No	Yes (.00)	No
DeGreeff	2016	Holland, Europe	8.1 (.7)	Typically developing	**Cognitively engaging physical activity:** "Physically active academic lessons" (n = 176)	Passive control (n = 167)	**Working memory (2 measures):**			
							1. Digit Span Backward	No	Yes (−.10)	No
							2. Visual Span Backward	No	Yes (−.12)	No
							Inhibition (1 measure):			
							1. Golden Stroop test	No	Yes (−.03)	No
							Cognitive flexibility (1 measure):			
							1. Wisconsin Card Sorting Test (modified version)	No	Yes (.12)	No
Fisher	2011	England, Europe	6.2 (.3)	Typically developing	**Aerobic exercise:** Aerobically active PE lesson (n = 33)	Active control: regular PE lesson (n = 27)	**Working memory (1 measure):**			
							1. Spatial working memory (CANTAB)	No	Yes (.24)	No
							Inhibition (2 measures):			
							1. Attention Network Test	Yes (−.62)	Yes (−.16)	No
							2. CAS Attention	No	Yes (−.33)	No
							Cognitive flexibility (1 measure):			
							1. CAS Planning	No	Yes (−.83)	No
Hillman	2014	USA, North America	7–9	Typically developing	**Aerobic exercise:** FitKids (n = 109)	Passive control (n = 112)	**Inhibition (1 measure):**			
							1. Flanker test–incongruent trials	No	Yes (−.08)	No
							Cognitive flexibility (1 measure):			
							1. Color-shape switch task–heterogeneous trials	No	Yes (.13)	No
Lakes	2004	USA, North America	from kindergarten through Grade 5	Typically developing	**Cognitively engaging physical activity:** Tae Kwan Do training (n = 97)	Active control: regular PE lesson (n = 96)	**Working memory (1 measure):**			
							1. Digit Span (WISC)	No	Yes (.26)	No

(*table continues*)

Table 4 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Pan	2015	Taiwan, Asia	7–12	Atypical: diagnosed with ADHD	**Cognitively engaging physical activity:** Table tennis exercises (n = 15)	Passive control (n = 15)	**Inhibition (1 measure):**			
							1. Color-Word Stroop test	No	Yes (1.84)	No
							Cognitive flexibility (1 measure):			
							1. WCST	No	Yes (perseverative error) (.31)	No
Pan	2016a	Taiwan, Asia	9.08 (1.75)	Atypical: diagnosed with ADHD	**Cognitively engaging physical activity:** Table tennis exercises (n = 11)	Passive control (n = 11)	**Cognitive flexibility (1 measure):**			
							1. WCST	No	Yes (perseverative error) (−.38)	No
*Pan	2016b	Taiwan, Asia	6–12	Atypical: diagnosed with ASD	**Cognitively engaging physical activity:** Table tennis exercises (n = 16)	Passive control (n = 16)	**Inhibition (1 measure):**			
							1. Color-Word Stroop test	No	Yes (2.88)	No
Pesce	2013 Contrast 1	Italy, Europe	5–10	Typically developing	**Aerobic exercise:** Specialist-led PE lesson (n = 44)	Active control: regular PE lesson (n = 65)	**Inhibition (1 measure):**			
							1. CAS Expressive Attention	No	Yes (−.31)	No
							Cognitive flexibility (1 measure):			
							1. CAS Receptive Attention	No	Yes (−.38)	No
Pesce	2013 Contrast 2	Italy, Europe	5–10	Typically developing	**Cognitively engaging physical activity:** Specialist-led cognitively enriched PE lesson (n = 62)	Active control: regular PE lesson (n = 65)	**Inhibition (1 measure):**			
							1. CAS Expressive Attention	No	Yes (.27)	No
							Cognitive flexibility (1 measure):			
							1. CAS Receptive Attention	No	Yes (.24)	No
Pesce	2013 Contrast 3	Italy, Europe	5–10	Atypical: diagnosed with Developmental Coordination Disorder	**Aerobic exercise:** Specialist-led PE lesson (n = 27)	Active control: regular PE lesson (n = 28)	**Inhibition (1 measure):**			
							1. CAS Expressive Attention	No	Yes (.21)	No
							Cognitive flexibility (1 measure):			
							1. CAS Receptive Attention	No	Yes (.08)	No
Pesce	2013 Contrast 4	Italy, Europe	5–10	Atypical: diagnosed with Developmental Coordination Disorder	**Cognitively engaging physical activity:** Specialist-led cognitively enriched PE lesson (n = 21)	Active control: regular PE lesson (n = 28)	**Inhibition (1 measure):**			
							1. CAS Expressive Attention	No	Yes (−.10)	No
							Cognitive flexibility (1 measure):			
							1. CAS Receptive Attention	No	Yes (−.23)	No
Pesce	2016	Italy, Europe	5–10	Typically developing	**Cognitively engaging physical activity:** Specialist-led PE lesson (n = 232)	Active control: regular PE lesson (n = 228)	**Working memory (1 measure):**			
							1. Random Number Generation Task–memory updating index	No	Yes (.25)	No
							Inhibition (1 measure):			
							1. CAS Expressive Attention	No	Yes (−.31)	No
							Cognitive flexibility (1 measure):			
							1. CAS Receptive Attention	No	Yes (−.18)	No
Pindus	2015	England, Europe	8–9	Typically developing	**Aerobic exercise:** FitKids2 (n = 16)	Passive control (n = 16)	**Working memory (1 measure):**			
(study 3)							1. Operation Span Task	No	Yes (.35)	No
							Inhibition (1 measure):			
							1. Flanker task–incongruent	Yes (.27)	Yes (.14)	No
Razza	2013	USA, North America	3.8–4.75	Typically developing	**Cognitively engaging physical activity:** Mindful yoga program (n = 16)	Passive control (n = 13)	**Inhibition (4 measures):**			
							1. Head Shoulders Knees and Toes Test	No	Yes (.98)	No
							2. Pencil Tapping Task	No	Yes (.93)	No
							3. Toy Wait	No	Yes–latency to touch (.71)	No
							4. Toy Wrap	No	Yes (latency to peek) (−.31)	No

(*table continues*)

Table 4 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Schmidt Contrast 1	2015	Switzerland, Europe	10–12	Typically developing	**Aerobic exercise:** Aerobic exercise (n = 57)	Active control: regular PE lesson (n = 55)	**Working memory (1 measure):**			
							1. Spatial N-back test	No	Yes (−.09)	No
							Inhibition (1 measure):			
							1. Flanker test–standard incongruent block	Yes (.26)	Yes (−.35)	No
							Cognitive flexibility (1 measure):			
							1. Flanker test–mixed block (switch)	Yes (.28)	Yes (−.53)	No
Schmidt Contrast 2	2015	Switzerland, Europe	10–12	Typically developing	**Cognitively engaging physical activity:** Team games (n = 69)	Active control: regular PE lesson (n = 55)	**Working memory (1 measure):**			
							1. Spatial N-back test	No	Yes (.11)	No
							Inhibition (1 measure):			
							1. Flanker test–standard incongruent block	Yes (.17)	Yes (−.14)	No
							Cognitive flexibility (1 measure):			
							1. Flanker test–mixed block (switch)	Yes (.26)	Yes (−.34)	No
Tsai	2009	Taiwan, Asia	9–10	Atypical: diagnosed with Developmental Coordination Disorder	**Cognitively engaging physical activity:** Table tennis exercises (n = 14)	Passive control (n = 14)	**Inhibition (1 measure):**			
							1. Visuospatial attention paradigm	Yes–on incongruent trials (1.38)	Yes–overall error rate (.77)	No
Tsai	2012	Taiwan, Asia	9–10	Atypical: diagnosed with Developmental Coordination Disorder	**Cognitively engaging physical activity:** Soccer training (n = 16)	Passive control (n = 14)	**Inhibition (1 measure):**			
							1. Visuospatial attention paradigm	Yes–on incongruent trials (.32)	Yes–overall error rate (−.24)	No
Tsai	2013	Taiwan, Asia	11–12	Atypical: diagnosed with Developmental Coordination Disorder	**Aerobic exercise:** Endurance Training Program (Running, cycling, step aerobics, or rope jumping) (n = 20)	Passive control (n = 20)	**Working memory (2 measures):**			
							1. Visuospatial Working Memory Paradigm–3-s delayed	Yes (.29)	Yes (.89)	No
							2. Visuospatial Working Memory Paradigm–6-s delayed	Yes (.38)	Yes (.91)	No
Van der Niet	2015	Holland, Europe	8–12	Typically developing	**Cognitively engaging physical activity:** Aerobic exercise and cognitively engaging activities (n = 47)	Passive control (n = 52)	**Working memory (2 measures):**			
							1. Visual memory span test	No	Yes (.14)	No
							2. Digit span test	No	Yes (.38)	No
							Inhibition (1 measure):			
							1. Stroop test	No	Yes–ratio (.36)	No
							Cognitive flexibility (2 measures):			
							1. Trail Making Test	No	Yes (.15)	No
							2. Tower of London	No	Yes (−.21)	No
Verret	2010	Canada, North America	7–12	Atypical: diagnosed with ADHD	**Cognitively engaging physical activity:** Aerobic exercise and cognitively engaging activities (e.g. ball games) (n = 10)	Passive control (n = 11)	**Inhibition (1 measure):**			
							1. Walk/Don't Walk (Test of Everyday Attention for Children)	No	Yes (−.10)	No
Westendrop	2014	Holland, Europe	7–11	Atypical: diagnosed with Learning Disorder	**Cognitively engaging physical activity:** Ball skill intervention (n = 43)	Active control: regular PE lesson (n = 44)	**Cognitive flexibility (2 measures):**			
							1. Trail Making Test	No	Yes (time on Part A subtracted from time on Part B) (−.10)	Yes (.04)
							2. Tower of London	No	Yes (.06)	Yes (.00)

Note. The study marked by * was excluded from the analyses because it had an outlying effect size.

Table 5
Overview of the Studies That Assessed the Effects of Mindfulness Trainings Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Abdi	2016	Iran, Asia	8–10	Typically developing	**Mindfulness:** "mindful awareness practices" (n = 16)	Passive control (n = 16)	**Working memory (2 measures):**			
							1. Digit Span Backward	No	Yes (1.01)	No
							2. Letter-Number Sequencing	No	Yes (1.11)	No
							Inhibition (1 measure):			
							1. CPT–Commission error	No	Yes (.21)	No
							Flexibility (1 measure):			
							1. Wisconsin Card Sorting Test–Perseverative error	No	Yes (−.52)	No
Flook	2015	USA, North America	M = 4.67 SD = .27	Typically developing	**Mindfulness:** "Kindness Curriculum" (n = 27)	Passive control (n = 35)	**Inhibition (2 measures):**			
							1. Flanker test	No	Yes (−.29)	No
							2. Delay of gratification (all trials)	No	Yes (.32)	No
							Flexibility (1 measure):			
							1. DCCS (postswitch block)	No	Yes (.35)	No
Parker	2014	USA, North America	9–11	Typically developing	**Mindfulness:** "Master Mind" (n = 71)	Passive control (n = 40)	**Flexibility (1 measure):**			
							1. Flanker Fisk task	No	Yes (.54)	No
Poehlmann-Tynan	2015	USA, North America	3–5	Typically developing	**Mindfulness:** "Kindness Curriculum" (n = 12)	Active control: Dialogic reading (n = 12)	**Inhibition (2 measures)**			
							1. Go/No-Go Task–correct rejection	No	Yes (.99)	Yes (1.61)
							2. Head-Toes-Shoulders-Knees Task	No	Yes (.19)	Yes (.92)
Viglas	2015	Canada, North America	4–6	Typically developing	**Mindfulness:** "mindfulness based program" (n = 72)	Passive control (n = 55)	**Inhibition (1 measure)**			
							1. Head-Toes-Shoulders-Knees Task	No	Yes (.58)	No
Wimmer	2016	Germany, Europe	M = 10.80 SD = .53	Typically developing	**Mindfulness:** "mindfulness based stress reduction approach" (n = 16)	Passive control (n = 10)	**Inhibition (1 measure)**			
							1. Stroop Color-Word Interference Test	No	Yes (.38)	No
							Flexibility (2 measures)			
							1. Reversible figures	No	Yes (.17)	No
							2. Wisconsin Card Sorting Test–Perseverative error	No	Yes (.09)	No

Table 6
Overview of the Studies That Assesse the Effects of Curricula Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' g)	Accuracy (Hedges' g)	Follow-up assessment (Hedges' g)
Blair	2014	USA, North America	5.5	Typically developing	**Complex curricula:** "Tools of the Mind" (n = 416)	Passive control (n = 284)	**Working memory (1 measure):**			
							1. Backward Digit Span	No	Yes (.15)	No
							Inhibition (1 measure):			
							1. Hearts and Flowers	Yes (.13)	Yes (.06)	No
							Cognitive flexibility (2 measures):			
							1. DCCS	No	Yes (.00)	No
							2. Reverse Flanker	Yes (.08)	Yes (.06)	No
Clements (conference paper)	2012	USA, North America	4	Typically developing	**Complex curricula:** "Building Blocks–Scaffolding Self-Regulation" (n = 298)	Passive control (n = 275)	**Working memory (1 measure):**			
							1. Backward Digit Span	No	Yes (.00)	Yes (.05)
							Inhibition (2 measures):			
							1. Head-Toes-Shoulders-Knees task	No	Yes (.05)	Yes (.01)
							2. Peg Tapping task	No	Yes (.02)	Yes (.06)
Diamond	2007	USA, North America	5.1	Typically developing	**Complex curricula:** "Tools of the Mind" (n = 85)	Active control: "Balanced Literacy curriculum" (n = 63)	**Inhibition (2 measures):**			
							1. Dots task–incongruent	No	Yes (.43)	No
							2. Standard Flanker test	No	Yes (.47)	No
							Cognitive flexibility (1 measure):			
							1. Reverse Flanker	No	Yes (.64)	No
Dias	2015a	Brazil, South America	M = 5.5 SD = .21	Typically developing	**Complex curricula:** Intervention Program for Self-regulation and Executive Functions ("PIAFEx") (n = 32)	Passive control (n = 37)	**Inhibition (5 measures):**			
							1. Semantic Stroop Test–Part 2	Yes (−.42)	Yes (.55)	No
							2. Go/No-Go	No	Yes–total score (−.34)	No
							3. Simon task Part 1–incongruent	No	Yes (.51)	No
							4. Simon task Part 2–incongruent	No	Yes (.17)	No
							5. Simon task Part 3–incongruent	No	Yes (−.06)	No
							Flexibility (1 measure):			
							1. Trail Making Test–Part B	No	Yes (.09)	No

(*table continues*)

Table 6 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Dias	2015b	Brazil, South America	*M* = 6.03 *SD* = .17	Typically developing	**Complex curricula:** Intervention Program for Self-regulation and Executive Functions ("PIAFEx") (n = 31)	Passive control (n = 37)	**Inhibition (5 measures):**			
							1. Semantic Stroop Test–Part 2	Yes (.13)	Yes (.43)	No
							2. Go/No-Go–nontarget items	No	Yes (.37)	No
							3. Simon task Part 1–interference	Yes (.17)	Yes (−.69)	No
							4. Simon task Part 2 – interference	Yes (.64)	Yes (.41)	No
							5. Simon task Part 3–interference	Yes(−.17)	Yes (−.17)	No
							Flexibility (1 measure):			
							1. Trail Making Test–Part B	No	Yes (.48)	No
Farran	2014	USA, North America	4	Typically developing	**Complex curricula:** "Tools of the Mind" (n = 465)	Passive control (n = 348)	**Working memory (1 measure):**			
							1. Corsi block task–Backward span	No	Yes (.00)	Yes (−.15)
							Inhibition (2 measures):			
							1. Peg tapping test	No	Yes (.02)	Yes (.02)
							2. Head-Toes-Knees-Shoulders test	No	Yes (−.02)	Yes (−.03)
							Cognitive flexibility (1 measure):			
							1. DCCS	No	Yes (−.17)	Yes (−.17)
Lillard	2006	USA, North America	5.3–6.4	Typically developing	**Complex curricula:** "Montessori" (n = 30)	Passive control (n = 25)	**Cognitive flexibility (1 measure):**			
							1. DCCS	No	Yes (.56)	No

Table 7
Overview of the Studies That Assessed the Effect of Art Trainings Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up (Hedges' *g*)
Chacona (Dissertation)	2007	USA, North America	9	Atypical: diagnosed with ADHD	**Art activities:** "World Music Drumming" (n = 30)	Passive control (n = 30)	**Inhibition (2 measures):**			
							1. TOVA Auditory	Yes (.48)	Yes (commission error) (−.12)	No
							2. TOVA Visual	Yes (.27)	Yes (commission error) (−.31)	No
Schellenberg Contrast 1	2004	Canada, North America	6	Typically developing	**Art activities:** "Drama" (n = 34)	Passive control (n = 36)	**Working memory (1 measure):**			
							1. Digit Span	No	Yes (−.07)	No
Schellenberg Contrast 2	2004	Canada, North America	6	Typically developing	**Art activities:** "Keyboard" (n = 30)	Passive control (n = 36)	**Working memory (1 measure):**			
							1. Digit Span	No	Yes (.39)	No
Schellenberg Contrast 3	2004	Canada, North America	6	Typically developing	**Art activities:** "Voice" (n = 32)	Passive control (n = 36)	**Working memory (1 measure):**			
							1. Digit Span	No	Yes (−.15)	No
Smith (Dissertation)	2010	USA, North America	M = 6.6 years, SD = 3.79 months	Typically developing	**Art activities:** "Georgia Wolf Trap Program - drama" (n = 41)	Passive control (n = 42)	**Inhibition (1 measure):**			
							1. Inhibition task	No	Yes (errors) (.21)	No
Thibodeauo Contrast 1	2016	USA, North America	4	Typically developing	**Art activities:** "Fantastical pretend-play" (n = 39)	Active control: "Nonimaginative pretend-play" (n = 32)	**Inhibition (1 measure):**			
							1. Stroop test	No	Yes (−.04)	No
							Flexibility (1 measure):			
							1. DCCS test	No	Yes (.39)	No
Thibodeauo Contrast 2	2016	USA, North America	4	Typically developing	**Art activities:** "Fantastical pretend-play" (n = 39)	Passive control (n = 39)	**Inhibition (1 measure):**			
							1. Stroop test	No	Yes (−.10)	No
							Flexibility (1 measure):			
							1. DCCS test	No	Yes (.34)	No

Table 8
Overview of the Studies That Assessed the Effect of Biofeedback-Enhanced Relaxation Trainings Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time (Hedges' *g*)	Accuracy (Hedges' *g*)	Follow-up assessment (Hedges' *g*)
Beauregard	2006	Canada, North America	8–12	Atypical: diagnosed with ADHD	**Biofeedback-enhanced relaxation:** "EEG neuro-feedback training" (n = 15)	Passive control (n = 5)	**Working memory (1 measure):**			
							1. Digit Span	No	Yes (.74)	No
							Inhibition (2 measures):			
							1. Counting Stroop test	No	Yes (.64)	No
							2. Go/No-Go test–No-Go trials	No	Yes (1.39)	No
Omizo	1982a	USA, North America	8–11	Atypical: diagnosed learning disabled	**Biofeedback-enhanced relaxation:** "EMG biofeedback-induced relaxation training" (n = 16)	Active control: "Listen to a neutral story with inoperative biofeedback" (n = 16)	**Inhibition (1 measure):**			
							1. Matching Familiar Figures	No	Yes (number of errors) (.95)	No
Omizo	1982b	Texas, North America	10–12	Atypical: reported to be hyperactive	**Biofeedback-enhanced relaxation:** "EMG biofeedback-induced relaxation training" (n = 16)	Active control: "Relaxation with inoperative biofeedback" (n = 16)	**Inhibition (1 measure):**			
							1. Matching Familiar Figures	No	Yes (number of errors) (.89)	No
Parziale	1982	Arizona, North America	8–11	Atypical: reported to be hyperactive	**Biofeedback-enhanced relaxation:** "EEG biofeedback training" (relaxation) (n = 8)	Active control: "Listening to a tape on the value of courage" (n = 8)	**Working memory (1 measure):**			
							1. Digit Span	No	Yes (.77)	No
Rivera	1980	California, North America	7–11	Atypical: reported to be hyperactive	**Biofeedback-enhanced relaxation:** "EMG relaxation training and biofeedback" (n = 18)	Active control: "Relaxation with inoperative biofeedback" (n = 18)	**Inhibition (1 measure):**			
							1. Matching Familiar Figures	No	Yes (number of errors) (1.03)	No

Table 9
Overview of the Studies That Assessed the Effect of Strategy Learning Trainings Included in the Meta-Analysis

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Bierman	2008	USA, North America	3.72–6.56	Typically developing	**Strategy learning:** "Head Start REDI + PATHS" (*n* = 178)	Passive control (*n* = 158)	**Working memory (1 measure):**			
							1. Backward word span	No	Yes (−.10)	No
							Inhibition (2 measures):			
							1. Walk-A-line slowly	No	Yes (−.10)	No
							2. Peg tapping	No	Yes (.04)	No
							Cognitive flexibility (1 measure):			
							1. DCCCS	No	Yes (.19)	No
Deano	2015	Spain, Europe	9–12	Atypical: low intelligence	**Strategy learning:** PASS Remedial Program (*n* = 10)	Passive control (*n* = 10)	**Inhibition (1 measure):**			
							1. Cognitive Assessment System - Attention	No	Yes (.91)	No
							Flexibility (1 measure):			
							1. Cognitive Assessment System - Planning	No	Yes (.97)	No
Domitrovich	2007	USA, North America	4.28	Typically developing	**Strategy learning:** "Head Start PATHS" (*n* = 101)	Passive control (*n* = 100)	**Inhibition (2 measures):**			
							1. Day/Night Stroop test	No	Yes (.04)	No
							2. Peg tapping task	No	Yes (−.29)	No
García-Madruga	2013	Spain, Europe	8–9	Typically developing	**Strategy learning:** "Working memory's executive processes embedded in reading tasks" (*n* = 15)	Passive control (*n* = 16)	**Working memory (1 measure):**			
							1. Reading span task	No	Yes (−.03)	No
Hannesdottir	2014	Island, Europe	8–10	Atypical: diagnosed with ADHD	**Strategy learning: "**OutSMARTers Program" (*n* = 16)	Passive control (*n* = 14)	**Working memory (1 measure):**			
							1. Letter number sequencing	No	Yes(.15)	No
							Inhibition (1 measure):			
							1. Stop signal task - correct	No	Yes (1.39)	No
Kenworthy	2014	USA, North America	Third–fifth graders	Atypical: diagnosed with ASD	**Strategy learning:** "Unstuck and On Target" (*n* = 43)	Active control: "Social-communication skills lessons" (*n* = 19)	**Flexibility (1 measure):**			
							1. Challenge Test	No	Yes (.74)	No

(*table continues*)

Table 9 (*continued*)

First author	Publication year	Place	Age (year)	Clinical status of the sample	Intervention condition	Control condition	Outcome measure	Reaction time	Accuracy	Follow-up assessment
Meichenbaum contrast 1	1971	USA, North America	7–9	Atypical: reported to have hyperactivity, poor self-control, low IQ	**Strategy learning:** "Cognitive self-instructional training" (n = 5)	Active control: "Attention control group" (n = 5)	**Inhibition (1 measure):**			
							1. Matching Familiar Figures	No	Yes - latency (2.33)	No
							Flexibility (1 measure):			
							1. Porteus Maze	No	Yes (.48)	No
Nash	2014	Canada, North America	8–12	Atypical: diagnosed with Fetal Alcohol Spectrum Disorder	**Strategy learning:** "Alert Program for Self-Regulation" (n = 12)	Passive control (n = 13)	**Inhibition (2 measures):**			
							1. NEPSY II–Inhibition subtest - Naming	No	Yes (1.03)	No
							2. NEPSY II–Inhibition subtest - Inhibition	No	Yes (.43)	No
							Flexibility (3 measures):			
							1. CANTAB–Intra/Extra dimensional Shift Task	No	Yes (.28)	No
							2. CANTAB–Stockings of Cambridge	No	Yes (.05)	
							3. NEPSY II–Inhibition subtest - Switching	No	Yes (.32)	No
Riggs	2006	USA, North America	7–9	Typically developing	**Strategy learning:** "Head Start PATHS" (n = 153)	Passive control (n = 165)	**Inhibition (1 measure):**			
							1. Stroop test	No	Yes (.31)	No
Wimmer Contrast 2	2016	Germany, Europe	Mean of 10.8 (fifth-graders)	Typically developing	**Strategy learning:** "Concentration training" (n = 16)	Passive control (n = 5)	**Inhibition (1 measure):**			
							1. Stroop Color-Word Interference Test	No	Yes (−.06)	No
							Flexibility (2 measures):			
							1. Reversible Figures	No	Yes (.39)	No
							2. WCST	No	Yes (.42)	No

studies were published between 1971 and 2016 with only five studies that appeared up to 1982 and the rest were published after 2000. After excluding those five early studies, publication year had no significant effect on the effect size (coefficient: −0.007, p = .50). For 43 of the effect sizes data was collected in Europe, for 39 in North America, for 10 in Asia, for five in Australia, and for three in South America. After excluding the effect sizes from South America as this category did not have enough effect sizes, this variable was not a significant moderator, Q (3) = 2.11, p = .55. Children's age ranged from 2 to 12 years. The mean age of the sample did not have a significant effect on the effect size (coefficient: 0.02, p = .35).

As shown in Table 2, 47 of the effect sizes utilized an explicit EF training intervention (28 computerized and 19 noncomputerized), 22 reported on the effects of physical activity intervention (eight on aerobic exercise and 17 on cognitively engaging physical activity programs), seven used EF-specific full-time curricula, four studies tested art activities (two effect sizes testing music and three testing drama or pretend play), and 20 effect sizes reported on interventions that provide children new strategies of self-regulation (including six on mindfulness meditation, five on biofeedback-induced relaxation, and 10 studies directly teaching children strategies). Regarding the length of the intervention, the number of months children were enrolled in the seven studies testing an EF-specific curriculum had a significant effect with longer programs having a larger effect size (coefficient: 0.03, p = .02). The number of intervention sessions in the rest of the studies did not have an effect on the effect size (coefficient: −0.001, p = .28).

Sixty-two of the effect sizes reported on a randomized controlled trial, while 38 effect sizes used a quasiexperimental design. There was no difference between the two on the average effect size, Q (1) = 2.56, p = .11. Finally, 55 of the effect sizes were based on comparison with a passive control condition, 39 to an active control condition, and six were based on comparisons with both. There were no differences between these three groups of studies, Q (2) = 1.25, p = .54.

When assessing publication bias we found an asymmetrical funnel plot. The Duval and Tweedie trim and fill procedure estimated 33 hypothetical studies missing. However, the adjusted effect size was still significant (estimate: 0.10, 95% CI [0.02, 0.18]). Furthermore, the fail-safe n was 3,439 which suggests a robust effect.

As shown in Table 2, there was a small but significant overall effect of behavioral interventions on children's posttest accuracy results on executive function tests ($g^+ = 0.30$). This was a heterogeneous effect, Q (99) = 237.79, $p < .001$. For seven effect sizes only change scores from pre- to posttest were available instead of raw posttest scores. Excluding those did not change the results substantially ($g^+ = 0.29$, $k = 93$, $SE = 0.04$, 95% CI [0.21, 0.36], $p < .001$). More specifically, there were small but significant effects on measures of working memory ($g^+ = 0.35$, $k = 53$, SE = 0.05, 95% CI [0.24, 0.45], $p < .001$), inhibition ($g^+ = 0.22$, k = 73, SE = 0.04, 95% CI [0.13, 0.30], $p < .001$) and flexibility ($g^+ = 0.18$, $k = 48$, $SE = 0.05$, 95% CI [0.09, 0.28], $p < .001$).

As shown in Table 2, the intervention was tested on an atypically developing sample for 41 effect sizes and on a typically developing sample for 59 effect sizes. In both cases small but significant effects of behavioral interventions was found and there was no difference between the two.

Reaction time (posttest). Reaction time data on an executive function test was reported for 20 effect sizes in 19 studies including data of 1,614 children. The studies were published between 2005 and 2015. The year of publication had a marginally significant negative effect on the effect size (coefficient: −0.06, p = .06) showing a tendency for earlier studies showing larger effects. For 12 effects data was collected in Europe, for 3-3 effects in Asia and South America, and for two effect sizes in North America. Due to the low number of studies in the categories, the effect of continent could not be tested. The age of the samples ranged between 5 and 12. The mean age of the sample did not have an effect on the effect size (coefficient: 0.01, p = .82).

Ten of these effect sizes applied explicit practice on EF tasks as intervention including seven computer and three noncomputer trainings. Six studies used a physical activity intervention including three studies with an aerobic exercise program, two studies with a cognitively challenging exercise intervention, and one study using both kinds. In one study, an art program was utilized and in three studies an EF-specific curriculum was used. In the three studies assessing curricula the length of intervention ranged from 4 to 6 months. The number of intervention sessions in the other studies ranged from 4 to 157 sessions. The number of intervention sessions, however, did not have an effect on the effect size (coefficient: 0.0005, p = .88). Thirteen effect sizes were based on a randomized controlled trial, while seven used a quasiexperimental design. There was no effect of design on the effect size, Q (1) = 0.40, p = .53. In 11 of the effect sizes the intervention was compared with a passive control group, while it was compared with an active control condition in nine effect sizes. The average effect was marginally significantly larger when the intervention was compared to a passive ($g^+ = 0.46$, $k = 11$, $SE = 0.16$, 95% CI [0.15, 0.76], p = .004) than to an active control condition ($g^+ = 0.12$, $k = 9$, $SE = 0.12$, 95% CI [−0.12, 0.36], p = .32), Q (1) = 2.85, p = .09. All the effect sizes were based on raw posttest scores.

There were no outlying values. A small but significant overall effect of intervention on RT measures on executive function tests was found ($g^+ = 0.30$, $k = 20$, $SE = 0.10$, 95% CI [0.10, 0.51], p = .003). The effect was heterogeneous, Q (19) = 60.37, $p <$ .001. We found a symmetrical funnel plot and no signs of publication bias, and the fail-safe number was 109, which implies a robust effect.

More specifically, only two studies reported on RTs on tests of working memory. There was no significant effect of training in these two studies ($g^+ = 0.35$, $k = 2$, $SE = 0.22$, 95% CI [−0.09, 0.79], p = .12). In contrast, the 19 contrasts that reported on RTs on measures of inhibitory control showed a small but significant effect ($g^+ = 0.29$, $k = 19$, $SE = 0.09$, 95% CI [0.11, 0.48], p = .002) and the nine contrasts including RT information on tests of cognitive flexibility also showed a marginally significant effect ($g^+ = 0.39$, $k = 9$, $SE = 0.20$, 95% CI [−0.003, 0.79], p = .052).

When we tested the effect of intervention on RT data separately for typically and nontypically developing samples of children we found small but significant effects both in typical ($g^+ = 0.29$, k = 12, $SE = 0.14$, 95% CI [0.007, 0.57], p = .045) and in nontypical samples ($g^+ = 0.33$, $k = 8$, $SE = 0.14$, 95% CI [0.07, 0.60], p =

.01). The difference between the two was not significant, Q (1) = 0.05, p = .82.

Follow-up assessment (accuracy). Fifteen studies reported on follow-up assessment, which ranged from 6 weeks to 12 months from the end of the intervention (M = 21.6 weeks). This included data of 2,134 children. There were no outliers. The studies were published between 2005 and 2016. The year of publication did not have an effect on the effect size (coefficient: −0.03, p = .43). Data for nine effect sizes were collected in Europe, for four effect sizes in North America, and for one-one effect size in Asia and Australia. Excluding the two studies from Asia and Australia, continent had no effect on the effect size, Q (1) = 0.22, p = .64. The age of the samples ranged from 4 to 11 years. The mean age of the sample did not have an effect on the effect size (coefficient: 0.01, p = .72).

Eleven studies used explicit practice interventions including 10 computer training and one noncomputer intervention, one study applied a cognitively engaging physical activity program, one study used a mindfulness intervention and two studies reported on EF-specific curricula. In the two studies with an EF curricula the intervention took 9 and 10 months. In the rest of the studies, the interventions ranged between four and 32 sessions. The number of intervention sessions did not have a significant effect on the effect size (coefficient: −0.001, p = .95). Ten studies were randomized controlled trials and 5 studies used a quasi-experimental design. There was no difference between the average effect sizes of the two, Q (1) = 2.70, p = .10. Nine studies compared the intervention to an active control condition, five studies used a passive control group and one study applied both. Excluding the study that used both an active and a passive control condition, this variable did not have an effect on the effect size, Q (1) = 1.32, p = .25.

A small but significant effect appeared on follow-up assessment (g^+ = 0.18, k = 15, SE = 0.08, 95% CI [0.02, 0.35], p = .03). This effect was heterogeneous, Q (14) = 32.06, p = .004. We tested in a metaregression if the time between the end of the intervention and the follow-up measurement (in weeks) had a significant effect. It did not (coefficient: −0.004, p = .48).

The funnel plot showed asymmetrical distribution and the Duval and Tweedie's trim and fill analysis estimated five hypothetical studies missing. The adjusted effect was not significant (adjusted g^+ = 0.008, 95% CI [−0.18, 0.19]). Finally, the fail-safe number was 24, which does not imply a robust effect in case of 15 studies.

There was a small, significant effect on follow-up measures of working memory (g^+ = 0.34, k = 11, SE = 0.12, 95% CI [0.11, 0.56], p = .004) but no effect on inhibitory control (g^+ = 0.04, k = 11, SE = 0.08, 95% CI [−0.12, 0.21], p = .62). Finally, there was a marginally significant negative effect on cognitive flexibility (g^+ = −0.10, k = 8, SE = 0.06, 95% CI [−0.21, 0.02], p = .09). A plausible explanation is that two thirds of the studies assessed an explicit training intervention, the majority of which focused on training working memory.

When inspecting effects on follow-up separately for typically and atypically developing samples, we found no significant effects for either groups (typically developing children: g^+ = 0.17, k = 6, SE = 0.12, 95% CI [−0.06, 0.40], p = .15; atypically developing samples: g^+ = 0.19, k = 9, SE = 0.13, 95% CI [−0.06, 0.44], p = .14). The difference between the two was not different, Q (1) = 0.01, p = .91.

The Effect of the Type of Intervention

Explicit practice. There were 47 independent effect sizes in 38 articles testing the effect of an intervention explicitly training children's EF skills. As shown in Table 1 and 2, studies were published between 2000 and 2016. Data for 29 effect sizes were collected in Europe, in North America for 10, in Australia for five, in Asia for two, and in South American for one effect size. The age of the sample ranged between 2 and 11 years.

Twenty-eight effect sizes tested a computerized training, while 19 assessed a noncomputerized explicit EF training program. The number of intervention sessions applied in the primary studies ranged from 2 to 42. Thirty-eight effect sizes were based on randomized controlled trials, and nine effect sizes used quasiexperimental designs. Twenty-four effect sizes were based on a comparison with an active control condition, 18 included a passive control condition, and five effect sizes were based on comparisons with both.

As shown in Table 2, there was a significant effect of explicit training on accuracy measures of posttest executive function tests (g^+ = 0.38). This was a heterogeneous effect, Q (46) = 80.32, p = .001. In three studies we could only find growth scores or effect sizes for the difference between the experimental and the control group for the change from pre- to posttest. After excluding these studies, the results remained very similar (g^+ = 0.36, k = 44, SE = 0.06, 95% CI [0.25, 0.47], p < .001).

More specifically, a moderate-sized significant effect was found on working memory tests (g^+ = 0.46, k = 34, SE = 0.07, 95% CI [0.32, 0.60], p < .001), and small but significant average effects on inhibitory control (g^+ = 0.21, k = 31, SE = 0.05, 95% CI [0.12, 0.31], p < .001) and cognitive flexibility (g^+ = 0.31, k = 20, SE = 0.07, 95% CI [0.17, 0.44], p < .001).

As shown in Table 2, for 20 effect sizes a nontypically developing sample was used and for 27 effect sizes a typical sample was applied. Interestingly, there was a significant difference between the efficacy of explicit training of EF skills for the two groups: It is more effective for typically (g^+ = 0.46) than for atypically developing children (g^+ = 0.24).

When synthesizing RT data in the studies utilizing explicit practice of EF tasks we found a significant moderate-sized effect in the 10 studies that reported on such data (g^+ = 0.45, k = 10, SE = 0.16, 95% CI [0.15, 0.76], p = .004). There was a marginally significantly larger effect for typically developing samples (g^+ = 0.66, k = 6, SE = 0.21, 95% CI [0.24, 1.08], p = .002) than for samples showing atypical development (g^+ = 0.15, k = 4, SE = 0.16, 95% CI [−0.16, 0.46], p = .33), Q (1) = 3.66, p = .06. These are in line with the results of accuracy, although, the difference between typical and nontypical samples seems to be even bigger on RT data.

Eleven studies reported on follow-up results and showed a small but significant average effect (g^+ = 0.24, k = 11, SE = 0.11, 95% CI [0.03, 0.46], p = .03). More specifically, there was a moderate-sized significant effect on follow-up measures of working memory (g^+ = 0.48, k = 9, SE = 0.12, 95% CI [0.24, 0.73], p < .001) but no effects on inhibitory control (g^+ = −0.01, k = 8, SE = 0.12, 95% CI [−0.25, 0.23], p = .94) or cognitive flexibility (g^+ = 0.04, k = 6, SE = 0.11, 95% CI [−0.18, 0.25], p = .73). We could not test the differences on follow-up measures between typically and atypically developing samples due to the low number of studies.

Computer training. We found 28 independent effect sizes testing the effects of a computer training targeting executive function skills in 25 papers. As shown in Table 1, the studies were published between 2001 and 2015. Of the 28 effect sizes data was collected in Europe for 19, in North America for six, one study was conducted in South America, and two in Asia. The age of the children in the samples ranged from 2 to 11.

Ten effect sizes tested the effects of the software CogMed, two used Braingame Brian, three utilized the program Memory Booster, one study used Jungle Memory, one tested the program Mate Marote, one used LocuTour Multimedia Cognitive Rehabilitation as the intervention, nine studies used researcher-constructed computer trainings of executive function skills, and one study used both CogMed and a researcher-constructed intervention. The number of intervention sessions in the studies ranged from two to 42. Twenty-two effect sizes were based on a randomized controlled design, while children were not randomly assigned to experimental and control conditions on an individual basis in six cases. Some information regarding intervention fidelity was reported in 20 out of the 28 effect sizes. Seventeen effect sizes were based on a comparison to an active control, while eight applied a passive control condition, and three effect sizes were based on comparison with both.

As shown in Table 2, overall a significant, moderate effect of computer trainings of executive functions ($g^+ = 0.42$) was found. This was a heterogeneous effect, Q (27) = 63.32, $p < .001$. Three studies only reported growth scores. After excluding these studies, results remained very similar ($g^+ = 0.39$, $k = 25$, $SE = 0.09$, 95% CI [0.22, 0.56], $p < .001$).

There was a working memory measure in 21 effect sizes, a measure of inhibitory control in 15 effect sizes and a cognitive flexibility test in 12 effect sizes. The effect was significant on measures of working memory ($g^+ = 0.48$, $k = 21$, $SE = 0.10$, 95% CI [0.29, 0.67], $p < .001$); inhibition ($g^+ = 0.18$, $k = 15$, $SE = 0.07$, 95% CI [0.04, 0.32], $p = .02$); and cognitive flexibility ($g^+ = 0.24$, $k = 12$, $SE = 0.12$, 95% CI [0.01, 0.46], $p = .04$). While the effects were small on inhibition and cognitive flexibility, a moderate effect was found on working memory. This is conceivable as most of the computer trainings explicitly targeted working memory skills.

As shown in Table 2, there was a significant difference in the average effect found for typically developing and nontypical samples. There were 15 effect sizes that were based on nontypically developing groups: eight utilized samples with a diagnosis of ADHD, one study tested children with an ASD diagnosis, one study used a sample with learning impairments, one study had children with Down's syndrome, and three studies recruited children with low working memory capacities. The effect was significant for both groups but it was significantly larger for typically developing ($g^+ = 0.60$) as compared with nontypical samples ($g^+ = 0.25$).

When assessing the studies that reported RT data on the outcome measures, we found seven contrasts with a small but significant effect ($g^+ = 0.24$, $k = 7$, $SE = 0.11$, 95% CI [0.01, 0.46], $p = .04$). This is line with the results of accuracy data if we consider that the majority of these RT data was collected on inhibitory control or cognitive flexibility tests.

Ten studies reported on follow-up data and showed a small but significant average effect ($g^+ = 0.25$, $k = 10$, $SE = 0.12$, 95% CI [0.01, 0.49], $p = .04$). More specifically, computer training had a significant moderate-sized effect on follow-up measures of working memory ($g^+ = 0.49$, $k = 8$, $SE = 0.14$, 95% CI [0.22, 0.77], $p < .001$) but no effects on inhibitory control ($g^+ = -0.02$, $k = 7$, $SE = 0.14$, 95% CI [−0.29, 0.25], $p = .91$) or cognitive flexibility ($g^+ = 0.00$, $k = 5$, $SE = 0.12$, 95% CI [−0.23, 0.23], $p = .997$). Only two studies with typically developing children reported on follow-up data ($g^+ = 0.39$, $k = 2$, $SE = 0.22$, 95% CI [−0.04, 0.81], $p = .07$), the rest of the studies focused on nontypically developing samples ($g^+ = 0.22$, $k = 8$, $SE = 0.15$, 95% CI [−0.07, 0.51], $p = .14$). The effect of computer training on follow-up was marginally significant for typically developing samples.

Noncomputer training. We found 19 effect sizes in 13 publications that assessed the effectiveness of noncomputer games targeting executive function skills of children. As shown in Table 3, the studies were published between 2000 and 2016. Of the 19 effect sizes, data for 10 was collected in Europe, five in Australia, and four were conducted in North America. The children in the samples ranged from 2 to 9 years of age.

Noncomputer trainings of EFs in the primary studies included a range of activities that required explicit practice of EF tasks such as a card sorting game, a waiting game, classroom circle time games, or executive function tasks embedded in shared book reading, as shown in Table 3. The number of intervention sessions applied in the studies ranged from 3 to 30. Sixteen effect sizes were based on a randomized controlled design, while three on a quasiexperimental design. In 12 of the 19 effect sizes some information regarding intervention fidelity was reported. In seven of the effect sizes the intervention was compared with an active control condition, in 10 with a passive control condition, and two effect sizes were based on contrast to both an active and a passive control condition.

A small but significant effect ($g^+ = 0.30$) was found for the efficacy of noncomputer training of executive function skills of children, as shown in Table 2. This was not a heterogeneous effect, Q (18) = 13.01, $p = .79$.

There was a working memory measure in 13 contrasts, a measure of inhibitory control in 15 contrasts, and a cognitive flexibility test in eight contrasts. Results were significant on measures of working memory ($g^+ = 0.41$, $k = 13$, $SE = 0.10$, 95% CI [0.22, 0.60], $p < .001$), inhibition ($g^+ = 0.25$, $k = 16$, $SE = 0.07$, 95% CI [0.11, 0.38], $p < .001$) and flexibility ($g^+ = 0.37$, $k = 8$, $SE = 0.08$, 95% CI [0.21, 0.52], $p < .001$).

There were five contrasts that utilized nontypically developing samples: One contrast included children diagnosed with ADHD, in one contrast a sample with ADHD symptoms was assessed, and children with low inhibition were recruited for three of the effect sizes. Although the difference was not significant, the effect of noncomputer games was only significant for the typically developing samples ($g^+ = 0.31$) and not for the nontypical groups ($g^+ = 0.22$), as shown in Table 2.

Only three studies reported on RT data. These studies show a significant, large effect of noncomputer practice of EF tasks ($g^+ = 0.93$, $k = 3$, $SE = 0.35$, 95% CI [0.26, 1.61], $p = .007$). It should be noted that all three studies used a typically developing sample and measures of inhibitory control and flexibility. However, this result does not entirely align with the accuracy data and indicates a somewhat stronger effect.

One study conducted follow-up assessment with a typically developing sample and found a nonsignificant effect on a mix of working memory, inhibitory control, and cognitive flexibility measures (Hedges' $g = 0.27$, $k = 1$, $SE = 0.31$, 95% CI [−0.33, 0.87], $p = .38$).

Physical activity. Among the contrasts that tested a physical activity intervention we identified an outlying contrast (Pan et al., 2016). After excluding it, there were a total of 22 effect sizes in 21 studies. The studies were published between 2004 and 2016. Data for five effect sizes was collected in North America, seven in Asia, and 10 in Europe. The age of the children in the primary studies ranged from 4 to 12 years of age.

As shown in Table 4, a wide range of physical activity was used in the studies as intervention from aerobic exercises like running and jump rope to team games like basketball, tennis, or martial arts. The number of intervention sessions applied in the studies ranged from 10 to 157. In 17 of the 22 effect sizes some information regarding intervention fidelity was reported. Eight effect sizes were based on randomized controlled trials, while 14 contrasts utilized a quasiexperimental design. Six effect sizes compared the physical activity condition with an active and the remaining 16 with a passive control condition.

Overall, a small but significant effect of physical activity on children's executive functions ($g^+ = 0.16$) was found. However, considering the wide confidence interval, we cannot make firm conclusions. This was a heterogeneous effect, Q (21) = 50.24, $p <$ .001.

A working memory test was utilized in nine, a measure of inhibitory control in 17, and a test of cognitive flexibility was used in 12 effect sizes. More specifically, there was a small but significant effect on working memory ($g^+ = 0.21$, $k = 9$, $SE = 0.08$, 95% CI [0.05, 0.37], $p = .01$), and nonsignificant effects appeared on inhibitory control ($g^+ = 0.17$, $k = 17$, $SE = 0.11$, 95% CI [−0.04, 0.38], $p = .11$) and cognitive flexibility ($g^+ = -0.07$, $k = 12$, $SE = 0.08$, 95% CI [−0.22, 0.08], $p = .33$).

Ten of the effect sizes tested effects of physical activity interventions on nontypically developing samples: In four effect sizes participants were diagnosed with developmental coordination disorder, four included children diagnosed with ADHD, one recruited children with ASD, and one was based on data of children with learning disorder. When inspecting the results separately for typically developing and nontypical samples of children, the effect of physical exercise was significant only for nontypically developing groups ($g^+ = 0.40$) and not for typical samples ($g^+ = 0.03$), which difference was marginally significant, as shown in Table 2. Again, it should be noted that although the effect was significant for the nontypically developing samples, the lower end of the confidence interval was 0.02. Thus, it is questionable whether the average effect size shows a meaningful effect.

Six studies reported on RT data and showed a nonsignificant average effect ($g^+ = 0.28$, $k = 6$, $SE = 0.24$, 95% CI [−0.19, 0.75], $p = .25$). More specifically, there was no effect for typically developing samples ($g^+ = -0.04$, $k = 3$, $SE = 0.30$, 95% CI [−0.63, 0.54], $p = .89$) but there was a significant, moderate-sized effect for samples showing atypical development ($g^+ = 0.64$, $k = 3$, $SE = 0.32$, 95% CI [0.005, 1.28], $p = .048$). It is again questionable how meaningful this average effect is as the confidence interval is very broad and includes 0.005. These results are in line with the effects found on accuracy data.

Aerobic exercise. Eight of the effect sizes tested a physical activity intervention that used an aerobic exercise program. From the eight effect sizes, one reported on the FitKids and one on the FitKids 2 programs, two assessed specialist-led PE lessons, one tested the Aquatic Exercise Program, one utilized aerobically intense PE lessons, one used the Endurance Training Program, and one reported to test the effects of "aerobic exercise with low cognitive engagement."

As shown in Table 2, aerobic exercise had no significant effect on children's EF skills ($g^+ = 0.05$). This effect was heterogeneous, Q (7) = 18.03, $p = .01$. The effect was not significant on any of the three executive function components (working memory: $g^+ = 0.30$, $k = 4$, $SE = 0.21$, 95% CI [−0.11, 0.70], $p = .16$; inhibition: $g^+ = -0.10$, $k = 7$, $SE = 0.10$, 95% CI [−0.30, 0.11], $p = .36$; cognitive flexibility: $g^+ = -0.29$, $k = 5$, $SE = 0.18$, 95% CI [−0.64, 0.07], $p = .12$).

Of the eight effect sizes three tested the intervention on a nontypically developing sample: One included children with an ADHD diagnosis and two contrasts recruited children with developmental coordination disorder. The effect based on these three contrasts was moderate and significant ($g^+ = 0.52$). In contrast, aerobic exercise did not have a significant effect for typically developing samples ($g^+ = -0.15$). The difference between the two could not be tested as there were less than four contrasts with a nontypical sample. Again, it should be noted that although the average effect was significant and moderate in size for the nontypically developing samples, due to the large confidence interval, we cannot make strong conclusions.

Four contrasts reported on RT data and showed no effect of aerobic exercise ($g^+ = 0.05$, $k = 4$, $SE = 0.24$, 95% CI [−0.41, 0.52], $p = .82$). This result is similar to the effect found on accuracy measures if we consider that three out of the four studies investigated samples of typically developing children.

Cognitively engaging exercise. Seventeen effect sizes included a cognitively challenging sport intervention, a physical activity program that required more cognitive processing as compared with aerobic exercise. As shown in Table 4, three effect sizes utilized table tennis as the physical activity intervention; one assessed a tennis-based PE program; four contrasts focused on aerobic exercises and cognitively engaging activities (e.g., ball games); two assessed specialist-led, cognitively enriched PE lessons; one contrast tested a perceptual-motor training; one assessed "physically active academic lessons"; one utilized taekwondo; one tested a yoga program; one focused on team games; one used soccer training; and one assessed a ball skill intervention.

A significant effect of cognitively engaging physical activity ($g^+ = 0.17$) was found, as shown in Table 2. However, the broad confidence interval does not suggest that this effect is very meaningful. This was a heterogeneous effect, Q (16) = 39.59, $p = .001$.

When inspecting the results separately on the three components, there were no effect on flexibility ($g^+ = -0.02$, $k = 10$, $SE = 0.07$, 95% CI [−0.16, 0.12], $p = .79$), however, a marginally significant, small effect was found on inhibition ($g^+ = 0.25$, $k = 13$, $SE = 0.13$, 95% CI [−0.01, 0.51], $p = .06$) and a small but significant effect on working memory ($g^+ = 0.16$, $k = 6$, $SE = 0.08$, 95% CI [0.01, 0.32], $p = .04$).

Of these 17 effect sizes, eight utilized a nontypically developing sample: Children with a diagnosis of ADHD were included in three, children with a learning disorder were recruited for one, children with developmental coordination disorder participated in three effect sizes, and one effect size had a sample of children with an ASD diagnosis. As shown in Table 2, the average effect for these groups was small and nonsignificant ($g^+ = 0.29$), while the average effect in the nine effect sizes including typically developing samples of children was not significant ($g^+ = 0.08$). This difference was not significant.

Three studies reported on RT data. There was a marginally significant, moderate effect of cognitively engaging exercise on these indicators ($g^+ = 0.58$, $k = 3$, $SE = 0.34$, 95% CI [−0.08, 1.24], $p = .09$). This is probably due to the fact that two of the three studies tested the effect on atypically developing samples. One study collected data on follow-up regarding cognitive flexibility in a sample of learning disordered children and found a nonsignificant effect (Hedges' $g = 0.02$, $k = 1$, $SE = 0.21$, 95% CI [−0.40, 0.44], $p = .92$).

EF-specific curricula. We found seven effect sizes in seven studies that tested the effects of a full-time curriculum that targets children's executive function skills, including three effect sizes utilizing Tools of the Mind, one focusing on Montessori, and two using PIAFEx, as shown in Table 6. There were no outlying values. The length of these interventions ranged from 4 to 24 months. The age of the participants ranged from 4 to 6 years. In all but one effect sizes some information regarding intervention fidelity was reported. All effect sizes included samples of typically developing children. Five studies were conducted in North America and two in South America. Studies were published between 2006 and 2015. In case of six effect sizes, a quasiexperimental design was applied, while only one effect size utilized a randomized controlled design. In six of the effect sizes a passive was utilized, while in one effect size an active control group (Balanced Literacy curriculum) was utilized.

The average effect of EF-specific curricula was small and marginally significant ($g^+ = 0.12$). This was a heterogeneous effect, $Q(6) = 13.22$, $p = .04$. One study reported data regarding the change from pre- to posttest. Excluding this study did not change the results substantially ($g^+ = 0.17$, $k = 6$, $SE = 0.10$, 95% CI [−0.02, 0.36], $p = .07$).

The average effect of the three effect sizes assessing the Tools of the Mind program was not significant ($g^+ = 0.13$, $k = 3$, $SE = 0.12$, 95% CI [−0.11, 0.37], $p = .28$). Similarly, the two effect sizes testing the PIAFEx program found no effects ($g^+ = 0.15$, $k = 2$, $SE = 0.17$, 95% CI [−0.19, 0.48], $p = .39$). There was only one contrast assessing the Montessori method and it found a significant moderate effect on cognitive flexibility (Hedges' $g = 0.56$, $k = 1$, $SE = 0.27$, 95% CI [0.03, 1.10], $p = .04$). The one study focusing on the building blocks–scaffolding self-regulation program found no effects (Hedges' $g = 0.03$, $k = 1$, $SE = 0.08$, 95% CI [−0.14, 0.19], $p = .77$).

There was no effect of EF-specific curricula on any of the three executive function components (working memory: $g^+ = 0.05$, $k = 3$, $SE = 0.05$, 95% CI [−0.05, 0.15], $p = .33$; inhibitory control: $g^+ = 0.07$, $k = 6$, $SE = 0.05$, 95% CI [−0.03, 0.17], $p = .16$; cognitive flexibility: $g^+ = 0.23$, $k = 6$, $SE = 0.14$, 95% CI [−0.05, 0.50], $p = .10$). All contrasts included samples of typically developing children so this variable could not be tested as a moderator.

In three contrasts RT data was also reported. These studies showed a nonsignificant effect ($g^+ = -0.01$, $k = 3$, $SE = 0.16$, 95% CI [−0.32, 0.30], $p = .97$), similar to the accuracy result. Additionally, two studies reported on follow-up assessment and found a nonsignificant average effect ($g^+ = -0.03$, $k = 2$, $SE = 0.06$, 95% CI [−0.14, 0.09], $p = .65$).

Art activities. We identified four effect sizes in four studies including assessing art activities to foster executive function capacities: One including music (drumming, keyboard lessons, voice lessons), two testing a drama or pretend play intervention, and one utilizing both. There were no outlying values. The number of intervention sessions applied in the studies ranged from 13 to 36. None of the studies commented on intervention fidelity. The age of the sample ranged from 4 to 9.

As shown in Table 7, the studies were published between 2004 and 2016, and the data was collected in North America in all cases. In three effect sizes a randomized controlled trial, while in one effect size a quasi-experimental design was applied. While three effect sizes used a passive control condition, one effect size was based on comparisons to both an active (nonimaginative pretend play) and a passive control group.

As shown in Table 2, the average effect of art activities was small and nonsignificant ($g^+ = 0.07$). This was not a heterogeneous effect, $Q(3) = 1.73$, $p = .63$. There was a measure of working memory in one effect size, an inhibitory control measure in three, and a cognitive flexibility measure in one. There was no significant effects on inhibitory control ($g^+ = -0.002$, $k = 3$, $SE = 0.14$, 95% CI [−0.27, 0.26], $p = .99$), or, based on only one–one study, on working memory (Hedges' $g = 0.06$, $k = 1$, $SE = 0.24$, 95% CI [−0.42, 0.53], $p = .82$) or cognitive flexibility (Hedges' $g = 0.36$, $k = 1$, $SE = 0.23$, 95% CI [−0.09, 0.82], $p = .12$).

Only one contrast utilized a nontypical sample: children diagnosed with ADHD. The effect size found in that study was not significant (Hedges' $g = -0.21$). Similarly, the remaining three effect sizes including samples of typically developing children did not show a significant effect ($g^+ = 0.14$). The difference between the effects for typical and nontypical samples could not be tested because there were less than four effect sizes with nontypically developing samples.

Music. Two studies utilized music training to foster executive function skills. As shown in Table 2, the average effect of music interventions was not significant ($g^+ = -0.04$). This was a homogeneous effect, $Q(1) = 0.88$, $p = .35$. As mentioned above, one effect size tested the effect on a nontypically developing sample, and the result was not significant (Hedges' $g = -0.21$). The one effect size with a typically developing sample did not have a significant average effect either (Hedges' $g = 0.12$). The difference in effect sizes could not be tested because there were less than four effect sizes in both categories.

One study reported on RT data and found a nonsignificant effect (Hedges' $g = 0.38$, $k = 1$, $SE = 0.26$, 95% CI [−0.13, 0.88], $p = .15$), which aligns the result on accuracy measures.

Drama/pretend play. Three studies utilized a drama or a pretend play intervention for children's executive function skills. All of those included a typically developing sample. As shown in Table 2, the average effect was not significant ($g^+ = 0.10$).

Providing new strategies of self-regulation. We found 20 effect sizes in 20 studies with an intervention providing children new strategies of self-regulation. There were no outlying values. The studies were published between 1971 and 2016. For 15 of the effect sizes data was collected in North America, for four in Europe, and for one in Asia. The age of the samples ranged between 3 and 12 years.

Six effect sizes used a mindfulness meditation intervention, five applied a biofeedback-induced relaxation program, and 10 studies utilized a strategy teaching intervention. The number of intervention sessions applied in the studies ranged from three to 40. Twelve studies reported on a randomized controlled trial and eight studies used a quasiexperimental design. Twelve studies compared the intervention group to a passive control group and six studies used an active control condition.

There was a significant, moderate-sized effect of interventions that provide children new strategies of self-regulation ($g^+ = 0.46$), as shown in Table 2. This effect was heterogeneous, Q (19) = 43.46, $p = .001$. In three studies we could only find growth scores. Excluding those did not change the results substantially ($g^+ = 0.41$, $k = 17$, $SE = 0.10$, 95% CI [0.23, 0.60], $p < .001$).

When inspecting results separately, there was no effect on children's working memory ($g^+ = 0.34$, $k = 6$, $SE = 0.22$, 95% CI [−0.10, 0.76], $p = .13$). However, a moderate-sized significant effect appeared on inhibitory control ($g^+ = 0.52$, $k = 16$, $SE = 0.12$, 95% CI [0.28, 0.76], $p < .001$) and there was a small but significant effect on cognitive flexibility ($g^+ = 0.34$, $k = 9$, $SE = 0.12$, 95% CI [0.10, 0.57], $p = .005$).

There were 10 effect sizes that were based on data of atypically developing samples. Interestingly, interventions that provide children new strategies of self-regulation had a significantly larger effect for atypically developing than compared to typically developing samples, as shown in Table 2. While there was a significant, small effect for typically developing children ($g^+ = 0.24$), the average effect was large for nontypically developing samples ($g^+ = 0.84$).

Mindfulness practices. We identified six effect sizes in six studies that tested the effects of a mindfulness meditation intervention. We found no outlying values. As shown in Table 5, the studies were published between 2014 and 2016. For four effect sizes, data was collected in North America, while in Europe and in Asia for one–one effect sizes. The age of the samples ranged from 3 to 11 years of age.

Two studies tested the Kindness Curriculum program, one used the Master Mind program, one made an adaptation of the Mindful Schools Curriculum, one used a training that was based on the mindfulness-based stress reduction approach, and one used a researcher-constructed protocol of mindful awareness practices. The number of the intervention sessions ranged from eight to 25 sessions. Half of the studies reported some information regarding intervention fidelity. Four effect sizes utilized a quasiexperimental, while two used a randomized controlled design. In five effect sizes the intervention group was compared with a passive control, while in one study an active control condition (dialogic reading) was utilized.

The average effect of mindfulness meditation was moderate and significant ($g^+ = 0.46$). This was a homogeneous effect, Q (5) = 2.64, $p = .76$. No indication of publication bias was found based on the funnel plot. The fail-safe n was 19, which suggests that the effect was not robust.

There was a measure of working memory in one study, an inhibitory control measure in five studies, and a cognitive flexibility measure in four contrasts. The following average effects were found: Only one contrast assessed working memory skills and it found a significant, large effect (Hedges' $g = 1.06$, $k = 1$, $SE = 0.37$, 95% CI [0.34, 1.78], $p = .004$), the average effect on inhibitory control was significant and small in size ($g^+ = 0.39$, $k = 5$, $SE = 0.12$, 95% CI [0.15, 0.63], $p = .002$), but no effect was found on flexibility ($g^+ = 0.18$, $k = 4$, $SE = 0.23$, 95% CI [−0.27, 0.63], $p = .44$). All of the contrasts utilized a typically developing sample.

One study reported on follow-up assessment of inhibitory control and found a significant large effect of mindfulness 8 weeks after the end of the intervention ($g^+ = 1.27$, $k = 1$, $SE = 0.44$, 95% CI [0.41, 2.12], $p = .004$).

Biofeedback-enhanced relaxation. Five effect sizes in five studies were found reporting on a biofeedback intervention: two studies used electroencephalogram (EEG) signal and three utilized electromyography (EMG) data for providing feedback. The lengths of the intervention programs ranged from three to 40 sessions. There were no outlying values.

As shown in Table 8, all the studies were published in North America, between 1980 and 2016. The age of the children ranged from 7 to 12 years. All the studies included a nontypically developing sample: Three of the studies recruited children reported to be hyperactive, one study tested effects on a sample diagnosed with ADHD, and for one study learning disabled children were recruited. None of the studies provided information regarding intervention fidelity. All the studies used a randomized controlled design. Four of the studies compared the results of the experimental group with a passive control condition and one used an active control condition.

We found a significant, large average effect of biofeedback programs ($g^+ = 0.93$), as shown in Table 2. This effect was not heterogeneous, Q (4) = 0.21, $p = .995$. In one study only growth scores were reported. Excluding that study did not change the results substantially ($g^+ = 0.96$, $k = 4$, $SE = 0.19$, 95% CI [0.58, 1.33], $p < .001$).

There was no indication of publication bias according to the funnel plot. The fail-safe n was 29, which suggests that the effect was not robust.

We found a measure of working memory in two studies, a measure of inhibitory control in four but no measures of cognitive flexibility. Significant, large effects of biofeedback were found both on working memory ($g^+ = 0.75$, $k = 2$, $SE = 0.35$, 95% CI [0.06, 1.44], $p = .03$) and inhibition ($g^+ = 0.97$, $k = 4$, $SE = 0.19$, 95% CI [0.59, 1.34], $p < .001$). Because all the studies included nontypically developing children, the effect of this variable could not be tested.

Strategy teaching interventions. We found 10 effect sizes in 10 studies that tested the effects of interventions that overtly teach strategies of self-regulation: Three studies utilized the Head Start PATHS program and one-one study tested the PASS Remedial Program, the Unstuck and On Target program, the OutSMARTers Program, and the Alert Program for Self-Regulation. The remaining three contrasts used researcher-constructed interventions: a training on working memory executive processes that was embedded in reading tasks, a cognitive self-instructional training, and a concentration training. The number of the intervention sessions ranged from six to 35. Seven of the 10 effect sizes reported information about intervention fidelity.

As shown in Table 9, the studies were published between 1971 and 2016. Of the 10 studies, data for four was collected in Europe and for six in North America. The age of the participants in the studies ranged from 4 to 12. Five studies utilized a randomized controlled design, and the other five studies used a quasiexperimental design. In three of the studies, an active control condition was applied, while in seven studies the results of the intervention group were compared with a passive control condition.

As shown is Table 2, a significant small effect of strategy teaching programs ($g^+ = 0.30$) was found. This effect was heterogeneous, Q (9) $= 21.73$, $p = .01$. Two studies only reported growth scores. Excluding these studies from the analysis turned the average effect small and only marginally significant ($g^+ = 0.19$, $k = 8$, $SE = 0.11$, 95% CI [−0.03, 0.41], $p = .09$).

Three studies utilized a test of working memory, eight reported on a measure of inhibitory control, and six assessed cognitive flexibility. There was no effect on measures of working memory ($g^+ = -0.08$, $k = 3$, $SE = 0.10$, 95% CI [−0.27, 0.12], $p = .43$), however, significant effects were found on inhibitory control ($g^+ = 0.42$, $k = 8$, $SE = 0.18$, 95% CI [0.08, 0.76], $p = .02$), and cognitive flexibility ($g^+ = 0.36$, $k = 6$, $SE = 0.12$, 95% CI [0.12, 0.60], $p = .003$).

Five studies utilized typically developing samples, while in one–one contrast children were diagnosed with ADHD, ASD, had fetal alcohol spectrum disorder, and reported to have behavior problems and low intelligence. As shown in Table 2, strategy teaching interventions were significantly more effective for nontypical samples than for typically developing sample. While for typically developing children these interventions did not have a significant effect ($g^+ = 0.08$), they had a large effect for samples showing nontypical development ($g^+ = 0.76$).

Discussion

The present meta-analysis aimed to assess all the available evidence regarding the efficacy of different behavioral interventions to foster children's executive function skills (working memory, inhibitory control, and cognitive flexibility) in one study thus allowing for comparison. A total of 100 contrasts in 90 studies including data of 8,925 children were identified. The primary outcome measure was accuracy data but we also synthesized RT measures in a separate meta-analysis. Moreover, we tested long-term effects of intervention by conducting a meta-analysis on follow-up data. Data was synthesized over the different interventions to test whether it is possible to train children's executive function skills and whether children showing atypical development benefit more from intervention as compared to typically developing samples. Furthermore, the effects of different intervention approaches were also assessed. The efficacy of (a) interventions explicitly training executive function skills (including computerized and noncomputerized training); (b) physical activity interventions (including aerobic exercise and cognitively challenging physical activity); (c) EF-specific full-time curricula (e.g., Tools of the Mind); (d) art activities (including music and drama); and (d) interventions that provide children new strategies of self-regulation including mindfulness practices, biofeedback-enhanced relaxation, and strategy teaching programs (e.g., Unstuck and On Target).

First of all, we found evidence that it is possible to train children's executive function skills. A small but significant effect was found on accuracy measures. Although there were some signs of publication bias, the adjusted average effect size was still significant and the effect was found robust. In contrast to our expectation, similar effects were found for typically and atypically developing children. Although much less frequently reported, RT results aligned with and confirmed these conclusions.

We expected a smaller but significant effect on follow-up assessment, however, there was no convincing evidence that benefits of interventions are sustained over time. Although a small but significant effect was found, we also discovered signs of publication bias and the effect was not robust. Additionally, the effect was only significant on measures of working memory and not on inhibitory control or cognitive flexibility. It should be noted that the majority of the studies reporting on long-term effects used explicit trainings of executive function skills, most often working memory. The intervention types that were found most effective on posttest results were underrepresented in the meta-analysis on follow-up results: no biofeedback-enhanced relaxation studies and only one study testing mindfulness practices reported such results. This might have resulted in an underestimation of the long-term benefits of the trainings assessed in the posttest meta-analyses. Finally, follow-up findings have to be treated with caution because only a small number of studies reported on follow-up results. The lack of a significant effect thus might be due to low statistical power. Further research is clearly warranted.

Explicit training of executive function skills had significant effects. The somewhat larger effect on working memory as compared with the other two components of executive functions is conceivable because most of the studies tested working memory training programs like CogMed. Effects on working memory skills was sustained over time as shown by a significant follow-up effect. Surprisingly, the effect of such explicit training was significantly lower for nontypically developing groups as compared with typically developing children. Results were very similar for computerized and noncomputerized training programs. It is important to note that noncomputer explicit training had significant but small effects on all three components, not only inhibitory control as previously concluded (Diamond & Lee, 2011). However, this effect seems to be applicable only for typically developing groups of children and not to atypical samples.

Furthermore, interventions that explicitly train EF skills use tasks for practice during the intervention that are similar to the neurocognitive tests used as outcome measures in the studies. Even though we excluded measures that were the same as practiced during the intervention, it is still very plausible that the effects found in these studies are an overestimation of the real benefits of such trainings (Blair, 2017). In contrast, the other intervention types in the present meta-analysis did not use tasks that are similar to the outcome measures. Taking this into account further questions the practical relevance of explicitly training children's EF skills.

Physical activity only had a very small effect. Upon closer inspection, beneficial effects of physical activity only appeared for samples of atypically developing children. While for these children there was a significant, moderate-sized effect, there were no significant benefits of physical activity for children showing typical development. Even with significant average effects, the estimates were quite imprecise as shown by broad confidence intervals including very small estimates. Accordingly, we cannot make strong conclusions regarding the efficacy of physical activity interventions.

We did not find evidence for the hypothesis that cognitively engaging physical activity like ball games are more effective than simple aerobic exercise (Best & Miller, 2010; Diamond, 2015; Diamond & Ling, 2016, in press). This pattern might suggest that it is not the cognitive demands during the physical activity (e.g., planning and continuous adjustment to the ever-changing situation during a ball game) that might facilitate executive function skills but the physiological reactions to any kind of physical activity. Future research should investigate the working mechanisms of physical activity for children's executive functioning.

Surprisingly, EF-specific curricula only had a marginally significant, very small effect on children's executive function skills. Furthermore, there were no effects of these curricula on follow-up assessment. However, a promising preliminary result based on only one study is that the Montessori curriculum had a moderate effect on children's cognitive flexibility. The lack of substantial benefits of EF-specific curricula on children's executive functions contrasts the conclusions of previous reviews (Blair & Diamond, 2008; Diamond & Lee, 2011) and it is an especially surprising result as these were the interventions with the longest durations (ranging from 4 to 24 months).

In contrast to the suggestions of Diamond (2012) and a meta-analytic result showing a positive effect of music training on IQ (Protzko, 2017), we did not find evidence for the capacity of art activities to foster children's executive function skills either: Neither music training nor drama/pretend play interventions had a significant overall effect. At the same time, it has to be noted that we could only identify a very limited number of studies assessing these activities (two effect sizes on music training and three effect sizes on drama/pretend play). Thus, the lack of significant effect can be an issue of low statistical power. No firm conclusions can be drawn. Further research is warranted.

While explicit training programs offer children possibilities to practice tasks that require executive function skills, some interventions provide children new strategies of self-regulation instead of practice. These include mindfulness practices, biofeedback-enhanced relaxation, and interventions that teach children such strategies such as the Unstuck and On Target program. This intervention approach was found to be effective in enhancing children's executive function skills with a moderate effect size. Interestingly, these programs were more effective for samples showing atypical development (large effect) as compared with typically developing children (small but significant effect).

More specifically, mindfulness practices had a significant moderate effect on executive function skills. Moreover, one study showed a large beneficial effect on follow-up assessment. Although the available evidence is still quite limited, the present results extend the conclusions of previous literature reviews on the beneficial effects of mindfulness practices on children's cognitive development (Mak et al., 2017; Zenner et al., 2014; Zoogman et al., 2014) by synthesizing the effects specifically on neurocognitive tests of executive function measures. The mechanisms by which mindfulness practice fosters children's executive function skills are still unknown: Both top-down and bottom-up processes have been proposed (Zelazo & Lyons, 2012). It has to be noted that we only found studies including typically developing samples so it remains a question how effective mindfulness meditation is for children showing nontypical development such as neurodevelopmental disorders.

Another intervention that provides children new strategies of self-regulation was biofeedback-enhanced relaxation. This was found to have a large effect on children's working memory and inhibitory control skills—in fact it had the largest effect of all interventions. This is contrary to a previous meta-analysis (Sonuga-Barke et al., 2013) showing no significant benefits for ADHD symptoms. No results regarding a neuropsychological test of cognitive flexibility is available in the literature so we can make no conclusions on that skill. Only studies assessing nontypically developing children were found so the question remains whether biofeedback has the potential to foster typically developing children's EF skills.

Interventions that focused on teaching children strategies for regulating their behavior (including teaching children about executive function-related skills, practicing the manner they can apply them during academic tasks, teaching strategies for self-regulation like planning before acting or self-instruction) were found to be beneficial. More specifically, these programs had significant moderate effects on inhibitory control and cognitive flexibility skills but not on working memory. Upon closer inspection, these interventions were only effective for nontypically developing samples with a large average effect. It seems that teaching children strategies for effective self-regulation is an effective and highly underrated approach in the literature.

Effects for typically developing and nontypical samples were also investigated separately in order to assess whether atypically developing children benefit more from intervention (Melby-Lervåg et al., 2016) and to explore the possibility that different interventions work for different groups of children. While generally we did not find larger effects of intervention for samples showing atypical development, an intriguing finding of the present study is that different interventions seem to be optimal for typically and nontypically developing children. Interventions that provide children new strategies of self-regulation were indeed more effective in fostering executive function skills of nontypically developing samples as compared with typically developing children. In contrast, explicit practice with tasks requiring executive function skills were found to be less effective for nontypical as compared with typically developing samples. In fact, it seems that those children for whom practicing working memory or inhibition tasks would make most sense do not benefit that much from it. It is plausible that in order to profit from such explicit practice one needs sufficient executive function and sustained attention skills. In contrast, these children seem to benefit more from acquiring new strategies of self-regulation.

For nontypically developing samples, gaining new strategies of self-regulation including biofeedback-induced relaxation and strategy learning interventions were found most effective (with large effect sizes), while explicit practice also had a small but significant effect. For typically developing groups mindfulness meditation had a moderate effect. Although for these samples explicit training was also moderately effective, it seems unnecessary for these children to practice such paradigms in a decontextualized manner. It is questionable how the skills they gain from these trainings transfer to real-life problems (Blair, 2017). Altogether, we propose that explicitly training children's executive function skills does not seem to be necessary as other, more enjoyable activities that can be easily fitted in children's everyday routine like mindfulness meditation were found to be just as effective.

An important conclusion of the present study is that the effective approaches to fostering children's executive functioning are not necessarily costly. Mindfulness practices and strategy learning programs can be conducted in large groups and have minimal requirements regarding devices, and are thus feasible in the classrooms. Biofeedback-induced relaxation in contrast might be more expensive, although consumer-grade devices providing biofeedback, like the Muse headband, are increasingly more available on the market.

Limitations

Although all different interventions aiming to improve children's executive function skills were included and synthesized in the present meta-analysis, we excluded studies that tested the effects of training parents and teachers and thus indirectly aimed to enhance children's executive functioning (e.g., Connor et al., 2010). This might be another promising intervention approach as it has been shown to reduce children's ADHD symptoms (Sonuga-Barke et al., 2013).

Based on previous literature reviews (Diamond & Lee, 2011; Diamond & Ling, 2016, in press) we identified different intervention approaches that appear in the primary literature. These categories are, however, quite broad in some cases. For instance, different curricula focusing on EF skills appear in the literature including Tools of the Mind, PIAFEx, or even Montessori. In the same vein, the effects of very different art activities are reported. Although we report the results separately for the different curricula and for music and drama/pretend play interventions, the available evidence is quite limited. In fact, the difference between drama and pretend play interventions is not clear but the number of available studies were not enough to assess the differential effects. Additionally, we found studies not discussed in previous reviews that teach strategies for effective self-regulation. Here we merged the results of a variety of techniques. Future literature reviews should assess the differences between those.

In the present study, due to the low number of studies regarding some intervention approaches, we made two categories regarding the samples: typically and nontypically developing children. Nontypically developing samples included a wide range of children from diagnosed neuropsychological disorders such as ADHD and ASD to children with low working memory capacities or for whom parents or teachers reported behavior problems. Accordingly, the results of the present study regarding nontypically developing children is somewhat preliminary and more studies are needed before we can draw more specific conclusions on what works for whom.

Although we found 100 effect sizes in 90 studies in total, the number of studies that could be synthesized was low in the case of a couple of intervention approaches. For instance, only six studies were available assessing mindfulness practices, five studies with a biofeedback-enhanced relaxation intervention, and two studies testing some kind of music training. Furthermore, this was further confounded by the sample recruited in some cases. For example, all the studies on mindfulness meditation utilized a typically developing sample, while the biofeedback-enhanced relaxation studies recruited groups of children showing atypical development exclusively. As we showed in the present meta-analysis, often times different interventions work differently for different groups of children. Accordingly, we cannot draw conclusions regarding the efficacy of mindfulness practices for nontypically developing children or discuss the potential of biofeedback-enhanced relaxation for typically developing groups. At the same time this systematic review highlights the apparent gaps in the literature.

On a related note, as a result of the low number of studies in the case of some intervention categories and moderator analyses like the difference between typically and nontypically developing samples, nonsignificant results should be interpreted with caution. The lack of significant findings might be due to underpowered analyses instead of truly no effect. With more cumulating evidence these issues should be revisited.

Results on neuropsychological tests of children's executive function skills were included and other measurement approaches like parent or teacher reports of children's behavior was excluded. This was decided in order to focus on unbiased, objective measurement. Future research should test the efficacy of these interventions when measured by informants reporting on the children's everyday behavior. Additionally, it would be interesting to assess how such an improvement in executive function skills transfer to other related skills such as social-emotional well-being, school readiness, and academic performance.

Future Research

As already mentioned, apparent gaps in the literature appear. Mindfulness practices, art activities including music and drama, or pretend play interventions and EF-specific curricula should be tested in future studies, especially with nontypically developing groups of children. The results of the present study highlight the interaction of different interventions and different samples. Thus, future experiments should assess the efficacy of the interventions with different groups of nontypically developing children including clinically diagnosed and different at-risk groups so we can make fine-grained suggestions regarding what works for whom.

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Appendix A

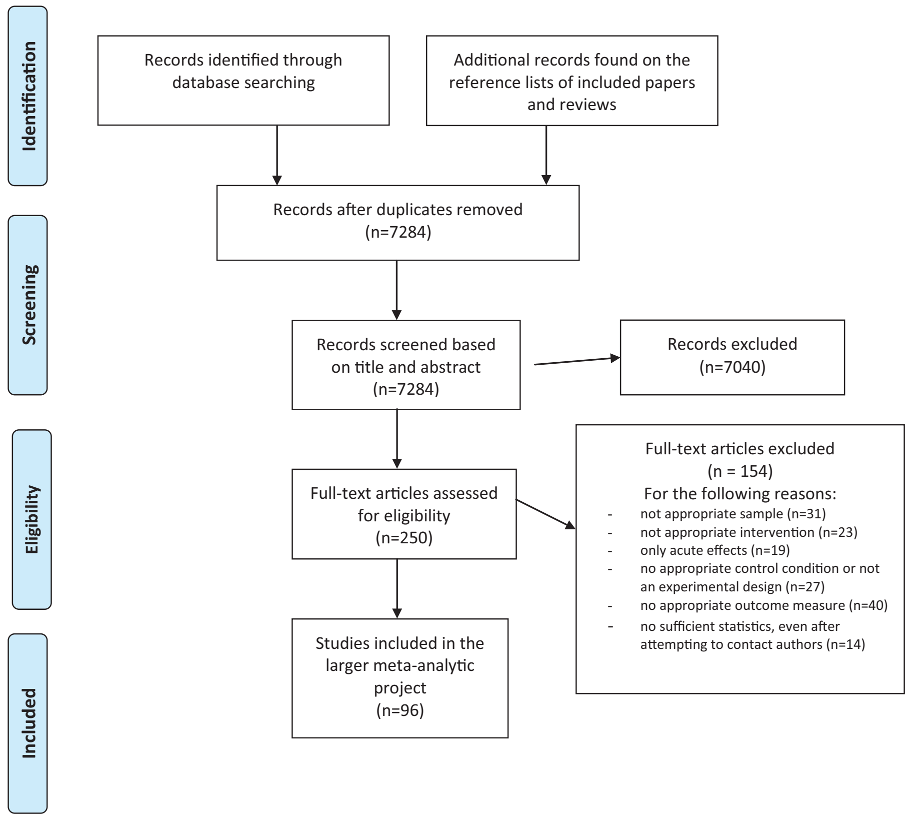
Search String Utilized During the Systematic Literature Search

(Training OR intervention OR curricul* OR Mindful* OR meditat* OR sport* OR exercise OR physical activity OR aerobic* OR martial OR yoga OR mindful* OR "tools of the mind" OR montessori OR "Promoting Alternative Thinking Strategies" OR CogMeg OR "Head Start REDI" OR "Chicago School Readiness Project") AND ("cognitive control" OR "behavioral control" OR "self-control" OR "effortful control" OR "self-regulat*" OR regulat* OR "executive functi*" OR attention OR "working memory" OR inhibit* OR planning OR "cognitive flexibility" OR "delayed gratification" OR monitoring) AND (child* OR student* OR toddler* OR preschooler* OR kindergartner*) AND (experiment* or quasi-experiment*)

(*Appendices continue*)

Appendix B

PRISMA Flow Diagram



See the online article for the color version of this figure.

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