Protocol:
The Direct and Indirect Effects of School-Based Executive Function Interventions on Children and Adolescents' Executive Function, Academic, Social-Emotional, and Behavioral Outcomes: A Systematic Review

Saiying Steenbergen-Hu, Paula Olszewski-Kubilius, and Eric Calvert

Submitted to the Coordinating Group of:

☐	Crime and Justice
☒	Education
	☐ Disability
☐	International Development
	☐ Nutrition
☐	Social Welfare
☐	Other:

Plans to co-register:

☒	No		
☐	Yes	☐ Cochrane	☐ Other
☐	Maybe		

Date Submitted: 14 December 2015
Date Revision Submitted: 16 December 2016
Approval Date: 12 February 2017
Publication Date: 13 February 2017

Campbell Collaboration Systematic Review Protocol Template version date: 9 February 2014

TITLE OF THE REVIEW

The Direct and Indirect Effects of School-Based Executive Function Interventions on Children and Adolescents' Executive Function, Academic, Social-Emotional, and Behavioral Outcomes: A Systematic Review

BACKGROUND

Introduction

Executive function is an umbrella term for a collection of cognitive and behavioral functions such as switching focus, organizing, sustaining attention, and controlling inappropriate speech or behavior. Similar terms include cognitive control, executive control, and everyday cognitive skills. Although there is still no unanimous theoretical or operational definition of executive functions, it is now commonly believed that executive functions are essential for purposeful, goal-directed, problem-solving behaviors and actions (Gioia, Isquith, Guy, & Kenworthy, 2000). Some researchers have characterized attention deficit hyperactivity disorder (ADHD) as executive functioning deficits and dysfunction (e.g., Barkley, 1997, 2012). Deficits or disorders of executive functions can greatly diminish a person's ability to perform in school or work environments, function independently, or maintain appropriate social relationships (Best, Miller, & Naglieri, 2011; Bull & Lee, 2014). Executive functions have attracted interest from researchers across several fields, including medicine, neuroscience, psychiatry, neuropsychology, psychology, and education.

Executive function (EF) has been linked to many important aspects of child and adolescent functioning, such as academic achievement, self-regulated learning, social-emotional development, physical well-being, and behavioral problems. For example, a number of longitudinal studies and studies with national representative samples have reported that early executive function skills predict growth in academic achievement over time (e.g., Best, Miller, & Naglieri, 2011; Fuhs, Nesbitt, Farran, & Dong, 2014), although some studies have found no compelling causal connection between the two (e.g., Jacob & Parkinson, 2015). Also, improved general executive functioning ability is found to be associated with fewer behavioral problems, and vice versa (Young et al., 2009). Planning and organization, two key executive functions, are found to be the most important predictors of school grades for middle school students with ADHD (Langberg, Dvorsky, & Evans, 2013). Recently, some researchers have advocated for increasing opportunities to assess students' executive function so that schools can add such information to students' profiles, to better understanding of their academic and social-emotional status, and provide appropriate for interventions when necessary (Bracken & Brown, 2006).

Three Core Executive Function Components

The current meta-analysis will focus on three core components of executive functions: inhibition (also called inhibitory control), working memory (or updating), and cognitive

flexibility (or shifting, task-switching). We choose to focus on these components for three reasons. First, there is a strong literature base for them. Results from factor analyses of many measures of executive functions of various populations have typically identified inhibition, working memory, and cognitive flexibility as core or important constituents of executive function (e.g., Donder, DenBraber, & Vos, 2010; Egeland & Fallmyr, 2010; Gioia, Isquith, Retzlaff, & Espy, 2002; Laztman & Markon, 2010; Miyake et al., 2000). Second, some reviews have identified them as the most important executive function components based on the frequency of their appearances in literature (e.g., Best, Miller, & Jones, 2009). Lastly, the current meta-analysis intends to take a developmental perspective on executive function in a period from childhood through adolescence. Our previous narrative review of executive function literature (e.g., Steenbergen-Hu, Olszewski-Kubilius, & Calvert, 2014) found that studies of early childhood executive function predominantly focused on inhibition, working memory, and cognitive flexibility (see the Center on the Developing Child at Harvard University, 2011).

Common Assessments of Executive Function

Both performance-based tests and rating scales of executive function skills have been used in clinical and research settings (Toplak, West, & Stanovich, 2013). Performance-based executive function measures involve highly standardized procedures that are often administered on a one-on-one basis to assess an individual's response accuracy or speed on specific tasks. For example, the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtis, 1993) assesses a person's ability to be flexible in response to feedback, avoid perseverative tendencies, and inhibit a prior response that is no longer appropriate in a new situation (Salthouse, Atkinson, & Berish, 2003). Commonly used performance-based EF measures include the WCST, the Halstead Category Test (Halstead, 1947), Trail Making Test (Lewis & Rennick, 1979), the Delis–Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) and the Stroop Test (Jensen & Rohwer, 1966). Performance-based executive function assessments are the foremost measurement tools in clinical- or laboratory-based settings.

Rating scales assess executive function in complex, daily, problem-solving situations through responses provided by either an informant (e.g., parents and/or teachers) or the examinee themselves (Roth, Isquith, & Gioia, 2005). Some most frequently used rating scales of executive function include the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000), the Childhood Executive Functioning Inventory (CHEXI; Thorell, Eninger, Brocki, & Bohlin, 2010; Thorell & Nyberg, 2008), the Behavioral Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996), the Current Behaviors Scales (CBS; Barkley, 1997), and the Deficits in Executive Function Scale (Barkley & Murphy, 2010). Rating scales of executive function have increasingly gained popularity in education and psychology. Recently, some researchers have recommended utilizing data from multiple and different measures, such as both performance-based and rating scales, and also taking into account of some other factors, such as health problems,

age, and economic and cultural influences when assessing and diagnosing EF deficits (Duckworth & Kern, 2011; Randolph & Chaytor, 2013).

Key Interventions of Interest and Their Design Mechanisms

The current meta-analysis is interested in various types of school-based nonpharmacological EF interventions for typically developing school children and adolescents across multiple disciplines. Our review of literature shows that majority of interested EF interventions fall into two broad categories: school curricula/educational programs and mind-body interventions. These school-based interventions both target on EF but differ in key design mechanisms. Table 1 presents some representative programs for these two broad categories interventions, as well as some respective representative randomized controlled trials on these interventions.

School curricula/educational programs. Representatives of such interventions include Tools of the Mind (Barnett et al., 2008), Head Start REDI (Research-Based Developmentally Informed; Bierman et al., 2008; Domitrovich, Gest, Gill, Bierman, Welsh, & Jones, 2009), Promoting Alternative Thinking Strategies (PATHS) curriculum (which is a social-emotional component of the Head Start REDI) (Riggs et al., 2006), Chicago School Readiness Project (CSRP) (Raver et al., 2011), and The Incredible Years Program (Webster-Stratton, Reid, & Hammond, 2004). A theoretical mechanism of this category of interventions is that executive functions and self-regulation interplay together (e.g., Blair & Razza, 2007; von Hippel & Gonsalkorale, 2005). Some researchers have recently proposed to integrate EF into the theory of self-regulation (Barkley, 2012; Miyake & Friedman, 2012). As Bandura (1991) noted that "The major self-regulative mechanism operates through three principle subfunctions. These include self-monitoring of one's behavior, its determinants, and its effects; judgement of one's behavior in relation to personal standards and environmental circumstances; and affective self-reaction" (p.248). More specifically, such curricula and programs function on a bidirectional model of the development of self-regulation during which cognition and emotion interact with each other (Ursache, Blair, & Raver, 2012). Based on this bidirectional developmental model, such interventions are designed to promote students' learning, create learning environments that are predictable and supportive for students to maintain optimal emotional arousal levels, and thus develop executive functions such as the ability to pay attention and engage in self-regulated learning. For example, the Tools of the Mind curriculum was designed to use activities to target students' EF such as the ability to take turns and to view things from others' perspectives while emphasizing collaborative, scaffolded learning (Diamond, Barnett, Thomas, & Munro, 2007). The CSRP aimed to enhance low-income preschoolers' school readiness by increasing their emotional and behavioral self-regulation skills through coaching and training teachers to create classroom environments that are less stressful for both teachers and students (Raver et al., 2011).

Such category of curricula and programs differ in varying degrees or aspects such as the scope of interventional components or with whom the interventions need to involve in

implementations, although they share a similar design mechanism. Some curricula and programs incorporate academic learning with activities to scaffold EF and/or social emotional skills. For example, the REDI intervention has four components, covering curriculum-based lessons, center-based extension activities, teacher training on instructional strategies, and students' participation in classroom learning and various activities (Bierman et al., 2008). In contrast, others are designed to primarily focus on EF and/or social emotional skills without an academic component. For instance, activities of the Incredible Years focus on helping children with challenging behaviors build social-emotional skills (Webster-Stratton, Reid, & Hammond, 2004). In general, most of school curricula/educational programs are designed to engage multiple parties such as teachers, school counselors, students, and even parents in implementing the interventions.

Mind-body interventions. This category of interventions includes some mindfulness-based practices (e.g., meditation or biofeedback) and exercise-based activities (e.g., yoga, Tai Chi, and Qi Gong) implemented in school settings. As first defined by the United States National Center for Complementary and Integrative Health (NCCIH) in 2000, mind-body interventions "employ a variety of techniques designed to facilitate the mind's capacity to affect bodily function and symptoms" (NCCIH, 2000, p.26). Needless to say, such interventions tackle a biological/physiological basis of human emotion and behavior. They are built upon a model of body-mind connection that has been utilized in many health practices such as psychotherapy (Aposhyan, 2004). In most of such programs, children and adolescents are the direct and, most often, the only target of the interventions.

EXISTING REVIEWS

The rising public awareness of the importance of executive function has led to a wealth of interventions designed to promote and enhance executive function skills in children and adolescents. Commonly used executive function interventions comprise two categories: pharmacological (e.g., stimulants used to treat ADHD patients) and non-pharmacological (e.g., computerized training, cognitive behavior therapy, and school-based interventions). As is the case for pharmacological interventions, researchers have conducted a number of systematic reviews or meta-analyses to investigate how effective non-pharmacological interventions are and whether their effectiveness was supported by reliable and convincing evidence. A big portion of such reviews are conducted on clinical samples or laboratory-based settings on non-school-based interventions such as dietary (e.g., free fatty acid supplementation) and computerized training programs (e.g., computerized working memory training programs) (e.g., Karch, Albers, Renner, Lichtenauer, & von Kries, 2013; Melby-Lervåg & Hulme, 2013; Sonuga-Barke et al., 2013; Wayne et al., 2014). Such reviews may not be particularly useful and informative for stakeholders of education arena.

Some researchers have reviewed the effects of school-based executive function interventions on normal children and adolescents, particularly some direct outcomes relevant to executive function, such as general EF skills and/or specific skills in inhibition, working memory, and

cognitive flexibility. Most often, these researchers chose to limit their scope of reviews to one particular form of EF interventions. For example, Smith et al.'s (2010) meta-analysis synthesized randomized controlled trials on the impact of aerobic exercise on attention and processing speed, executive function, and memory performance of adults over 18 years of age (also see Maynard, Solis, & Miller, 2014; Randolph, Rosenstein, & Michaels, 2014).

Additionally, there exists a number of reviews focusing on the effects of school- or home-based executive function interventions. Most such reviews examine indirect rather than direct outcomes of executive function interventions, such as academic achievement, social-emotional development, or behavioral performance. For example, Jacob and Parkinson (2015) conducted a systematic review of the association between executive function and student academic achievement in reading and math. Randolph et al. (2014) developed a Campbell Collaboration (C2) systematic review protocol on the effects of Montessori education on academic and behavioral improvements among 5-12 years old elementary students. Similarly, Maynard et al. (2014) was another C2 review protocol on mindfulness-based interventions for improving academic achievement, behavioral and socio-emotional functioning of primary and secondary students. Currently, Baron, Evangelou, Malmberg, and Melendez-Torres (2016) are conducting a systematic review concerning the effectiveness of Tools of the Mind on young children's self-regulation, particularly in comparison to other similar school curricula or programs.

The What Works Clearinghouse (WWC) have also reviewed research on the effectiveness of some executive function interventions. For example, the WWC (2008) reviewed research evidence for Tools of the Mind, an early childhood curriculum for preschool and kindergarten children. They found that one study (Barnett et al., 2008) met their evidence standards, three studies did not meet their evidence standards, and seven other studies did not meet their eligibility screens. Similarly, the WWC (2011) reviewed the research evidence of the Incredible Years program (see Webster-Stratton, 2011; Webster-Stratton, Reid, & Hammond, 2004). It is noteworthy that the WWC reviews are different from Campbell systematic reviews. Specifically, the WWC reviews aim to identify the best available evidence on an educational intervention, rather than the general effectiveness of an intervention or the potential moderators of the effects.

There also exist a number of reviews of studies that do not focus on executive functions but broadly investigate the effects of school- or home-based social, emotional, or behavioral interventions on normal or disadvantaged young children and adolescents. Such interventions include self-monitoring interventions (e.g., Thompson, Maynard, Bowen, & Pelts, 2013), group-based parent trainings (Barlow & Parsons, 2005), social competence interventions (e.g., Kennedy & Pigott, 2012), instructional strategies (e.g., Spivak, Lipsey, Farran, & Polanin, 2013), school-based universal interventions (e.g., Durlak et al., 2011), and after-school programs (e.g., Durlak, Weissberg, & Pachan, 2010). These reviews typically concentrate on outcomes such as reducing challenging behaviors, developing prosocial

behaviors, social competence and performance, improving academic achievement in children, adolescents, or young adults.

Taken together, our survey of existing and ongoing executive function interventions reviews suggests there are no systematic reviews that have all of the following three features: (a) integration of non-pharmacological executive function intervention research from fields like neuroscience, neuropsychology, and psychology with research in education, with a primary focus on serving and informing stakeholders in education; (b) inclusion of multiple types of school-based interventions for typically developing children and adolescents, such as school curricula/educational programs or mind-body interventions; and (c) examination of both direct (e.g., general or specific executive function skills) and indirect intervention outcomes (e.g., academic achievement, social-emotional development, and behavioral performance). We thus propose to conduct a meta-analysis that will have all these three features.

THE CURRENT META-ANALYSIS

Objectives

The aim of current meta-analysis is to comprehensively synthesize the efficacy of school-based executive function interventions on typically developing children and adolescents. Specifically, this review will address the following five key questions:

1. Do school-based executive function interventions help improve children and adolescents' executive function in general and/or their specific skills in inhibition, working memory, and cognitive flexibility?

2. Do school-based executive function interventions help improve the academic achievement, social-emotional and behavioral performance of children and adolescents?

3. Are some types of school-based executive function interventions more effective than others (e.g., school curricula/educational programs versus mind-body interventions)?

4. How, for whom, and under what circumstances do school-based executive function interventions work or work the best?

5. What are noteworthy features (e.g., dosage, duration, and design mechanisms of interventions) of effective school-based EF interventions and key aspects of program implementation and evaluation of the interventions' outcomes that have great potential practical and policy implications for future research and practices?

In summary, this meta-analysis will make a unique contribution to executive function research and practice as it will focus on the efficacy of multiple school-based interventions on typically developing children and adolescents. It will integrate executive function

intervention research across multiple disciplines and include various types of school-based interventions provided to typically developing school children and adolescents. It will not only examine the effects of executive function interventions on some indirect outcomes, such as academic achievement, social-emotional, or behavioral performance, but also on specific, direct outcomes, such as EF in general and/or inhibition, working memory, and cognitive flexibility. Finally, it will explicate issues of practical importance surrounding the efficacy of EF interventions, such as those regarding whether executive function interventions work but which components work and how they work, for whom they work, and in what circumstances they work.

METHODOLOGY

Inclusion Criteria

Intervention

Studies of executive function interventions need to meet three key criteria to be eligible for this meta-analysis:

Relevant intervention. An intervention has to be conceptually and/or operationally designed and implemented with a focus on executive function. In other words, the core purpose of an intervention in a study is to promote the development of executive functions and it is in this way that the intervention stands out from other numerous school-based education or psychological practices that may share similar goals with EF interventions for promoting academic and social-emotional outcomes.

Theoretically, we select interventions following a definition that executive function is a collection of cognitive and behavioral skills and capacities essential for purposeful, goal-directed, and problem-solving behaviors and actions (Gioia et al., 2000). Operationally, we will evaluate an intervention upon two key features to determine whether it falls into one of the two broad categories of EF interventions as described in the Introduction above: **school curricular/educational programs** or **mind-body interventions**. We selected these two features on the basis of our previous research on EF (e.g., Steenbergen-Hu, & Calvert, 2014; Steenbergen-Hu, Olszewski-Kubilius, & Calvert, 2015a, 2015b) and familiarity with research literature on EF interventions after close review of approximately 100 relevant primary studies and previous systematic reviews.

The first feature is that a large portion of studies of EF interventions share a common literature base, often using terminologies like executive function, executive control, inhibitory control, cognitive flexibility, task-switching, working memory, attention, cognitive control, and effortful control (more detailed EF terminologies are described in the section of Search Keywords and Terms later). The second feature is that an intervention must involve at least one component that targets either (1) some direct EF outcomes such as those concerning EF in general and/or at least one of the three key dimensions – inhibition,

working memory, and cognitive flexibility; or (2) outcomes relevant to self-regulation skills, social-emotional development, or behavioral and conduct in schools.

Intervention settings. Interventions must be implemented on a group or individual basis within school-based environments, such as early childhood settings (e.g., preschool, Head Start), public, private, or charter schools. Interventions implemented in clinical- or laboratory-based settings will be excluded. Interventions implemented in home- or community-based settings, such as parent training, community prevention programs, will also be excluded.

Intervention duration. The length of an intervention in studies has to be in place for at least 10 hours or two weeks, as research shows that executive function interventions need to be repeated over a sustained period of time to be effective (Barkley, 2012).

We describe four exemplary eligible interventions below.

> **Tools of the Mind.** Tools of the Mind, first implemented in 1993, is an early childhood curriculum for preschool and kindergarten children, based on the Vygotskian approach (Bodrova & Leong, 2007). It consists of more than 60 activities implemented over a two-year period designed to foster children's executive functions such as self-regulation, working memory, and cognitive flexibility, as well as their academic skills. Dramatic play is a key component of the curriculum, which requires teachers to engage in intensive professional development. It is actively used in dozens of states and multiple regions in the United States and Canada (http://toolsofthemind.org). The efficacy of Tools of the Mind has been evaluated through randomized controlled trials (e.g., Barnett et al., 2008).
>
> **Head Start REDI**. Head Start is a program authorized by the Improving Head Start for School Readiness Act of 2007. Head Start REDI (REsearch-based, Developmentally Informed) is a federally funded randomized intervention and control group study, developed in partnership with the Head Start Program in 2003. It aims to promote school readiness skills such as prosocial skills, emotional understanding, self-regulation, aggression control, language and emergent literacy skills. The intervention is implemented through conducting professional development and mentoring with teachers to help them improve the quality of their language use, emotional support, and positive management (e.g., Bierman et al., 2008; Domitrovich, Gest, Gill, Bierman, Welsh, & Jones, 2009). Similar to Head Start REDI, the Chicago School Readiness Program (CSRP) is an intervention series that primarily supports Head Start students, particularly those who attend Head Start sites in Chicago area.
>
> **Promoting Alternative THinking Skills (PATHS) Curriculum**. The PATHS curriculum, established in 2000, is designed, based on neurocognitive science research of brain development and executive functioning, to be used by educators

and counselors for promoting social and emotional competencies and reducing aggression and behavior problems in children in preschool through grade 6 (Riggs et al., 2006). It is typically taught two or more times per week for approximately 20-30 minutes per day. The current version of the PATHS curriculum consists of grade-specific classroom kits for Pre-K/Kindergarten, Grade 1-4, and Grade 5/6. The efficacy of PATHS curriculum has been evaluated with some randomized controlled trials (e.g., Domitrovich, Cortes, & Greenberg, 2007; Kam, Greenberg, & Kusché, 2004).

Mindfulness Meditation. Mindfulness meditation is a common form of mind-body interventions that involves practicing and engaging in a number of techniques which aim to support and improve one's physical, psychological, and emotional well-being (Tan, 2015). Mindfulness meditation is often practiced through engaging several different activities such as breathing, gentle movement, formal meditation, and discussion in a period of time that ranges from minutes to hours. During the course of such activities, one pays attention to and accepts the present-moment feelings and experience in a non-judgmental way (Baer, 2003). The rationale is that through these activities, one trains his/her mind to shift attention and increase awareness in way which are beneficial both mentally and physically. Mindfulness meditation techniques have been widely embraced by people of all ages including school children in the past decade. A growing body of research has been conducted to study the effects of meditation as well as other forms of mind-body interventions on children and adolescents EF skills such as attention and working memory (e.g., Quach, Mano, & Alexander, 2015). Unlike the three interventions above that mostly target young children, mindfulness meditation is often introduced to youth and adolescents in school settings.

Comparison condition

Eligible comparison conditions in randomized controlled trials will include traditional school curricula, waitlist control groups, placebos (no treatment), treatments as usual, or any other alternative treatment conditions set up as a contrast to the intervention conditions that allow the efficacy of interventions to be revealed.

Population

This meta-analysis will include studies with populations of typically developing children and adolescents from ages 3 to 18. There are three reasons for selecting early childhood through adolescence as the developmental period of focus in this review. First, this age range is the key developmental period during which foundational executive functions, such as inhibition, working memory, and cognitive flexibility, rapidly progress (Best & Miller, 2010; Best et al., 2009). Second, evidence supports that early childhood and adolescence are significant periods during which to intervene for executive function development through intentional teaching and support due to brain plasticity (Cramer et al., 2011). Lastly, selecting this age

range corresponds to the main objective of this review, which is to provide evidence-based information regarding the effects of executive function interventions that can guide educational practices for children and adolescents to enhance outcomes. There will be no exclusion criteria based on study participants' demographic characteristics. Eligible studies may have been conducted on participants of any country but must be reported in English. Studies that have no full-texts available in English will not be included as translating such studies into English will greatly extend the time needed to complete the current meta-analysis.

In other words, this meta-analysis will exclude studies conducted on primarily special populations that were clinically or medically diagnosed with biological, neurological, mental, behavioral, or learning disabilities. Examples of such special populations include children and adolescents with major cognitive deficits or brain injury, diagnosed with ADHD or attention deficit disorder (ADD), autism spectrum, oppositional defiant disorder (ODD), conduct disorder (CD), or disruptive behavior disorders (DBD), or other severe disorders. Many existing systematic reviews or meta-analyses have been conducted to synthesize the effects of EF interventions on such special populations (e.g., Cortese et al., 2015).

Outcomes

Primary outcomes. This meta-analysis will focus on two primary outcomes: *direct EF outcomes* and *indirect outcomes*. Studies that provided either direct, indirect, or both types of outcomes could be eligible for inclusion as long as they met all other inclusion criteria.

> ***Direct EF outcomes*** refer to those that are either directly concerning EF in general, or those that are relevant to specific components of EF, particularly on inhibition, working memory, and cognitive flexibility. More detailed information on common assessments of executive function are described in the Background section above. Table 3 presents direct EF outcomes and measures for a sample of 23 among the 45 RCTs that we have preliminarily determined to be eligible for the current meta-analysis.
>
> ***Indirect outcomes*** include those of two different types: academic and non-academic ones. Examples of academic outcomes include scores on standardized achievement or ability tests, school grades, measures of content mastery, or school readiness. Common non-academic outcomes include self-regulation skills, self-regulation skills, social-emotional development, or behavioral and conduct in schools.

Secondary outcomes. Although the current meta-analysis primarily focuses on reviewing eligible quantitative studies of school-based EF interventions, we will also gather some qualitative information from eligible quantitative studies included and a selective number of high quality qualitative studies. Examples of such information include measurement issues, elements that are influential on the effectiveness of interventions that are often not assessed in quantitative manners, factors relevant to the quality and fidelity of implementations, and cost-effectiveness of intervention components. Supplementing the two primary quantitative

outcomes, such information might have valuable implications for policy-makers and future practices and research.

Study design

Eligible quantitative studies need to employ strong empirical experimental research designs, particularly randomized controlled trials (RCTs). Randomized controlled trials (RCTs) include, but are not limited to, parallel group trials, cross-over trials, cluster-randomized trials, and factorial trials. Studies need to employ appropriate comparison groups, which ought to resemble the main characteristics of the intervention groups in terms of the baseline measures, age, grade levels, or other demographic factors, or these features can be statistically controlled to discount the prior differences.

Time and language

All eligible studies have to be conducted during the period from January 1985, when most of the school-based EF interventions began to be prevalent, to the time of literature search conclusion (approximately February 28th, 2017) and their full texts have to be available in English.

Search Strategies

We will use the following six strategies to identify published or unpublished eligible studies:

Search in electronic databases

1) Academic Search Premier
2) Applied Social Science Index and Abstracts (ASSIA)
3) Australian Education Index
4) British Education Index
5) CBCA Education (i.e., Canada bibliographic database)
6) Dissertation Abstracts International
7) Education Abstracts
8) Education Complete
9) Education Full Text: Wilson
10) ERIC
11) FRANCIS (i.e., a database for humanity and social sciences studies)

12) International Bibliography of the Social Sciences (IBSS)

13) PsycInfo

14) Scopus

15) Social Science Citation Index

16) Sociological Abstracts

17) Web of Science

18) What Works Clearinghouse (WWC)

Web search using search engines

1) Google

2) Google Scholar

Grey literature search

1) The Society for Research on Educational Effectiveness

2) American Educational Research Association Repository

3) American Institutes for Research

4) Society for Research on Child Development (SCRD)

5) Society for Research on Adolescence (SRA)

6) Campbell Systematical Reviews

7) Database of Abstracts of Reviews of Effectiveness

8) National Technical Information Service

9) System for Information on Grey Literature

10) Evidence-Based Program Database

Track bibliographies of previous literature reviews and retrieved studies

We will screen the reference list of prior reviews and related meta-analyses conducted between 2000 and 2016 for additional relevant studies. We have identified 11 relevant previous meta-analyses or reviews that are useful for us to identify eligible studies (see Appendix). We will also examine the reference of the retrieved primary studies for

potentially eligible studies. This procedure will be carried out not only in the search stage but the study coding process.

Hand searching

We will conduct hand searching of the Table of Contents of at least 3 journals which published most of the identified eligible studies, including *Developmental Science, Journal of Consulting and Clinical Psychology,* and *Society for Research on Educational Effectiveness.*

Contact leading authors

We will contact authors who were the first authors of two eligible studies to request unpublished or in-press studies.

Search Keywords and Terms

We have conducted a pilot review of a set of primary studies and existing reviews to identify relevant free text terms/keywords. We have also consulted database-specific thesauri to locate relevant standardized subject terms (i.e., controlled vocabulary). We will use combinations of terms/keywords related to the intervention, study design/focus, targeted population, and outcomes to conduct the search. Database-specific strategies will be explored for each database, including the use of truncation (such as “”), wildcard (e.g., *), Boolean operators (AND, OR and NOT), and limiting commands to ensure search sensitivity and precision. Below are examples of search term combinations we plan to use:

1) *Intervention*: “executive funct*” OR “executive control*”OR “executive systems*”, “executive skills*”OR “inhibitory control*”OR “cognitive flexibility*” OR “task-switching*”OR “working memory*”OR “attention*”OR “supervisory attentional system*”OR “cognitive control*”OR “everyday cognitive skills*”OR “effortful control*”OR “neurocognitive functioning*”OR “conscious control*”OR “behavioral regulation*”OR “emotion regulation*” OR “regulatory functions*” OR “mindful*”

   AND

1) *Study design/type*: “randomized control trial*” OR trial* OR experiment* OR evaluat* OR impact* OR assessment* OR influence* OR outcome*

2) *Targeted population*: “early childhood” OR “Pre-kindergarten” OR “Kindergarten” OR “Primary school” OR “Elementary school” OR “Middle school” OR “High School” “Secondary school” OR child* OR youngster* OR school* OR class* OR student* OR adoles* OR teen* OR P-12 OR K-12

   AND

3) *Outcomes*: achievement* OR readiness* OR "working memory" OR inhibit* OR cognit* OR self-regulat* OR "social-emotional competence" OR attention* OR behave* OR perform*

In addition, we will conduct searches with the names of major EF interventions, such as:

- "Tools of the Mind"
- "Head Start REDI"
- "PATHS Curriculum"
- "The Incredible Years"
- "Mindfulness-Based Interventions"
- "Social-emotional prevention"
- "Cognitive behavioral Intervention"

Procedures for Determining Eligible Studies

Two trained research assistants will independently conduct the initial search following the search strategies above. They will screen the titles and abstracts of all search hits and collect the studies that are judged to be eligible. These studies are called "first-stage-eligible studies". They then will cross-screen each other's list of "first-stage-eligible studies" and meet every other week to examine the consistency or discrepancies between their lists of studies. After each two-week period, they will meet with the leader author to go through the outcomes of their cross-screening meetings. Studies determined to be eligible after these processes are called "second-stage-eligible studies".

At the time of this revision, we have preliminarily identified 45 randomized controlled trials (RCTs) that evaluated the effects of EF interventions and met all inclusion criteria of this meta-analysis. Table 2 presents these identified 45 RCTs, their primary outcome(s), and key assessments of the outcome(s). Study search and screening will be completed by approximately February 2017. The full text of all second-stage-eligible studies will be obtained and enter the coding stage. Only studies that fully meet all inclusion criteria on the basis of their full texts will be determined eligible and included in the analyses.

Description of Exemplary Eligible Studies

This meta-analysis will include studies that are randomized controlled trials (RCTs) that compare outcomes for an intervention group to those for a control or comparison condition. Interventions were implemented with students in P-12 educational settings, either in a class, school, or after school program. In some studies, the inventions were delivered to children/adolescents, but in others, the interventions were delivered to teachers, school

psychologists, or relevant school personnel. At least one key outcome had to be relevant to one of the two primary outcomes that this meta-analysis is interested. Most potentially eligible studies include both pre-test and post-test measures for both intervention and comparison groups. Post-test measurements generally occur at the end of the intervention. Below are summaries of two representative eligible studies:

Barnett et al. (2008) conducted a randomized trial evaluating the effectiveness of the Tools of the Mind (Tools) curriculum in improving the learning and development of 3- and 4-year-old children. In this study, the effectiveness of Tools curriculum (treatment condition), which focuses on the development of self-regulation which teaching literacy and mathematics skills through playing, was compared with an established district-created model described as a "balanced literacy curriculum with themes" (comparison condition). Teachers and 121 students (88 Tools and 122 comparison) were randomly assigned to either treatment or comparison classrooms. Main study outcomes included social behavior, language, and literacy growth, measured in the fall and spring of the 2002-03 school year with six different instruments. They included the Woodcock-Johnson Applied Math Problems, the Wechsler Preschool Primary Scale of Intelligence Animal Pegs subtest, and the Peabody Picture Vocabulary Test-III (PPVT-III). The impact of the Tools curriculum was estimated using regression analysis and hierarchical linear models (HLM) with treatment at the classroom level. The Tools curriculum was found to improve children's EF (most evident in a reduction of problem behaviors in the classroom) and to slightly improve their language development.

Raver et al. (2011) implemented a multicomponent, cluster-randomized efficacy trial to evaluate the impact of the Chicago School Readiness Project (CSRP) on low-income children's self-regulation and pre-academic skills. The CSRP trained teachers in strategies for more effective regulation and management in their classrooms, e.g., rewarding positive behavior, implementing clearer rules and routines, and redirecting negative behavior. With pairwise matching and randomization procedures, 18 Head Start-funded classrooms (from 9 sites) were assigned in the CSRP (treatment) and 17 other Head Start-funded classrooms (from 9 sites) were assigned in the control group (total N = 602 children). There were no statistically significant differences between the two groups in the baseline. The intervention lasted for about one school year. Data on children's self-regulatory skills were collected with 8 self-regulation tasks using the Preschool Self-Regulation Assessment. Their pre-academic skills (vocabulary, letter naming, and math skills) were collected with a cognitively oriented, federally mandated assessment of Head Start. This study found significant effects of the CSRP intervention on all three pre-academic skills and on EFs and attention/impulsivity.

Study Coding

Study coding will be conducted using a coding form (see Table 4 for the preliminary coding protocol). We will conduct a pilot coding of approximately 10 studies to test and fine-tune

the preliminary coding form before proceeding to code all eligible studies. This coding protocol covers the major characteristics of eligible primary studies, such as (a) general features of the primary studies (e.g., the forms of EF intervention, context, nature, implementation, and the length of intervention), (b) the methodological features of the studies (e.g., research designs, participants, sample sizes, and outcome measures), and (c) effect size information (e.g., the statistical information needed to calculate effect sizes).

In the coding process, we will record the data in an Excel spreadsheet for the convenience of data management. To ensure the reliability of coding procedures and decisions, the leader author and a research assistant will independently code all the included studies and will compare the coding for each study, compute an inter-rater agreement, and resolve any coding discrepancies. The first author will meet regularly with the second and third authors to discuss difficult coding issues.

In cases of studies with missing data, we will first attempt to search and examine all relevant documents that might contain helpful supplemental information. Examples of such documents might be multiple versions of a study that were published in outlets such as research journals, books, or conference proceedings. We will also contact the lead author of the studies to request assistance if needed.

Effect Sizes

We will use standardized mean difference effect sizes (i.e., Hedges' *g*) for outcomes on continuous measures and odds ratios (OR) for outcomes presented as dichotomous variables. Hedges' *g* can reduce the bias that may arise when the sample size is small (i.e., $n < 40$; Glass et al., 1981; Hedges, 1981). The What Works Clearinghouse (WWC) (2013) adopted Hedges' *g* as the default effect size measure for continuous outcomes in the WWC reviews. We will take caution in examining the nature of these outcomes to ensure that a positive *g* generally indicates that the treatment group outperforms their counterparts in the comparison condition. We will use two computational tools for effect size calculation. The first one is the Comprehensive Meta-Analysis (CMA) software (Borenstein, Hedges, Higgins, & Rothstein, 2006). The CMA can calculate effect sizes from more than 100 types of data formats on the basis of a wide variety of statistics (e.g., means, standard deviations, and *p*-values) and types of data (e.g., binary, continuous, and correlational data). Another tool is David Wilson's practical effect size calculator, which can be accessed online free of charge through http://www.campbellcollaboration.org/resources/effect_size_input.php.

Adjusted and Unadjusted Hedges' g. Two types of Hedges' *g* will be extracted based on the information available in the studies. If a study only reported post-test outcomes, we will extract unadjusted Hedges' *g* which does not take into account the confounding impact of other variables on the outcomes. If a study provided outcomes that either adjusted or controlled for the influence of other variables (e.g., pre-test scores) or reported information that will allow us to do so, we will extract adjusted effect sizes. In some cases, adjusted effect sizes will be based on means and standard deviations of gain scores

(i.e., post-test minus pre-test scores), whereas in other cases they might be based on covariance-adjusted means and standard deviations. Extracting two types of Hedges' *g* will allow us to make the best use of study information and examine whether the effectiveness of school-based EF intervention differs depending on how it is estimated.

Effect sizes by comparison conditions. We will extract effect sizes corresponding to each comparison condition (e.g., regular curriculum, waitlist control, no treatment, or other alternative activities) to which the school-based EF intervention is compared within each study. For example, if a study compared the effects of Tools of the Mind curriculum with both regular curriculum and no treatment control, two separate effect sizes will be computed respectively with this study.

Conversion among different effect sizes. After all effect sizes are calculated, we will choose one type of effect sizes that appears most frequently as the primary effect size index (most likely Hedges' *g*), and convert other types of effect sizes (e.g., odds ratios) into the primary effect sizes prior to computing the mean effect sizes (Borentein et al., 2009). All effect sizes that entering the analysis will be Hedges'. The Comprehensive Meta-Analysis (CMA) can simultaneously compute and display various types of effect size (e.g., Hedges' *g*, odds ratios, log odds ratios, correlation coefficients, and Fisher's *z*, etc.) so this is achievable.

Data-Analysis

Compute mean effect sizes. For each meta-analysis, we will conduct the analysis with a random-effects model, which assumes that the treatment has more than one true effect size, and the study effect sizes are a random sample of a population of effect parameters. This model assumes that, in addition to sampling errors, some other variable, such as study setting, the length of the treatment, and the specific features of research designs, may be responsible for the variation in observed effect sizes (Schmidt & Hunter, 1977). Effect sizes from each study will be weighted with the Hedges–Vevea method which weights the study level effect sizes by inverse variances (i.e., dividing the value of one by the variance or standard error squared). It is worth noting that using inverse variance weights in a random-effects model includes an estimate of between-study variances along with within-study variances. We will report the mean effect sizes with their 95% confidence intervals, and *p*-values of tests of the null hypotheses.

Ensure effect size independence. In each analysis, ensuring effect size independence is a prerequisite. Effect size dependency may arise from many situations. We will use different methods to ensure effect size independence under different circumstances. We briefly describe four strategies and their related circumstances below.

First, we will use an independent sample as the unit of analysis (Cooper, 2010) to integrate effect sizes**.** With this approach, each independent sample contributes only one effect size to a mean effect size. If one research report contains two or more separate studies based on different samples, we will count each separate study (associated with each respective

independent sample) as a unit. As a result, the number of independent samples might be greater than the number of eligible study reports in the end. In cases in which more than one article reported study findings that were all based on the same sample, we will choose the study (article) of the sample with best design and/or psychometric quality to represent all relevant studies (reports).

Second, we will conduct separate meta-analysis corresponding to each category of conditions to which the school-based EF intervention was compared. For example, three separate meta-analyses will be conducted on three groups of studies (i.e., independent samples) in which EF interventions were compared to traditional school curriculum, no treatment control, or other alternative activities, respectively. When effect sizes are grouped by each type of comparison condition, all effect sizes associated with one type of comparison will be independent from one another because each sample contributed one effect to the estimation of that comparison.

Third, most commonly, effect size dependence arises when a single study produces more than one effect size due to multiple outcomes. These effect sizes are based on the same group of subjects and therefore are not independent. In such a situation, we will analyze the effect sizes in two stages. In the first stage, we will compute an average effect size across all available outcome measures in each study. This average effect size will represent the effect size estimate of this study. For example, if a study measured a group of participants with three different measures, the average effect sizes from these three measures will be the effect size contributing to the overall average effect size across studies.

In the second stage, we will conduct analyses using a shifting unit of analysis approach (Cooper, 2010). The preparation for using this approach will start in the effect size calculation in the coding stage. Particularly in the coding stage, one effect size will be calculated for each major outcome measure. For example, if a study (one independent sample) used both standardized test scores and course grades to measure students' learning, two separate effect sizes will be calculated. With the shifting unit of analysis approach, this study will contribute one effect size associated with the standardized test scores to a meta-analysis that focuses on integrating effect sizes from standardized outcome measures. Similarly, this study will contribute one effect size corresponding to the course grade to another meta-analysis that focuses on integrating effect sizes from non-standardized outcome measures, such as course grades. In sum, with shifting unit of analysis approach, although the two effect sizes are associated with the same sample, they are independent from one another when they each contribute to a different meta-analysis.

We will also utilize several multilevel meta-analysis software packages such as MLwiN or Metafor in R to help handle effect size dependency issues arising from the same study.

Heterogeneity analysis. We will conduct heterogeneity analysis to statistically assess the variation in study level effect sizes. Key statistics will include the value of total variance (*Q* statistic), the results of chi-square-like test based on the *Q* statistic (*p*-value), the

between-study variance (i.e., the true heterogeneity) (T^2), and the ratio of between-study variance to total variance (I^2). *I*-squared (I^2) ranges from 0 to 100 (%). The *Q* statistic and I^2 are algebraically related (Higgins & Thompson, 2002).

Moderator analysis. We will conduct moderator analysis (also called testing for moderators) to explore possible sources of heterogeneity in the effect sizes. In particular, based on prior theory and research literature, it explores whether the differences in key characteristics significantly change the magnitudes and/or direction of the mean effect sizes. Essentially, moderator analysis examines the degree to which the relation between the independent variable (i.e., study characteristics) and the dependent variable (i.e., the mean effect size) changes by study-level or person-level characteristics (Hedges & Pigott, 2004).

A tentative list of potential moderators that this meta-analysis will test include: age, gender, grade level, types of interventions, major components of interventions, the duration of interventions, the fidelity of intervention implementations, research design (i.e., comparing an complete RCT to clustering, matching, or other non-standard design features of RCTs) study methodological quality, the type of information sources (i.e., self, teacher, parent, etc), and rewards (a factor that some researchers believe it has some interesting relationship with EF) will be examined for their influence on the mean effect sizes.

For categorical variables, we will conduct moderator analysis with a method analogous to the analysis of variance (ANOVA) in the data-analysis of a primary study (Borenstein et al., 2009; Huizenga, Visser, & Dolan, 2010), also called subgroup analysis (Borenstein et al., 2009). Q_b and *p*-values are two key statistics in the ANOVA analog method. A Q_b denotes the total between-group variance associated with the sub-categories of a given moderator variable. A *p*-value denotes the results of a significance test for the mean difference between or among the subgroups. If there are at least 10 eligible studies for a subgroup, we will conduct meta-regression with which we may explore the relationship between some continuous variables (e.g., age) and the mean effect sizes.

To minimize the chance of Type I errors in moderator analyses – the increased chance of finding at least one significant result as more tests are added even if that is not true in reality, we will avoid conducting moderator analysis on too many variables, especially when the number of included studies in the meta-analysis is limited. Meanwhile, we will consider implement adjustment for multiplicity (i.e., adjustment of alpha level), such as using a Bonferroni (more conservative) correction approach in the analyses.

Assess Publication Bias and Risk of Bias

We will first visually assess publication bias through a funnel plot. Further, we will conduct the trim and fill analysis (Duval, 2005; Duvall & Tweedie, 2000), to unearth the existence of publication bias, to evaluate the sensitivity of results to possible publication bias, and to adjust results when there is a suspicion of publication bias. In addition, we will also conduct sensitivity analysis to assess the robustness of the results.

We will employ the Cochrane Collaboration's tool for assessing risk of bias (Higgins et al., 2011) given that all included studies will be RCTs. The outcomes of assessing risk of bias may be candidates for moderator analyses if they fit.

Interpret Meta-Analysis Results

We will use the "meta-analytic thinking" approach (Thompson, 2006) to interpret the meta-analysis results. This approach generally involves taking into consideration multiple contextual factors in interpreting results. First, we will consider multiple factors in interpreting results, including the size of the effect, statistical significance, confidence intervals, and the number of studies providing the evidence. This approach is similar to the What Works Clearinghouse's (WWC) recent guidelines for determining the evidence rating for an intervention in WWC reviews (WWC, 2013), which take into account the size of the effect, statistical significance, and the status of contrary evidence. Second, we will interpret the results in light of the methodological qualities of the primary studies upon which this review is based. Finally, we will connect and compare the results with prior meta-analyses of the same or similar topics.

Treatment of Qualitative Studies

Although we will not formally synthesize qualitative studies, we will gather some qualitative information from all quantitative studies included and a selective number of well-conducted qualitative studies. More details of such qualitative information is described in the Secondary Outcomes above. This information will be included in the data for the Secondary Outcomes.

REFERENCES

Aposhyan, S. M. (2004). *Body-Mind Psychotherapy: Principles, techniques, and practical applications*. W. W. Norton & Company, Inc. New York, NY.

Baer, R.A., (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology, 10*, 125-143. doi:10.1093/clipsy.bpg015

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes, 50*, 248-287.

Baron, A., Evangelou, M., Malmberge, L. E., & Melendez-Torres, G. J. (2016). The Tools of the Mind curriculum for improving self-regulation in early childhood: A systematic review. *Protocol for a Systematic Review, Campbell Collaboration*, retrieved 2/7/2017 from file:///C:/Users/ssw252/Desktop/Baron_Tools_of_the_Mind_Protocol_1.pdf

Barkley, R.A. (2012). *Executive functions*. New York, New York: The Guilford Press.

Barlow, J., Parsons, J., & Stewart-Brown, S. (2005). Preventing emotional and behavioral problems: the effectiveness of parenting programmes with children less than 3 years of age. *Child: Care, Health and Development, 31*, 33-42. doi:10.1111/j.1365-2214.2005.00447.x

Barnett, W. S., Jung, K., Yarosz, D. J., Thomas, J., Hornbeck, A., Stechhuk, R. Burns, M. S. (2008). Educational effects of the Tools of the Mind Curriculum: a randomized trial. *Early Childhood Research Quarterly, 23,* 299-313. doi:10.1016/j.ecresq.2008.03.001

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development, 81,* 1641-1660. doi: 10.1111/j.1467-8624.2010.01499.x

Best, J. R., Miller, P. H., & Jones, L. J. (2009). Executive functions after age 5: Changes and correlates. *Developmental Review, 29,* 180-200. doi:10.1016/j.dr.2009.05.002

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. *Learning and Individual Differences, 21,* 327-336. doi:10.1016/j.lindif.2011.01.007

Bierman, K. L., Domitrovich, C. E., Nix, R. L., Gest, S. D., Welsh, J. A., Greenberg, M. T., Blair, C., Nelson, K., & Gill, S. (2008). Promoting academic and social-emotional school readiness: The Head Start REDI program. *Child Development, 79,* 1802-1817. doi: 10.1111/j.1467-8624.2008.01227.x

Bodrova, E., & Leong, D. J. (2007). *Tools of the Mind: The Vygotskian approach to early childhood education* (2nd ed.). New York: Merrill/Prentice Hall.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2006). Comprehensive Meta-Analysis (Version 2.2.027) [Computer software]. Englewood, NJ: Biostat.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. doi:10.1002/9780470743386

Bracken, B. A., & Brown, E. F. (2006). Behavioral identification and assessment of gifted and talented students. *Journal of Psychoeducational Assessment, 24*, 112-122. doi: 10.1177

Bull, R. & Lee, K. (2014). Executive functioning and mathematics achievement. *Child Development Perspectives, 8,* 36-41. doi: 10.1111/cdep.12059

Center on the Developing Child at Harvard University (2011). *Building the brain's "air traffic control" system: How early experience shape the development of executive function: Working paper no. 11*. Retrieved from: http://www.developingchild.harvard.edu.

Cooper, H. (2010). *Research synthesis and meta-analysis: A step-by-step approach* (4th ed.). Thousand Oaks, CA: Sage.

Cortese et al. (2015). Cognitive training for attention-deficit/hyperactivity disorder: Meta-analysis of clinical and neuropsychological outcomes from randomized controlled trials. *Journal of the American Academy of Child & Adolescent Psychiatry, 54 (3),* 164-174. doi:10.1016/j.jaac.2014.12.010

Cramer, S. C., Sur, M., Dobkin, B. H., O'Brien, C., Sanger, T. D., Trojanowski, J. Q., ... & Vinogradov, S. (2011). Harnessing neuroplasticity for clinical applications. *Brain, 134,* 1591-609. doi:10.1093/brain/awr039

Delis, D.C., Kaplan, E., & Kramer, J.H. (2001). *Delis Kaplan Executive Function System: Examiner's manual.* San Antonio, TX: The Psychological Corporation.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318,* 1387-1388. doi:10.1126/science.1151148

Domitrovich, C. E., Cortes, R. C., & Greenberg, M. T. (2007). Improving young children's social and emotional competence: A randomized trial of the preschool 'PATHS' curriculum. *Journal of Primary Prevention, 28*(2), 67-91. doi:10.1007/s10935-007-0081-0

Domitrovich, C. E., Gest, S. D., Gill, S., Bierman, K. L., Welsh, J., & Jones, D. (2009). Fostering high quality teaching in Head Start classrooms: Experimental evaluation of an integrated curriculum. *American Education Research Journal, 46*, 567-597. doi: 10.3102/0002831208328089

Donder, J., DenBraber, D., & Vos, L. (2010). Construct and criterion validity of the Behavior Rating Inventory of Executive Function (BRIEF) in children referred for neuropsychological assessment after pediatric traumatic brain injury. *Journal of Neuropsychology, 4*(2), 197-209. doi:10.1348/174866409X478970.

Duckworth, A. L., & Kern, M. L. (2011). A Meta-Analysis of the Convergent Validity of Self-Control Measures. Journal of Research in Personality, 45(3), 259–268. http://doi.org/10.1016/j.jrp.2011.02.004

Durlak, J. A., Weissberg, R. P., & Pachan, M. (2010). A meta-analysis of after-school programs that seek to promote personal and social skills in children and adolescents. *American Journal of Community Psychology, 45,* 294-309. doi:10.1007/s10464-010-9300-6

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. *Child Development, 82,* 405-432. doi: 10.1111/j.1467-8624.2010.01564.x

Duval, S. J. (2005). Trim and fill method. In H. R. Rothsetin, A. J., Sutton, & M. Bornstein (Eds.), *Publication bias in meta-analysis: Prevention, assessment, and adjustments* (pp. 127–144). doi:10.1002/0470870168.ch8

Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot–based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*, 455–463. doi:10.1111/j.0006-341X.2000.00455.x

Egeland, J. & Fallmyr, O. (2010). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Functions (BRIEF): Support for a distinction between emotional and behavioral regulation. *Child Neuropsychology*, *16*, 326-337. doi: 10.1089/09297041003601462.

Flay, B. R. (2012). *Randomized evaluation of the Positive Action pre-K program*. Virginia Foundation for Healthy Youth and Positive Action, Inc., Retrieved from: https://www.positiveaction.net/research/downloads/pre-kindergarten-2012.pdf

Fuhs, M. W., Nesbitt, K. T., Farran, D. C., & Dong, N. (2014). Longitudinal associations between executive functioning and academic skills across content areas. *Developmental Psychology, 50,* 1698-1709. doi:10.1037/a0036633

Gioia, G. A., Isquith, P. K, Retzlaff, P. D., & Espy, K. A. (2002). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Functions (BRIEF). *Child Neuropsychology, 8*, 249-257.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). *Behavior rating inventory of executive function*. Odessa, Florida: Psychological Assessment Resources.

Glass, G. V., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research*. Beverly Hills, CA: Sage.

Halstead, W. C. (1947). *Brain and intelligence*. Chicago: University of Chicago Press.

Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G., & Curtis, G. (1993). *Wisconsin Card Sorting Test (WCST) manual, revised and expanded*. Odessa, FL: Psychological assessment Resources.

Hedges, L. V. (1981). Distribution theory for Glass's estimator of effect size and related estimators. *Journal of Educational Statistics*, *6*, 107–128. doi:10.3102/10769986006002107

Hedges, L. V., & Pigott, T. D. (2004). The power of statistical tests for moderators in meta-analysis. *Psychological Methods*, *9*, 426–445. doi:10.1037/1082-989X.9.4.426

Higgins, J. P., et al. (2011). The Cochrane Collaboration's tools for assessing risk of bias in randomised trials. *BMJ*, 343: d5928 doi: 10.1136/bmj.d5928

Huizenga, H. M., Visser, I., & Dolan, C. V. (2010). Testing overall and moderator effects in random effects meta-regression. *British Journal of Mathematical and Statistical Psychology*, *64*, 1–19. doi:10.1348/000711010X522687

Institute of Education Sciences, What Works Clearinghouse. (2013). *What Works Clearinghouse: Procedures and standards handbook* (Version 3.0). Retrieved from http://ies.ed.gov/ncee/wwc/pdf/reference_resources/wwc_procedures_v3_0_draft_standards_handbook.pdf

Institute of Education Sciences, What Works Clearinghouse (2008, September). *WWC intervention report early childhood education: Tools of the Mind*. Retrieved from http://ies.ed.gov/ncee/wwc/pdf/intervention_reports/wwc_toolsofmind_091608.pdf

Institute of Education Sciences, What Works Clearinghouse (2011, November*). WWC intervention report children classified as having an emotional disturbance: The Incredible Years*. Retrieved from http://ies.ed.gov/ncee/wwc/pdf/intervention_reports/wwc_incredibleyears_111511.pdf

Jacob, R. & Parkinson, J. (2015). The potential for school-based interventions that target executive function to improve academic achievement: A review. *Review of Educational Research*. Advance Online Publication. doi:10.3102/0034654314561338

Jensen, A. R., & Rohwer, W. D. (1966). The Stroop Color-Word Test: A review. *Acta Psychologica*, *25*, 36–93. http://dx.doi.org.turing.library.northwestern.edu/10.1016/0001-6918(66)90004-7

Kam, C., Greenberg, M. T., & Kusche, C. A. (2004). Sustained effects of the PATHS curriculum on the social and psychological adjustment of children in special education. *Journal of Emotional and Behavioral* Disorders, *12*, 66-78. doi:10.1177/10634266040120020101

Karch, D., Albers, L., Renner, G., Lichtenauer, N., & von Kries, R. (2013). The efficacy of cognitive training programs in children and adolescents: A meta-analysis. *Deutsches Artteblatt International, 110*, 643-652. doi:10.3238/arztebl.2013.0643.

Kennedy, A. S., & Pigott, T. M. (2012). *Social competence interventions for preschool-aged children with special needs in general and inclusive early childhood setting*. Retrieved from http://www.campbellcollaboration.org/lib/project/250/

Langberg, J. M., Dvorsky, M. R., & Evans, S. W. (2013). What specific facets of executive function are associated with academic functioning in youth with attention-deficit/hyperactivity disorder? *Journal of Abnormal Child Psychology, 41,* 1145-1159. doi:10.1007/s10802-013-9750-z

Laztman, R. D., & Markon, K. E., (2010). The factor structure and age-related factorial invariance of the Delis-Kaplan Executive Function System (D-KEFS). *Assessment, 17*(2), 172-184. doi:10.1177/1073191109356254.

Lewis, R. F., & Rennick, P. M. (1979). *Manual for the repeatable cognitive-perceptual-motor battery*. Grosse Pointe Park, MI: Axon Publishing.

Maynard, B. R., Brendel, K. E., Bulanda, J. J., & Pigott, T. (2011). *Interventions for school refusal behavior with elementary and secondary school students*. Retrieved from http://www.campbellcollaboration.org/lib/project/232/

Maynard, B. R., Solis, M. R., & Miller, V. L. (2014). *Mindfulness-Based Interventions for Improving Academic Achievement, Behavior and Socio-Emotional Functioning of Primary and Secondary Students*: Registration for a Systematic Review. Retrieved from http://campbellcollaboration.org/lib/project/342/

Melby-Lervåg, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Developmental Psychology, 49,* 270-291. doi:10.1037/a0028228

Miyake, A. & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 2*(1), 8-4.

Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A., & Wagner, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41,* 49-100. doi:10.1006/cogp.1999.0734

Randolph, J. J., & Chaytor, N. S. (2013). Promoting the executive functions: Core foundations, assessment considerations, and practical applications. In J. J. Randolph (ed.), *Positive Neuropsychology: Evidence-Based Perspectives on Promoting Cognitive Health*. (pp. 77-101). New York, NY: Springer Science + Business Media.

Quach, D., Mano, K. E. J., & Alexander, K. (2016). A randomized controlled trial examining the effect of mindfulness meditation on working memory capacity in adolescents. *Journal of Adolescent Health,* 58, 489-496. doi:10.1016/j.jadohealth.2015.09.024

Randolph, J. J., Rosenstein, D. L. W., & Michaels, S. (2014). *Montessori education for improving academic and behavioral outcomes among elementary students*. Retrieved from http://www.campbellcollaboration.org/lib/project/315/

Raver, C. C., Jones, S. M., Li-Grining, C. P., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's impact on low-income preschoolers' pre-academic skills: Self-regulation as a mediating mechanism. *Child Development, 82*, 362-378.

Riggs, N. R., Greenberg, M. T., Kusch´e, C. A., & Pentz, M. A. (2006). The mediational role of neurocognition in the behavioral outcomes of a social-emotional prevention program in elementary school students: Effects of the PATHS curriculum. *Prevention Sci*ence, *7*, 91-102. doi:10.1007/s11121-005-002201

Roth, R. M., Isquith, P. K., & Gioia, G. A. (2005). *Behavior rating inventory of executive function- Adult version*. Lutz, Flordia: Psychological Assessment Resources, Inc.

Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of Experimental Psychology: General, 132*, 566-594. doi:10.1037/t31298-000

Schmidt, F., & Hunter, J. (1977). Development of a general solution to the problem of validity generalization. *Journal of Applied Psychology*, *62*, 529–540. doi:10.1037/0021-9010.62.5.529

Smith, P. J., Blumenthal, J. A., Hoffman, B. M., Cooper, H., Strauman, T. A., Welsh-Bohmer, K., ... & Sherwood, A. (2010). Aerobic exercise and neurocognitive performance: A meta-analytic review of randomized controlled trials. *Psychosomatic Medicine, 72*, 239-252. doi:10.1097/PSY.0b013e3181d14633

Sonuga-Barke, E. J., Brandeis, D., Cortese, S., Daley, D., Ferrin, M., Holtmann, M., ... & Sergeant, J. (2013). Nonphamacological interventions for ADHD: Systematic review and meta-analyses of randomized controlled trials of dietary and psychological treatment. *American Journal of Psychiatry, 170*, 275-289. doi:10.1176/appi.ajp.2012.12070991

Spivak, A. L., Lipsey, M. W., Farran, D. C., & Polanin, J. R. (2013). *Instructional strategies for enhancing prosocial behavior in children and youth: A systematic review and meta-analysis*. Retrieved from http://www.campbellcollaboration.org/lib/project/317/

Steenbergen-Hu, S., & Calvert, E. C. (2014). Do Academically Gifted Children and Adolescents Also Score Well in Executive Functions? The Esther Katz Rosen Fund Grants, $43,500, funded.

Steenbergen-Hu, S., Olszewski-Kubilius, P., & Calvert, E. (April, 2015a). *Assessing executive functions: What educational researchers and practitioners are to know*. Presentation at 2015 Annual Meeting of American Educational Research Association, April 16 –April 20, Chicago, Illinois, USA.

Steenbergen-Hu, S., Olszewski-Kubilius, P., & Calvert, E. (April, 2015b). *Are executive functions and intelligence the same thing? A systematic review of research on the relationships between executive functions and intelligence across multiple disciplines*. Presentation at 2015 Annual Meeting of American Educational Research Association, April 16 –April 20, Chicago, Illinois, USA.

Steenbergen-Hu, S., Olszewski-Kubilius, P., & Calvert, E. (November, 2014). *Executive functions, intelligence, creativity, achievement, and the whole gifted*. Paper presented at the 2014 Annual Meeting of National Association for Gifted Children, Baltimore, Maryland.

Straus, S. E. (2000). Expanding horizons of healthcare, five-year strategic plan 2001–2005. *National Centre for Complementary and Alternative Medicine.* Retrieved from http://nccam.nih.gov/databases.html.

Tan, L. B. (2015). A critical review of adolescent mindfulness-based programmes. *Clinical Child Psychology and Psychiatry, 21,* 193-207. doi:10.1177/1359104515577486

Thompson, A. M., Maynard, B. R., Bowen, N. K., & Pelts, M. (2013). *Self-monitoring interventions for reducing challenging behaviors among school-age students: a systematic review*. Retrieved from http://www.campbellcollaboration.org/lib/project/264/

Thompson, B. (2006). Research synthesis: Effect sizes. In J. Green, G. Camilli, & P. B. Elmore (Eds.), *Complementary methods for research in education* (pp. 583–603). Washington, DC: American Educational Research Association

Thorell, L. B., & Nyberg, L. (2008). The Childhood Executive Function Inventory (CHEXI): A new rating instrument for parents and teachers. *Developmental Neuropsychology, 33,* 536-552. doi:10.1080/87565640802101516

Thorell, L. B., Eninger, L., Brocki, K. C., & Bohlin, G. (2010). Childhood Executive Function Inventory (CHEXI): A promising measure for identifying young children with ADHD? *Journal of Clinical and Experimental Neuropsychology, 32,* 38-43. doi:10.1080/13803390902806527

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54,* 131-143. doi: 10.1111/jcpp.12001

Ursache, A., Blair, C., & Raver, C. C. (2012). The promotion of self-regulation as a means of enhancing school readiness and early achievement in children at risk for school failure. *Child Development Perspectives, 6,* 122-128. doi:10.1111/j.1750-8606.2011.00209.x

Wayne, P. M., Walsh, J. N., Taylor- Piliae, R. E., Wells, R. E., Papp, K. V., Donovan, N. J., & Yeh, G. Y. (2014). Effect of Tai Chi on cognitive performance in older adults: Systematic review and meta-analysis. *Journal of the American Geriatrics Society, 62*(1), 25-39. doi:10.1111/jgs.12611

Webster-Stratton, C. (2011). *The incredible years parents, teachers, and children training series: program content, methods, research and dissemination, 1980–2011.* Seattle, WA: Incredible Years, Inc.

Webster-Stratton, C., Reid, M. J., & Hammond, M. (2004). Treating children with early-onset conduct problems: Intervention outcomes for parent, child, and teacher training. *Journal of Clinical Child and Adolescent Psychology, 33,* 105-124. doi: 10.1207/S15374424JCCP3301_11

Wilson, B. A., Alderman, N., Burgess, P. W., Emslie, H., & Evans, J. J. (1996). *Behavioral Assessment of the Dysexecutive Syndrome (BADS).* UK: Thames Valley Test Company.

Young, S. E., Friedman, N. P., Miyake, A., Willcutt, E. G., Corley, R. P., Haberstick, B. C., & Hewitt, J. K. (2009). Behavioral disinhibition: Liability for externalizing spectrum disorders and its genetic and environmental relation to response inhibition across adolescence. *Journal of Abnormal Psychology, 118,* 117-130. doi:10.1037/a0014657

REVIEW AUTHORS

Lead review author:

Name:	Saiying Steenebergen-Hu
Title:	Research assistant professor, research director
Affiliation:	Northwestern University
Address:	617 Dartmouth Place
City, State, Province or County:	Evanston, Illinois
Postal Code:	60208-4175
Country:	United States
Phone:	847-491-7660
Email:	hu@northwestern.edu

Co-author(s):

Name:	Paula Olszewski-Kubilius
Title:	Professor, director
Affiliation:	Northwestern University
Address:	617 Dartmouth Place
City, State, Province or County:	Evanston, Illinois
Postal Code:	60208-4175
Country:	United States
Phone:	847-491-3856
Email:	p-olszewski-kubilius@northwestern.edu

Co-author(s):

Name:	Eric Calvert
Title:	Associate director
Affiliation:	Northwestern University
Address:	617 Dartmouth Place
City, State, Province or County:	Evanston, Illinois
Postal Code:	60208-4175
Country:	United States
Phone:	847-497-0185
Email:	eric.calvert@northwestern.edu

ROLES AND RESPONSIBILITIES

Content: Saiying Steenbergen-Hu, Paula Olszewski-Kubilius, & Eric Calvert

Systematic review methods: Saiying Steenbergen-Hu & Paula Olszewski-Kubilius

Statistical analysis: Saiying Steenbergen-Hu & Eric Calvert

Information retrieval: Saiying Steenbergen-Hu & Eric Calvert

FUNDING

This project receives generous funding support from The Jacobs Foundation and the Campbell Collaboration's Crime & Justice and Education Coordinating Groups, through the 2015 "Better Evidence for Children and Youth" program.

POTENTIAL CONFLICTS OF INTEREST

None.

PRELIMINARY TIMEFRAME

Estimated project period: **July, 2015 --- June 30th, 2017**

- Date to submit a draft protocol: **December 14th , 2015**
- Date to submit a draft review: **June 30th, 2017**

PLANS FOR UPDATING THE REVIEW

The leading author will be responsible for updating the review approximately every 5 years.

AUTHOR DECLARATION

Authors' responsibilities

By completing this form, you accept responsibility for preparing, maintaining, and updating the review in accordance with Campbell Collaboration policy. The Coordinating Group will provide as much support as possible to assist with the preparation of the review.

A draft protocol must be submitted to the Coordinating Group within one year of title acceptance. If drafts are not submitted before the agreed deadlines, or if we are unable to contact you for an extended period, the Coordinating Group has the right to de-register the title or transfer the title to alternative authors. The Coordinating Group also has the right to

de-register or transfer the title if it does not meet the standards of the Coordinating Group and/or the Campbell Collaboration.

You accept responsibility for maintaining the review in light of new evidence, comments and criticisms, and other developments, and updating the review every five years, when substantial new evidence becomes available, or, if requested, transferring responsibility for maintaining the review to others as agreed with the Coordinating Group.

Publication in the Campbell Library

The support of the Coordinating Group in preparing your review is conditional upon your agreement to publish the protocol, finished review, and subsequent updates in the Campbell Library. The Campbell Collaboration places no restrictions on publication of the findings of a Campbell systematic review in a more abbreviated form as a journal article either before or after the publication of the monograph version in *Campbell Systematic Reviews*. Some journals, however, have restrictions that preclude publication of findings that have been, or will be, reported elsewhere and authors considering publication in such a journal should be aware of possible conflict with publication of the monograph version in *Campbell Systematic Reviews*. Publication in a journal after publication or in press status in *Campbell Systematic Reviews* should acknowledge the Campbell version and include a citation to it. Note that systematic reviews published in *Campbell Systematic Reviews* and co-registered with the Cochrane Collaboration may have additional requirements or restrictions for co-publication. Review authors accept responsibility for meeting any co-publication requirements.

I understand the commitment required to undertake a Campbell review, and agree to publish in the Campbell Library. Signed on behalf of the authors:

Form completed by: Saiying Steenbergen-Hu Date: 16/12/2016

Table 1. Two Broad Categories of School-Based EF Interventions, Representative Programs, and Exemplary Studies

Intervention Category	Representative Programs	Exemplary Studies
School Curricula/Education Programs		
	Tools of the Mind	Barnett, W. S., Jung, K., Yarosz, D. J., Thomas, J., Hornbeck, A., Stechuk, R., & Burns, S. (2008). Educational effects of the Tools of the Mind curriculum: A randomized trial. *Early Childhood Research Quarterly, 23*(3), 299-313.
		Farran, D., & Wilson, S. (2014). Achievement and self-regulation in pre-kindergarten classrooms: Effects of the Tools of the Mind curriculum. *Manuscript submitted for publication*.
	Head Start REDI (Research-Based, Developmentally Informed)	Bierman, K. L., Domitrovich, C. E., Nix, R. L., Gest, S. D., Welsh, J. A., Greenberg, M. T., ... Gill, S. (2008). Promoting academic and social-emotional school readiness: The Head Start REDI program. *Child Development, 79*(6), 1802-1817. doi:10.1111/j.1467-8624.2008.01227.x
		Nix, R. L., Bierman, K. L., Domitrovich, C. E., & Gill, S. (2013). Promoting children's social-emotional skills in preschool can enhance academic and behavioral functioning in kindergarten: Findings from Head Start REDI. *Early Education and Development, 24*(7), 1000-1019. doi:10.1080/10409289.2013.825565
	PATHS Curriculum (Promoting Alternative Thinking Strategies)	Greenberg, M. T., Kusche, C. A., Cook, E. T., & Quamma, J. P. (1995). Promoting emotional competence in school-aged children: The effects of the PATHS curriculum. *Development and Psychopathology, 7*(1), 117-136. doi:10.1017/S0954579400006374
	CSRP (Chicago School Readiness Project)	Li-Grining, C., Haas, K., & Society for Research on Educational Effectiveness, (2010). Academic outcomes of the Chicago School Readiness Project in first grade: Do children's approaches to learning mediate treatment effects on academic skills? *Society for Research on Educational Effectiveness*, 1-8.
		Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development, 82*(1), 362-378. doi:10.1111/j.1467-8624.2010.01561.x
	The Incredible Years Program	Reinke, W. M., Herman, K. C., Dong, N., & Society for Research on Educational Effectiveness. (2014). The Incredible Year Teacher Classroom Management Program: Initial Findings from a Group Randomized Control Trial. *Society for Research on Educational Effectiveness*, 1-7.

Intervention Category	Representative Programs	Exemplary Studies
Mind-Body Interventions		
	Exercise-based programs	Altenburg, T. M., Chinapaw, M. J., & Singh, A. S. (2015). Effects of one versus two bouts of moderate intensity physical activity on selective attention during a school morning in Dutch primary schoolchildren: A randomized controlled trial. *Journal of Science and Medicine in Sport*, *19*(10), 820-824.
		Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., Allison, J. D., & Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. *Health Psychology, 30*(1), 91-98. doi:10.1037/a0021766
	Mindfulness-based Practices	Quach, D., Jastrowski Mano, K. E., & Alexander, K. (2016). A randomized controlled trial examining the effect of mindfulness meditation on working memory capacity in adolescents. *Journal of Adolescent Health*, *58*(5), 489-496. doi:10.1016/j.jadohealth.2015.09.024
		Sibinga, E. M., Perry-Parrish, C., Chung, S. E., Johnson, S. B., Smith, M., & Ellen, J. M. (2013). School-based mindfulness instruction for urban male youth: A small randomized controlled trial. *Preventive Medicine*, *57*(6), 799-801.

Table 2. Forty-five Preliminarily Eligible RCTs, Primary Outcomes and Main Measures

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
1	Altenburg, T. M., Chinapaw, M. J., & Singh, A. S. (2016). Effects of one versus two bouts of moderate intensity physical activity on selective attention during a school morning in Dutch primary schoolchildren: A randomized controlled trial. *Journal of Science and Medicine in Sport, 19,* 820-824.	N/A	**1) 'Sky Search' subtest of the 'Test of Selective Attention in Children' (TEA-Ch)**= measures attention
2	Baker-Henningham, H., Scott, S., Jones, K., & Walker, S. (2012). Reducing child conduct problems and promoting social skills in a middle-income country: cluster randomised controlled trial. *The British Journal of Psychiatry, 201*(2), 101-108.	N/A	**1) Dyadic Parent–Child Interaction** **2) Coding System (DPICS)**= measures the aggressive/ destructive and disruptive behaviors **3) Multi-Option Observation System for Experimental Studies (MOOSES)**= measures the aggressive/destructive and disruptive behaviors **4) Sutter–Eyberg Student Behavior Inventory (SESBI)**= measures child conduct problems **5) Connor's Global Index**= measures hyperactivity and attention difficulties **6) Strengths and Difficulties Questionnaire (SDQ)**= measures behavior difficulties 5and prosocial skills

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
			7) P6reschool and Kindergarten Behavior Scales (PKBS): Social Skills Scale= measures social skills **8) Eyberg Child Behavior Inventory (ECBI)**= measures child conduct problems
3	Barnett, W. S., Jung, K., Yarosz, D. J., Thomas, J., Hornbeck, A., Stechuk, R., & Burns, S. (2008). Educational effects of the Tools of the Mind curriculum: A randomized trial. *Early Childhood Research Quarterly, 23*, 299-313.	**1) Woodcock–Johnson Psycho-Educational Battery-Revised (WJ-R)**= measures the cognitive abilities and achievement **2) Bateria Psico-Educativa Revisada de Woodcock–Munoz (WM-R)**= measures cognitive abilities and achievement **3) Get Ready to Read (GRTR)**= measures progress in developing early literacy skills **4) IDEA Oral Language Proficiency Test (OLPT)**= measures the receptive and expressive language skills of Spanish-speaking children **5) Wechsler Preschool Primary scale of Intelligence Animal Pegs subtest (WPPSI)**= measures nonverbal problem solving and visual-motor proficiency and	N/A

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
		accuracy, concentration, and speed of performance **6) Peabody Picture Vocabulary Test-III (PPVT-III)**= measures standard English vocabulary development	
4	Conduct Problems Prevention Research Group. (1999). Initial impact of the Fast Track prevention trial for conduct problems: II. Classroom effects. *Journal of Consulting and Clinical Psychology, 67*(5), 648-657.	N/A	**1) Teacher Observation of Classroom Adaptation- Revised (TOCA–R)**= measures child behavior
5	Bierman, K. L., Coie, J. D., Dodge, K. A., Greenberg, M. T., Lochman, J. E., McMahon, R. J., & Pinderhughes, E. (2010). The effects of a multiyear universal social–emotional learning program: The role of student and school characteristics. *Journal of Consulting and Clinical Psychology, 78,* 156.	N/A	**1) Teacher Observation of Classroom Adaptation— Revised (TOCA–R)** **2) Social Health Profile (SHP)**= measures student health
6	Bierman, K. L., Nix, R. L., Domitrovich, C. E., Welsh, J. A., & Gest, S. D. (2010). Fostering school readiness with preschool interventions that promote social-emotional learning and language skills: The Head Start REDI Project. Paper presented at the Human Capital Research Collaborative Fall Conference, Minneapolis, MN.	Same as study#5above	Same as study#5 above
7	Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008).	Same as study#6above	Same as study#6 above

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
	Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Development and Psychopathology, 20,* 821-843.		
8	Blair, C., & Raver, C. C. (2014). Closing the achievement gap through modification of neurocognitive and neuroendocrine function: Results from a cluster randomized controlled trial of an innovative approach to the education of children in Kindergarten. *Plos ONE, 9,* 1-13. doi:10.1371/journal.pone.0112393	**1) Applied Problems and Letter-Word subtests from the Woodcock-Johnson III Tests of Achievement (WJ III)**= measures general scholastic aptitude, oral language, and academic achievement **2) Expressive One Word Picture Vocabulary Test (EOWPVT)**= measures vocabulary abilities **3) Raven Colored Progressive Matrices Test**= measures general reasoning	**1) Hearts and Flowers Task**= measures executive function **2) Flanker with Reverse Flanker Task**= measures executive function **3) NIH Toolbox version of the Dimensional** **4) Change Card Sort Task**= measures executive function **5) Dot-Probe Task**= measures emotional control
9	Clements, D. H., Sarama, J., Unlu, F., & Layzer, C. (2012). The efficacy of an intervention synthesizing scaffolding designed to promote self-regulation with an early mathematics curriculum: Effects on executive function. *Society for Research on Educational Effectiveness*, 1-7.	N/A	**1) HTKS**= measures inhibitory control and working memory **2) Pencil Tap**= measures inhibitory control **3) Forward & Backward Digit Span**= measures general attention and verbal working memory

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
10	Davis, C. L., Tomporowski, P. D., Boyle, C. A., Wailer, J. L., Miller, P. H., Naglieri, J. A., & Gregoski, M. (2007). Effects of aerobic exercise on overweight children's cognitive functioning: A randomized controlled trial. *Research Quarterly for Exercise & Sport, 78*, 510-519.	N/A	**1) Cognitive Assessment System (CAS)**= measures children's mental abilities defined on the basis of four interrelated cognitive processes: Planning, Attention, Simultaneous, and Successive (PASS).
11	Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., Allison, J. D., & Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. *Health Psychology, 30*, 91-98. doi:10.1037/a0021766	**1) Woodcock-Johnson Tests of Achievement III**= measures children's academic achievement	**1) Cognitive Assessment System (CAS)**
12	Dunning, D. L., Holmes, J., & Gathercole, S. E. (2013). Does working memory training lead to generalized improvements in children with low working memory? A randomized controlled trial. *Developmental Science, 16*(6), 915-925.	**1) Wechsler Abbreviated Scales of Intelligence (WASI)**= measures ability	**1) Automated Working Memory Assessment (AWMA)**= measures working memory **2) Following Instructions** **3) Detecting Rhymes** **4) Sentence Counting and Recall**
13	Dunning, D. L., Holmes, J., & Gathercole, S. E. (2013). Does working memory training lead to generalized improvements in children with low working memory? A randomized controlled trial. *Developmental Science, 16*, 915-925.	**1) Wechsler Abbreviated Scales of Intelligence (WASI)**= measures ability	**1) Automated Working Memory Assessment (AWMA)**= measures working memory **2) Following Instructions** **3) Detecting Rhymes** **4) Sentence Counting and Recall**

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
14	Flay, B. R. (2012). *Randomized evaluation of the Positive Action pre-K program.* Virginia Foundation for Healthy Youth and Positive Action, Inc., Retrieved from: https://www.positiveaction.net/research/downloads/pre-kindergarten-2012.pdf	**1) Positive Action (PA) Pre-K Program**	N/A
15	Flook, L., Smalley, S. L., Kitil, M. J., Galla, B. M., Kaiser-Greenland, S., Locke, J., ... Kasari, C. (2010). Effects of mindful awareness practices on executive functions in elementary school children. *Journal of Applied School Psychology, 26*, 70-95. doi:10.1080/15377900903379125	N/A	**1) Behavior Rating Inventory of Executive Function (BRIEF)**
16	Gallotta, M. C., Emerenziani, G. P., Iazzoni, S., Meucci, M., Baldari, C., & Guidetti, L. (2015). Impacts of coordinative training on normal weight and overweight/obese children's attentional performance. *Frontiers in Human Neuroscience, 9*(577), 1-9.	N/A	**1) d2-R Test of Attention**= measures sustained attention and concentration under stress induced by completion time.
17	Greenberg, M. T., Kusche, C. A., Cook, E. T., & Quamma, J. P. (1995). Promoting emotional competence in school-aged children: The effects of the PATHS curriculum. *Development And Psychopathology, 7*, 117-136. doi:10.1017/S0954579400006374	N/A	**1) Kusche Affective Interview Revised (KAI-R)**= measures children's emotional understanding **2) Wechsler Intelligence Scale for Children- Revised (WISC-R)**= measures vocabulary of feelings
18	Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N. A., Raine, L. B., Scudder, M. R., ...	N/A	**1) Modified Flanker Task**= measures attentional inhibition

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
	Kamijo, K. (2014). Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics, 134*, e1063-e1071.		**2) Color-Shape Switch Task**= measures cognitive flexibility
19	Hutchings, J., Martin-Forbes, P., Daley, D., & Williams, M. E. (2013). A randomized controlled trial of the impact of a teacher classroom management program on the classroom behavior of children with and without behavior problems. *Journal of School Psychology, 51*, 571-585.	N/A	**1) Teacher version of the Strengths and Difficulties Questionnaire (TSDQ)**= measures hyperactivity problems, peer problems, emotional problems, and conduct problems **2) Teacher–Pupil Observation Tool (TPOT)**= measures the frequency of teacher and child behaviors
20	Kamijo, K., Pontifex, M. B., O'Leary, K. C., Scudder, M. R., Wu, C., Castelli, D. M., & Hillman, C. H. (2011). The effects of an afterschool physical activity program on working memory in preadolescent children. *Developmental Science, 14*, 1046-1058. doi:10.1111/j.1467-7687.2011.01054.x	N/A	**1) Sternberg Task**= measures memory
21	Lemberger, M. E., Selig, J. P., Bowers, H., & Rogers, J. E. (2015). Effects of the student success skills program on executive functioning skills, feelings of connectedness, and academic achievement in a predominantly Hispanic, low-income middle school district. *Journal of Counselling & Development, 93*, 25-37. doi:10.1002/j.1556-6676.2015.00178.x	**1) DEA**= academic achievement assessment	**1) Behavior Rating Inventory of Executive Function- Self Report (BRIEF-SR)** **2) Child and Adolescent Social Support Scale**= measures youth's perceptions of social support

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
22	Lewis-Morrarty, E., Dozier, M., Bernard, K., Terracciano, S. M., & Moore, S. V. (2012). Cognitive flexibility and theory of mind outcomes among foster children: Preschool follow-up results of a randomized clinical trial. *Journal of Adolescent Health, 51*, S17-S22.	**1) Peabody Picture Vocabulary Test–Third Edition (PPVT-III)**	**1) Dimensional Change Card Sort (DCCS)** **2) Penny-Hiding Game**= measures children's theory of mind abilities. **3) Brief Symptom Inventory (BSI)**
23	Li-Grining, C., Haas, K., & Society for Research on Educational Effectiveness, (2010). Academic outcomes of the Chicago School Readiness Project in first grade: Do children's approaches to learning mediate treatment effects on academic skills? *Society for Research on Educational Effectiveness*, 1-8.	**1) Early Childhood Longitudinal Study – Kindergarten Cohort (ECLS-K)**= measures academic skills **2) Peabody Picture Vocabulary Test (PPVT-III)**	**1) Cooper Farran Behavior Rating Scale (CFBRS)**= measures children's on-task behavior **2) Preschool Self-Regulation Assessment (PSRA)**= measures self-regulation **3) Balance Beam Task**= measures executive functions **4) Pencil Tap Task**= measures executive functions **5) Toy Wrap, Toy Wait, Snack Delay, and Tongue Task**= measures effortful control **6) Social Competence and Behavior Evaluation (SCBE-30)**= measures social competency
24	Lonigan, C. J., Phillips, B. M., Clancy, J. L., Landry, S. H., Swank, P. R., Assel, M., ... Eisenberg, N. (2015). Impacts of a comprehensive school readiness curriculum	**1) Pattern Analysis subtest of the Stanford–Binet Intelligence Scales, 4th ed. (SB–IV)**=	**1) Social Competence and Behavior Evaluation (SCBE)**= measures children's classroom behaviors

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
	for preschool children at risk for educational difficulties. *Child Development, 86*, 1773-1793.	measures nonverbal cognitive ability **2) EOWPVT** **3) TOPEL** **4) Child Math Assessment (CMA)**= measures young children's informal math knowledge across a range of concepts	
25	Monti, J. M., Hillman, C. H., & Cohen, N. J. (2012). Aerobic fitness enhances relational memory in preadolescent children: The FITKids randomized control trial. *Hippocampus, 22*, 1876-1882. doi:10.1002/hipo.22023	N/A	**1) "Memory task inspired by Hannula et al. (2007)"**
26	Nix, R. L., Bierman, K. L., Domitrovich, C. E., & Gill, S. (2013). Promoting children's social-emotional skills in preschool can enhance academic and behavioral functioning in kindergarten: Findings from Head Start REDI. *Early Education and Development, 24*, 1000-1019. doi:10.1080/10409289.2013.825565	**1) Expressive One-Word Picture Vocabulary Test**= measures vocabulary **2) Blending and Elision subtests from the Test of Preschool Early Literacy**= measures literacy skills	**1) Assessment of Children's Emotion Skills**= measures emotional understanding **2) Emotion Recognition Questionnaire**= measures emotional understanding **3) Challenging Situations Task**= measures children's competent social problem solving **4) Social Competence Scale** **5) Teacher Observation of Child Adaptation-Revised**

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
27	Nix, R. L., Bierman, K. L., Heinrichs, B. S., Gest, S. D., Welsh, J. A., & Domitrovich, C. E. (2016). The randomized controlled trial of Head Start REDI: Sustained effects on developmental trajectories of social–emotional functioning. *Journal of Consulting and Clinical Psychology, 84*, 310-322. doi:10.1037/a0039937	Same as study#26 above	Same as study#26 above
28	Peng, P. (2015). Drill and practice versus rehearsal: An experimental study of two approaches to strengthen verbal working memory and comprehension among young children. *Dissertation Abstracts International Section A, 76*(4-A), 1-32.	**1) WASI Matrix Reasoning**= measures non-verbal IQ **2) Woodcock–Johnson Oral Comprehension subtest**= measures listening comprehension **3) Word Identification Subtest of the Woodcock Reading Mastery Test-** **Revised**= measures word reading	**1) Counting Figures**= measures working memory **2) Calculation Span**= measures working memory **3) Operation Span**= measures working memory **4) Puzzles tasks**= measures working memory
29	Quach, D., Jastrowski Mano, K. E., & Alexander, K. (2015). A randomized controlled trial examining the effect of mindfulness meditation on working memory capacity in adolescents. *Journal of Adolescent Health, 58*, 489-496. doi:10.1016/j.jadohealth.2015.09.024	N/A	**1) Automated Operation Span Task (AOSPAN)**= measures working memory capacity **2) Perceived Stress Scale 10 (PSS-10)**= measures perceived stressful situations that may occur in daily life **3) Child Acceptance and Mindfulness Measure (CAMM)**= measures the degree to which respondents observe internal

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
			experiences, act with awareness, and accept internal experiences in a nonjudgmental manner.
30	Raver, C. C., Jones, S. M., Li-Grining, C. P., Metzger, M., Champion, K. M., & Sardin, L. (2008). Improving preschool classroom processes: Preliminary findings from a randomized trial implemented in Head Start settings. *Early Childhood Research Quarterly, 23*, 10-26.	N/A	**1) Classroom Assessment Scoring System (CLASS)**= measures classroom positive climate, negative climate, teacher sensitivity, and behavior management. **2) Early Childhood Environment Rating Scale, revised edition (ECERS-R)**= measures classroom positive climate, negative climate, teacher sensitivity, and behavior management
31	Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development, 82*(1), 362-378. doi:10.1111/j.1467-8624.2010.01561.x	**1) Peabody Picture Vocabulary Test (PPVT)** **2) Test de Vocabulario en Imagenes Peabody (TVIP)**= Spanish-language version of PPVT	**1) Preschool Self-Regulation Assessment (PSRA) Assessor Report**= measures self-regulation **2) Balance Beam task** **3) Pencil Tap task** **4) Toy Wrap**= measures effortful control **5) Toy Wait**= measures effortful control **6) Snack Delay**= measures effortful control **7) Tongue Task**= measures effortful control

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
32	Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F., Metzger, M. W., & Solomon, B. (2009). Targeting children's behavior problems in preschool classrooms: A cluster-randomized controlled trial. *Journal of Consulting and Clinical Psychology, 77*(2), 302-316. doi:10.1037/a0015302	Same as study#31 above	Same as study#31 above
33	Reinke, W. M., Herman, K. C., Dong, N., & Society for Research on Educational Effectiveness. (2014). The Incredible Year Teacher Classroom Management Program: Initial findings from a group randomized control trial. *Society for Research on Educational Effectiveness*, 1-7.	N/A	**1) Teacher Observation of Classroom Adaptation-Checklist (TOCA-C)**= measures student behavior **2) Revised Social Competence Scale-Teacher version (T-COMP)**= measures the teacher's perception of a student's prosocial behavior, emotional self-regulation, and academic competence
34	Staiano, A. E., Abraham, A. A., & Calvert, S. L. (2012). Competitive versus cooperative exergame play for African American adolescents' executive function skills: Short-term effects in a long-term training intervention. *Developmental Psychology, 48*(2), 337-342. doi:10.1037/a0026938	**1) Delis–Kaplan Executive Function System (D–KEFS)**= measures executive functioning	**N/A**
35	Thorell, L. B., Lindqvist, S., Nutley, S. B., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science,*	N/A	**1) Adapted version of the Day-Night Stroop Task**= measures interference control

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
	12(1), 106-113. doi:10.1111/j.1467-7687.2008.00745.x		**2) Go/no-go task**= measures response inhibition **3) Span board task from WAIS-R-NI**= measures visuo-spatial WM **4) Word span task**= measures verbal WM **5) Auditory continuous performance task (CPT) from NEPSY**= measures auditory attention **6) Block Design Subtest from WPPSI-R**= measures problem solving
36	Tominey, S. M., Wanless, S. B., McClelland, M. M., & Society for Research on Educational Effectiveness. (2009). From head to toes: Preliminary findings from a pilot self-regulation intervention over the pre-Kindergarten year. *Society for Research on Educational Effectiveness*.	**1) Woodcock Johnson Psycho-Educational Battery-III**	**1) Head-Toes-Knees-Shoulders Task (HTKS)**
37	Tomporowski, P. D., Davis, C. L., Lambourne, K., Gregoski, M., & Tkacz, J. (2008). Task switching in overweight children: effects of acute exercise and age. *Journal of Sport & Exercise Psychology, 30*(5), 497-511.	N/A	**1) Switch Task**
38	Ursache, A., Blair, C., Bierman, K., Nix, R., & Society for Research on Educational Effectiveness. (2011). Executive function as a	**1) Letter-Word subtests from the Woodcock-Johnson III Tests of Achievement (WJ III)**	**1) School Readiness Questionnaire**= measures learning behaviors

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
	mediator of effects on Kindergarten learning behaviors one year after the pre-K Head Start REDI intervention. *Society for Research on Educational Effectiveness*, 1-7.	**2) Word Attack Skills from TOWRE**	
39	Wilson, S. J., & Farran, D. C. (2012). Experimental evaluation of the Tools of the Mind preschool curriculum. *Society for Research on Educational Effectiveness*, 1-9.	**1) 7 subtests from the Woodcock-Johnson**= measures achievement	N/A
40	Zhai, F., Raver, C. C., Jones, S. M., Li-Grining, C. P., Pressler, E., & Gao, Q. (2010). Dosage effects on school readiness: Evidence from a randomized classroom-based intervention. *Social Service Review, 84*(4), 615-654. doi:10.1086/657988	**1) Peabody Picture Vocabulary Test (PPVT)**	**1) Behavior Problem Index (BPI)** **2) Preschool Self Regulation Assessment-Assessor Report**
41	Noggle, J. J., Steiner, N. J., Minami, T., & Khalsa, S. B. S. (2012). Benefits of yoga for psychosocial well-being in a US high school curriculum: A preliminary randomized controlled trial. *Journal of Developmental & Behavioral Pediatrics, 33*, 193-201.	N/A	**1) Profile of Mood States-Short Form (POMS-SF)**= measures mood **2) Positive and Negative Affect Schedule for Children (PANAS-C)**= measures affect **3) Perceived Stress Scale (PSS)**= measures perceived stress **4) Inventory of Positive Psychological Attitudes-32R (IPPA)**= measures Self-confidence During Stress and Life Purpose and Satisfaction.

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
			5) Resilience Scale (RS)= measures resilience **6) State-Trait Anger Expression Inventory-2TM (STAXI-2)**= measures anger expression **7) Child Acceptance and Mindfulness Measure (CAMM)**
42	Britton, W. B., Lepp, N. E., Niles, H. F., Rocha, T., Fisher, N. E., & Gold, J. S. (2014). A randomized controlled pilot trial of classroom-based mindfulness meditation compared to an active control condition in sixth-grade children. *Journal of School Psychology, 52*, 263-278.	N/A	**1) Youth Self Report (YSR)**= measures general well being **2) Spielberger State-Trait Anxiety Inventory— Child version (STAI-C)**= measures affect **3) Cognitive and Affective Mindfulness Scale (CAMS-R)**= measures mindfulness
43	Sibinga, E. M., Perry-Parrish, C., Chung, S. E., Johnson, S. B., Smith, M., & Ellen, J. M. (2013). School-based mindfulness instruction for urban male youth: a small randomized controlled trial. *Preventive Medicine, 57*, 799-801.	N/A	**1) Symptom Checklist-90R**= measures psychological functioning, coping, and mindfulness
44	Poehlmann-Tynan, J., et al. (2016). A pilot study of contemplative practices with economically disadvantaged preschoolers: Children's empathic and self-regulatory behaviors. *Mindfulness, 7*(1), 46-58.	N/A	**1) Distress Task**= measures empathic response in children **2) Attachment Story Completion Task (ASCT)**= measures children's representations of empathic and

ID	Study Reference	Measures of Two Primary Outcomes	
		Academic Outcomes	**Non-Academic Outcomes**
			compassionate responding within the family context. **3) Head-Toes-Knees-Shoulders Task (HTKS)** **4) Go/No-Go Task**
45	Pears, K. C., Healey, C. V., Fisher, P. A., Braun, D., Gill, C., Conte, H. M., ... Ticer, S. (2014). Immediate effects of a program to promote school readiness in low-income children: Results of a pilot study. *Education & Treatment of Children, 37*(3), 431-460.	**1) Dynamic Indicators of Basic Early Literacy Skills (DIBELS)**= measures children's letter-naming skills and initial-sound recognition **2) Wechsler Preschool and Primary Scales of Intelligence-Third edition**	**1) Head Toes Knees and Shoulders (HTKS) Test**

Table 3. Key Direct Outcomes and Measures of a Sample of 23 Eligible RCTs

#	Study Reference	Key Direct Outcomes	Measures of Outcomes
1	Blair, C., & Raver, C. C. (2014). Closing the achievement gap through modification of neurocognitive and neuroendocrine function: Results from a cluster randomized controlled trial of an innovative approach to the education of children in Kindergarten. *Plos ONE, 9*(11), 1-13. doi:10.1371/journal.pone.0112393	Cognitive Flexibility/ Inhibitory Control	Hearts and Flowers Task (Variation of the Dot-Probe Task)
		Cognitive Flexibility	Dimensional Change Card Sort Task (NIH Toolbox)
		Cognitive Flexibility	Dot-Probe Task
		Working Memory	Forward/Backward Digit Span task
		Inhibitory Control	Flanker with Reverse Flanker Task
2	Clements, D. H., Sarama, J., Unlu, F., & Layzer, C. (2012). The efficacy of an intervention synthesizing scaffolding designed to promote self-regulation with an early mathematics curriculum: Effects on executive function. *Society for Research on Educational Effectiveness*, 1-7.	Inhibitory Control	Pencil Tap Task
		Verbal working memory	Forward & Backward Digit Span
		Inhibitory Control and Working Memory	Head-Toes-Knees-Shoulders (HTKS)
3	Dunning, D. L., Holmes, J., & Gathercole, S. E. (2013). Does working memory training lead to generalized improvements in children with low working memory? A randomized controlled trial. *Developmental Science, 16*(6), 915-925.	Working Memory	Automated Working Memory Assessment (AWMA)
		Working Memory	Following Instructions Task
		Working Memory	Detecting Rhymes Task
		Working Memory	Sentence Counting and Recall Task
4	Farran, D., & Wilson, S. (2014). Achievement and self-regulation in pre-kindergarten classrooms: Effects of the Tools of the Mind curriculum. *Manuscript submitted for publication*.	Cognitive Flexibility	Dimensional Change Card Sort (DCCS)
		Attention and Visual-Spatial Skills	Copy Design Task
		Working Memory	Corsi Block-Tapping Task
		Inhibitory Control	Peg Tapping

		Inhibitory Control	Head-Toes-Knees-Shoulders (HTKS)
5	Flook, L., Smalley, S. L., Kitil, M. J., Galla, B. M., Kaiser-Greenland, S., Locke, J., ... Kasari, C. (2010). Effects of mindful awareness practices on executive functions in elementary school children. *Journal of Applied School Psychology*, *26*(1), 70-95. doi:10.1080/15377900903379125	Inhibitory control, Task Switching, Working Memory, Planning	Behavior Rating Inventory of Executive Function (BRIEF)
6	Greenberg, M. T., Kusche, C. A., Cook, E. T., & Quamma, J. P. (1995). Promoting emotional competence in school-aged children: The effects of the PATHS curriculum. *Development and Psychopathology*, *7*(1), 117-136. doi:10.1017/S0954579400006374	Working Memory	Wechsler Intelligence Scale for Children- Revised (WISC-R)
7	Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N. A., Raine, L. B., Scudder, M. R., ... & Kamijo, K. (2014). Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics*, *134*(4), e1063-e1071.	Inhibitory Control	Modified Flanker Task
		Cognitive Flexibility	Color-Shape Switch Task
8	Kamijo, K., Pontifex, M. B., O'Leary, K. C., Scudder, M. R., Wu, C., Castelli, D. M., & Hillman, C. H. (2011). The effects of an afterschool physical activity program on working memory in preadolescent children. *Developmental Science*, *14*(5), 1046-1058. doi:10.1111/j.1467-7687.2011.01054.x	Working Memory	Sternberg Task
9	Lemberger, M. E., Selig, J. P., Bowers, H., & Rogers, J. E. (2015). Effects of the student success skills program on executive functioning skills, feelings of connectedness, and academic achievement in a predominantly Hispanic, low-income middle school district. *Journal of Counseling & Development*, *93*(1), 25-37. doi:10.1002/j.1556-6676.2015.00178.x	Inhibitory control, Task Switching, Working Memory, Planning	Behavior Rating Inventory of Executive Function- Self Report (BRIEF-SR)

10	Lewis-Morrarty, E., Dozier, M., Bernard, K., Terracciano, S. M., & Moore, S. V. (2012). Cognitive flexibility and theory of mind outcomes among foster children: Preschool follow-up results of a randomized clinical trial. *Journal of Adolescent Health, 51*(2), S17-S22.	Cognitive Flexibility	Dimensional Change Card Sort (DCCS)
		Cognitive Flexibility	Penny-Hiding Game
11	Li-Grining, C., Haas, K., & Society for Research on Educational Effectiveness, (2010). Academic outcomes of the Chicago School Readiness Project in first grade: Do children's approaches to learning mediate treatment effects on academic skills? *Society for Research on Educational Effectiveness*, 1-8.	Inhibitory Control/ Self-Regulation	Preschool Self-Regulation Assessment (PSRA) (Tests which it includes are listed below)
		Inhibitory Control or Motor Inhibition	Balance Beam Task
		Inhibitory Control	Pencil Tap Task
		Effortful Control	Toy Wrap, Toy Wait, Snack Delay, and Tongue Task
12	Monti, J. M., Hillman, C. H., & Cohen, N. J. (2012). Aerobic fitness enhances relational memory in preadolescent children: The FITKids randomized control trial. *Hippocampus, 22*(9), 1876-1882. doi:10.1002/hipo.22023	Working Memory	"Memory task inspired by Hannula et al. (2007)"
13	Peng, P. (2015). Drill and practice versus rehearsal: An experimental study of two approaches to strengthen verbal working memory and comprehension among young children. *Dissertation Abstracts International Section A, 76*(4-A).	Working Memory	Counting Recall (Adaptation from the Working Memory Test Battery for Children)
		Working Memory	Listening Recall (Adaptation from the Working Memory Test Battery for Children)
		Working Memory	Digit Recall (Adaptation from the Working Memory Test Battery for Children)

14	Quach, D., Jastrowski Mano, K. E., & Alexander, K. (2015). A randomized controlled trial examining the effect of mindfulness meditation on working memory capacity in adolescents. Journal of Adolescent Health, 58(5), 489-496. doi:10.1016/j.jadohealth.2015.09.024	Working Memory	Automated Operation Span Task (AOSPAN)
15	Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development, 82*(1), 362-378. doi:10.1111/j.1467-8624.2010.01561.x	Inhibitory Control/ Self-Regulation	Preschool Self-Regulation Assessment (PSRA) (Tests which it includes are listed below)
		Inhibitory Control or Motor Inhibition	Balance Beam Task
		Inhibitory Control	Pencil Tap Task
		Effortful Control	Toy Wrap, Toy Wait, Snack Delay, and Tongue Task
16	Staiano, A. E., Abraham, A. A., & Calvert, S. L. (2012). Competitive versus cooperative exergame play for African American adolescents' executive function skills: Short-term effects in a long-term training intervention. *Developmental Psychology, 48*(2), 337-342. doi:10.1037/a0026938	Key components of executive functions within verbal and spatial modalities	Delis-Kaplan Executive Function System (D-KEFS)
17	Thorell, L. B., Lindqvist, S., Nutley, S. B., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science, 12*(1), 106-113. doi:10.1111/j.1467-7687.2008.00745.x	Inhibitory Control/ Interference Control	Adapted version of the Day-Night Stroop Task
		Inhibitory Control/ Response Inhibition	Go/no-go task
		Working Memory/ Visuo-Spatial Working Memory	Span board task from WAIS-R-NI

		Working Memory/ Verbal Working Memory	Word span task
18	Tominey, S. M., Wanless, S. B., McClelland, M. M., & Society for Research on Educational Effectiveness. (2009). From head to toes: Preliminary findings from a pilot self-regulation intervention over the pre-Kindergarten year. *Society for Research on Educational Effectiveness*, 1-11.	Inhibitory Control/ Self-Regulation	Head-Toes-Knees-Shoulders Task (HTKS)
19	Tomporowski, P. D., Davis, C. L., Lambourne, K., Gregoski, M., & Tkacz, J. (2008). Task switching in overweight children: effects of acute exercise and age. *Journal of Sport & Exercise Psychology, 30*(5), 497-511.	Cognitive Flexibility/ Task Switching	Switch Task Protocol
20	Ursache, A., Blair, C., Bierman, K., Nix, R., & Society for Research on Educational Effectiveness. (2011). Executive function as a mediator of effects on Kindergarten learning behaviors one year after the pre-K Head Start REDI intervention. *Society for Research on Educational Effectiveness*, 1-7.	Working Memory	Backward Word Span Task
		Inhibitory Control	The Peg Tapping Task
		Inhibitory Control / Attention Shifting	The Dimensional Change Card Sort Task
21	Wilson, S. J., & Farran, D. C. (2012). Experimental evaluation of the Tools of the Mind preschool curriculum. *Society for Research on Educational Effectiveness*, 1-9.	Inhibitory Control and Working Memory	Head-Toes-Knees-Shoulders Task (HTKS)
		Cognitive Flexibility	Dimensional Change Card Sort
		Inhibitory Control	Peg Tapping
22	Poehlmann-Tynan, J., et al. (2016). A pilot study of contemplative practices with economically disadvantaged preschoolers: Children's empathic and self-regulatory behaviors. *Mindfulness, 7*(1), 46-58.	Inhibitory Control/ Self-Regulation	Head-Toes-Knees-Shoulders Task (HTKS)
		Inhibitory Control	Go/No-Go Task

23	Pears, K. C., Healey, C. V., Fisher, P. A., Braun, D., Gill, C., Conte, H. M., ... Ticer, S. (2014). Immediate effects of a program to promote school readiness in low-income children: Results of a pilot study. *Education & Treatment of Children*, *37*(3), 431-460.	Inhibitory Control/ Self-Regulation	Head Toes Knees and Shoulders (HTKS) Test

Table 4. Preliminary Coding Protocol [a]

Item	Description	Notes
Section 1: Study Identification		
1	Study ID:	
2	Author(s) and year: e.g., Smith & Tuck, 1995	
3	Type of report (select one) 1) Journal article 2) Book/book chapter 3) Government report (e.g., federal, state, local) 4) Thesis or dissertation 5) Conference proceedings 6) Unpublished past report (e.g., non-government technical report) 7) Unpublished in press/in progress manuscript 8) Other(specify)	
Section 2: Study Context		
1	Country in which the study was conducted: 1) USA 2) Canada 3) UK 4) Australia 5) Other country (specify) 6) Cannot tell	
2	Regional location of the research site: 1) Suburban 2) Urban 3) Rural 4) Mixed	

	5) Cannot tell	
3	The motivation behind the implementation of the interventions in a study 1) Research program (i.e., whether the intervention was carried out mainly because of researchers' interest and initiation) 2) Demonstration program (i.e., whether the intervention took place as quasi-real-world test of a school program) 3) Real-world or routine program (i.e., whether the intervention was already in place prior to researchers' involvement to assess the intervention's efficacy)	
Section 3: Sample Description		
1	No. of participants (for treatment group, comparison group, and total)	
2	Gender (as described in the study)	
3	Age (3-18 years-old)	
4	Grade level 1) Early childhood (e.g., 3-years old to preschool) 2) Elementary school (K-5) 3) Middle school (6-8) 4) High school (9-12) 5) Mixture of grade levels 6) Cannot tell	
5	Race information(as described in the study)	
6	Socio-economic status (as described in the study)	
7	Participants attrition rate (treatment group, comparison group, or two groups combined)	
8	Reason for attrition (as described in the study)	

Section 4: Description of Intervention and Comparison Conditions		
1	Intervention condition (as described in the study)	
2	Comparison condition (as described in the study)	
3	Categorization of the intervention and comparison conditions (i.e., we will re-code them in relatively broad categories based on the description of intervention and comparison conditions across all eligible studies.)	
4	The primary setting of the intervention: 1) School 2) After-school program in the school context 3) Child care settings 4) Other (specify)	
5	Who delivered the intervention (select all that apply)? 1) Teachers 2) Childcare caregivers 3) School psychologists/counselors 4) Professionals from outside of the intervention settings	
6	Did the person(s) who delivered the intervention received any training on how to implement the intervention? 1) Yes (specify) 2) No	
7	Who was/were involved in the intervention (select all that apply)? 1) Children/adolescents/students 2) Teachers/childcare caregivers 3) School psychologists or other school personnel	

8	Role of research team in the intervention (select all that apply) 1) Designed the intervention 2) Planned the intervention 3) Delivered the intervention 4) Independent to the intervention (e.g., conducting research only)	
9	Describe the key features/processes of the EF intervention implementations as reported in the primary study.	
10	Were efforts made to monitor and measure the fidelity of implementation? 1) Yes (specify how, such as:) • Observations • Interviews of participants • Surveys of participants • Participant logs • Administrative records • Checklists • Other 2) No	
11	Dosage/duration/frequency of the intervention (as described in the study)	
12	Dosage/duration/frequency of the intervention (re-categorization by the review authors) 1) Short (2 weeks/10 hours or above, but less than 3 months/20 hours) 2) Medium length (3 months to 6 months) 3) Long (6 months or above)	
Section 5: Research Design		
1	Major categories of randomized controlled trials (RCTs) design:	

	1) parallel group trials (i.e., complete randomization) 2) cross-over trials 3) cluster-randomized trials 4) factorial trials	
2	Unit of assignment to conditions: 1) Individual 2) Group/cluster/sites (specify)	
3	Unit of analysis: 1) Individual 2) Group/cluster/sites (specify)	
4	Were the participants blinded to their conditions? 1) Yes 2) No	
5	Was the data collector blind to the group assignment? 1) Yes 2) No	
6	Results of statistical comparisons of pre-intervention group differences 1) No statistically significant differences 2) Statistically significant differences 3) No comparisons were made	
7	Upon what kind of the statistical analyses were the major findings of the primary study based? 1) Descriptive analysis 2) *t*-tests 3) ANOVA/MONAVA 4) ANCOVA/MONCOVA 5) Regression/multiple regression	

	6) Factor analysis 7) Path analysis 8) Hierarchical linear regression (HLM) 9) Other (specify)	
8	Were any influences of confounding factors taken into consideration in the data analyses of the primary studies? 1) Yes (Specify the factors) 2) No	
Section 6: Outcome Measures		
1	Outcomes, such as: 1) Academic or cognitive outcomes (e.g., pre-academic skills, scores in cognitive ability tests, and scores in achievement tests) 2) Executive function 3) Social-emotional 4) Behavioral/conduct performances ... *Note*. We will first record all relevant outcomes as reported in each primary study included. After finish coding all studies we will then recode the outcomes into categories as described in the Outcomes section of the review protocol (also shown in Table 2), i.e., primary/secondary, direct or indirect, as well as academic or non-academic outcomes.	
2	Types of outcome measures (record all that apply) 1) Achievement/cognitive outcome measures (e.g., standardized test scores, course grades) 2) Performance-based EF measures 3) Rating scales, survey, questionnaire, and checklist 4) Behavioral observation	
3	Source of outcome data: 1) Self 2) Parent report 3) Teacher report/caregiver report	

	4) Achievement or cognitive assessments 5) Other	
4	Were the measures of outcomes demonstrated adequate reliability and validity in existing research? 1) Yes (specify) 2) No	
5	When did the post-test measure(s) take place? 1) Immediately following the intervention 2) Follow-up/delayed (specify)	
6	Quantitative information on outcomes of interests (e.g., means, standard deviations, *t*-values) (Note: all related outcomes will be extracted from the study and will be recorded in an Excel file for effect size calculations)	
7	Effect size calculation (e.g., Hedges' *g*, odd ratio, and page number where the related outcome data located in the primary studies for each effect size, etc.)	
Section 7: Coding Information		
1	Coder	
2	Coding time: How much time (minutes) does it take to complete the coding?	
3	Date of coding	
4	Coding agreement rate with another independent coder (%)	

5	Areas/reasons of coding discrepancies (specify)	
6	How coding discrepancies were resolved (specify)	

Note. [a] This coding protocol was developed by incorporating many thoughtful ideas and examples from articles on meta-analysis coding techniques (e.g., Wilson, 2009) and some recent study or systematic reviews on EF interventions (e.g., Farran & Wilson, 2014; Jacob & Parkinson, 2015).

Appendix. A List of Relevant Recent Reviews

Anderson, L. S., Shin, C., Fullilove, M. T., Scrimshaw, S. C., Fielding, J. E., Normand, J., et al. (2003). The effectiveness of early childhood development programs: A systematic review. *American Journal of Preventive Medicine, 24*(suppl. 3), 32–46. http://www.prevention.psu.edu/projects/documents/Domitrovich_etalpreschoolPATHSJPrimaryPrevent2006.pdf

Cantin, R. H., Mann, T. D., & Hund, A. M. (2012). Executive Functioning Predicts School Readiness and Success: Implications for Assessment and Intervention. *Communique, 41*(4), 1.

Casey, E. C., Finsaas, M., Carlson, S. M., Zelazo, P. D., Murphy, B., Durkin, F., & ... Masten, A. S. (2014). Promoting resilience through executive function training for homeless and highly mobile preschoolers. In S. Prince-Embury, D. H. Saklofske, S. Prince-Embury, D. H. Saklofske (Eds.) , *Resilience interventions for youth in diverse populations* (pp. 133-158). New York, NY, US: Springer Science + Business Media. doi:10.1007/978-1-4939-0542-3_7

Jacob, R. & Parkinson, J. (2015). The potential for school-based interventions that target executive function to improve academic achievement: A review. *Review of Educational Research.* Advance Online Publication. doi: 10.3102/0034654314561338

Karch, D., Albers, L., Renner, G., Lichtenauer, N., & von Kries, R. (2013). The efficacy of cognitive training programs in children and adolescents: A meta-analysis. *Deutsches Artteblatt International, 110*(39), 643-652. doi: 10.3238/arztebl.2013.0643.http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3804756/

McCloskey, G., Gilmartin, C., & Vitanza, B. S. (2014). Interventions for students with executive skills and executive functions difficulties. In J. T. Mascolo, V. C. Alfonso, D. P. Flanagan, J. T. Mascolo, V. C. Alfonso, D. P. Flanagan (Eds.) , *Essentials of planning, selecting, and tailoring interventions for unique learners* (pp. 314-356). Hoboken, NJ, US: John Wiley & Sons Inc.

Melby-Lervåg, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Developmental Psychology, 49*(2), 270-291.

Riccio, C. A., & Gomes, H. (2013). Interventions for executive function deficits in children and adolescents. *Applied Neuropsychology: Child, 2*(2), 133-140. doi:10.1080/21622965.2013.748383

Smith, P. J., Blumenthal, J. A., Hoffman, B. M., Cooper, H., Strauman, T. A., Welsh-, K., .. Sherwood, A. (2010). Aerobic exercise and neurocognitive Performance: Ameta-analytic review of randomized controlled trials. *Psychosomatic Medicine, 72*(3), 239-252.http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2897704/

SPARKS, S. D. (2015). The Potential for School-Based Interventions That Target Executive Function to Improve Academic Achievement: A Review. *Education Week, 34*(24), 5.