

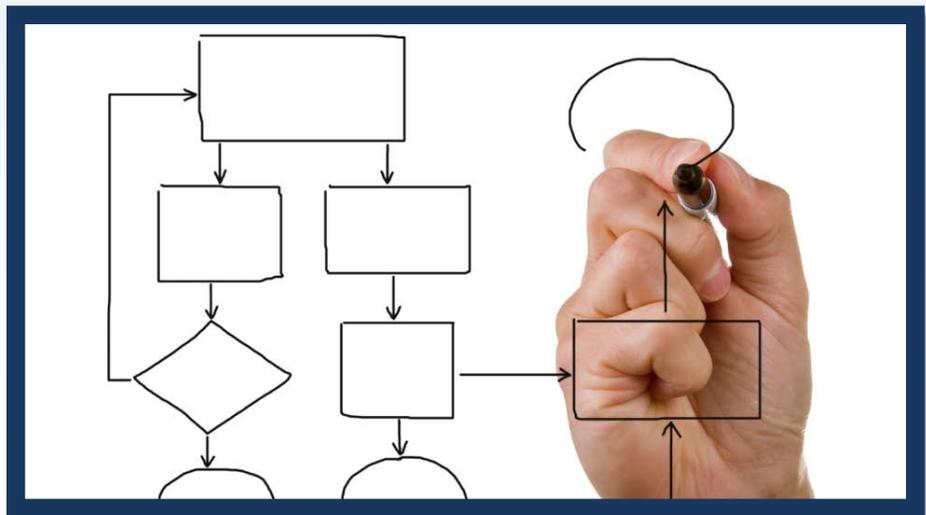
# EXECUTIVE FUNCTION MAPPING PROJECT:

Untangling the Terms and Skills Related  
to Executive Function and Self-Regulation  
in Early Childhood

Project Report

OPRE Report # 2016-88

October 2016



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Suggested citation: Jones, S. M., Bailey, R., Barnes, S. P., & Partee, A. (2016). Executive Function Mapping Project: Untangling the Terms and Skills Related to Executive Function and Self-Regulation in Early Childhood. OPRE Report # 2016-88, Washington, DC: Office of Planning, Research and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services.

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# I. Introduction

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**Executive function (EF)** is increasingly used to refer to a variety of skills including attention, self-control, emotion regulation, creativity, and problem solving, among others. This poses a challenge for stakeholders in early childhood programs and services, who need to be able to identify research findings that are tied to specific skills. Current investment and interest in children’s EF presents an opportunity to equip key stakeholders with the tools to untangle and interpret the meaningful differences between EF and regulation-related skills.

***We define “EF” as the following skills: working memory, response inhibition, attention shifting (also called cognitive flexibility), and attention control.<sup>1</sup>***

***We define “regulation-related skills” as a broader set of skills including self-control, emotion regulation, EF, problem solving, and grit, among others.***

*Note: EF is typically comprised of working memory, inhibition, attention shifting, and attention control. Each of these individual skills could be referred to as an EF, but it is more precise and transparent to use the specific term associated with the discrete skill, for example attention shifting, when referring to only one component of EF.*

Particularly in early childhood research, the term EF is used synonymously with other terms, including cognitive control, effortful control, emotion and behavior regulation, and self-control, to name a few. By using these terms interchangeably, researchers and other stakeholders may unintentionally obscure differences that exist in the research about each skill.

Executive function, effortful control, and emotion regulation are not all the same thing. Each skill has features that make it distinct from the others, and what we know about each skill – when and how it develops, when is the most important time to focus on it, how easy or difficult it is to change, what strategies are shown to improve it, and how strongly it predicts short- and long-term outcomes (social, health, education) – is specific to the term and the measures used to assess it.

*What one author calls self-control, when cited by another, is called EF. What do we know about the relationship between these skills? Are they the same thing, or are they different?*

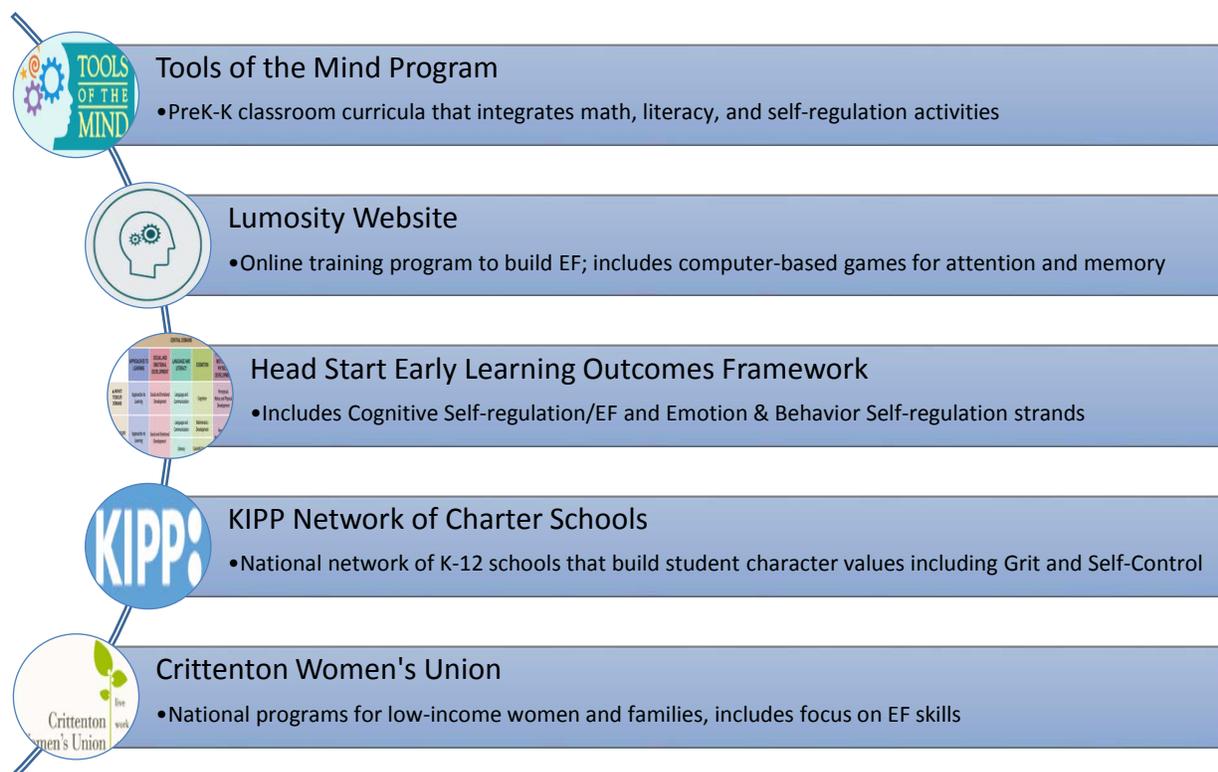
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<sup>1</sup> While some researchers do not include attention control in their definition of EF (e.g., Miyake et al., 2000), many researchers who study EF during early childhood include attention control as a key component (e.g., Garon et al., 2008), which is why we have chosen to include it here. This is described in detail in later pages.

It is not accurate to assume that the scientific evidence associated with one EF or regulation-related skill is also true for other similar skills. And yet, a glance through the literature seems to imply that all EF and regulation-related skills are identical. **This situation makes it challenging for policy-makers, educators, and other stakeholders to accurately identify the skills that are most important to target and the research findings associated with the skills or outcomes of interest.**

**Why does this matter?** Amidst these challenges, there is eagerness to use the science of EF to develop new programs and policies that support children and youth. Recent efforts to build EF and other regulation-related skills include a range of applications, from computer-based training programs (e.g., Lumosity Brain Training; Hardy et al., 2015) to social-emotional curricula (e.g., Tools of the Mind; Barnett et al., 2008), from school-wide character-building approaches (e.g., KIPP Public Charter Schools, n.d.) to national and state early learning standards (e.g., Head Start Early Learning Outcomes Framework 2015; HSELOF, 2015). A growing number of programs also target EF and regulation-related skills as a core mechanism for improving adult outcomes such as workforce preparation and financial independence (e.g., Crittenton Women’s Mobility Mentoring Program; Babcock, 2014).

The following are examples of national efforts to build and support EF and regulation-related skills:



Since 2014, Building Better Programs (a website that provides resources for program administrators about effective and promising program models; Building Better Programs: A Project of the Center on Budget and Policy Priorities, n.d.) has included Executive Function as one of five central foci. It is clear that the science of EF is influencing the design of programs, policies, and the public conversation about

“what matters” for positive life outcomes – and this is true across the nation, for both children and adults.

**These efforts have special relevance for at-risk children and youth.** Low-income children and children who have experienced trauma, abuse, neglect, and other adverse life experiences may have lower levels of EF and regulation-related skills than their more affluent peers (Evans & Kim, 2013; Farah et al., 2006; Noble, Norman, & Farah, 2005; Raver et al., 2013). In particular, the toxic stress associated with conditions of poverty has been linked to changes in the brain that can compromise the development of these important skills (Bos et al., 2009; Kishiyama et al., 2009; Shonkoff et al., 2012). At the same time, EF and regulation-related skills may protect low-income youth from some of the harmful effects of living in poverty, by enabling coping skills such as emotion regulation and flexible problem solving (Buckner, Mezzacappa, & Beardslee, 2003; 2009).

In the past 5-10 years, a handful of experimental and quasi-experimental studies have found that school-based interventions designed to build EF and regulation-related skills can be effective (Bierman et al., 2008; Diamond et al., 2007; Jones, Brown, & Aber, 2011; Raver et al., 2011; Riggs et al., 2006). EF and regulation-related skills appear to be a promising target for improving low-income children’s academic success and other positive outcomes. However, given the diverse set of terms and multiple skills lumped together in the category of EF, it is difficult to determine the specific targets for interventions that could generate broad, long-lasting, positive impacts. Increasing stakeholders’ abilities to define EF and other regulation-related skills accurately would help to specify the targeted skills of a program or intervention, to determine the best approaches for building those skills, to assess them, and to understand what short- and long-term outcomes are linked to the development of those skills.

Furthermore, when working with vulnerable populations, researchers and other stakeholders have an increased responsibility to be accurate and transparent in communicating findings with the broader field. Without a more precise, more consistent, and more transparent way to communicate about EF and regulation-related skills – what it is, what we know about it, and promising approaches to build it – the potential to leverage EF to impact the lives of large numbers of low-income children and youth may become a missed opportunity.

## The EF Mapping Project and Report

The major issue addressed in this report is that executive function, self-regulation, and other skills are often used interchangeably with each other – sometimes inaccurately – which ignores real differences in what these skills are, and how they are related to children’s learning and development. The Project was not designed to provide a comprehensive review of the literature on EF and regulation-related skills. The purpose of the EF Mapping Project is to help researchers, practitioners, and policy-makers more effectively navigate the growing body of literature on EF and regulation-related skills, which can be unwieldy given the large number of terms and the multiple research traditions that inform what is known about this area of children’s development. A major objective of the project has been to

**generate an organizing framework** for EF and regulation-related skills, and a set of tools to help stakeholders understand and communicate effectively about specific EF and regulation-related findings.

### Our project goals were to:

- **Support increased accuracy, precision, and transparency in how EF and regulation-related research is conducted and communicated**, starting within the research community and extending to the spheres of policy and practice; in order to
- Help ensure that new programs, policies, and practices aimed at building EF and regulation-related skills accurately reflect the knowledge-base.

To understand the current landscape of EF and regulation-related research, we organized our work around the following questions:

- **What are the key skills and terms identified in the EF and regulation-related literatures?**
- **How are they defined, described, and measured?**
- **What do we know about their development and their links to important outcomes?**

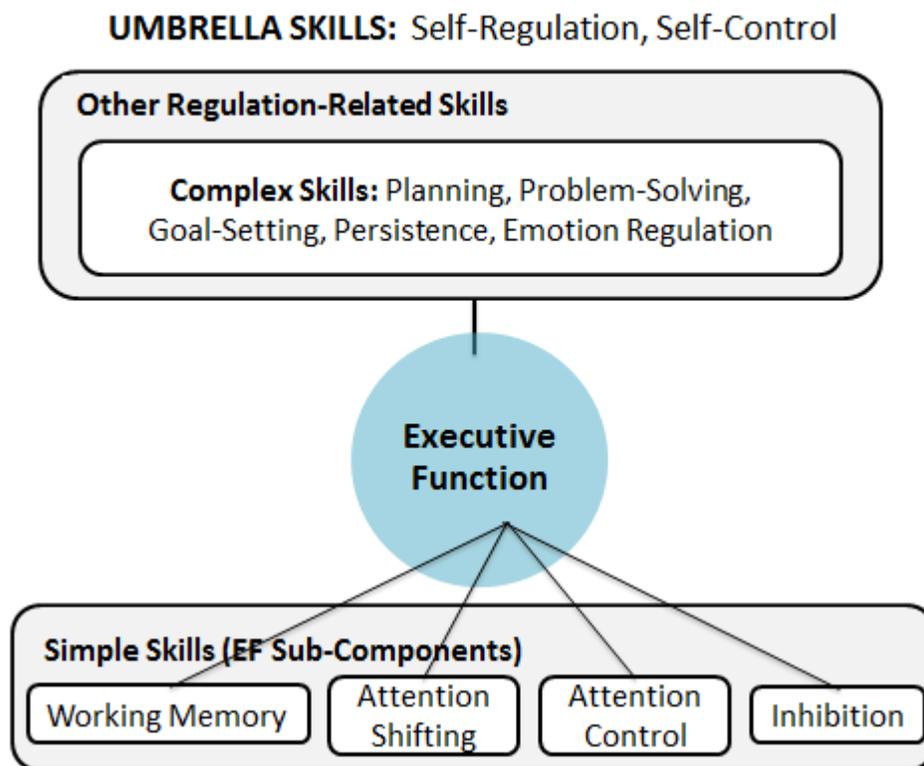
**Our project activities** began with a literature review on EF and regulation-related skills, focusing on identifying the similarities and differences between various skills (see Appendix A for a detailed description of the literature review and project approach). In our review, designed to capture the wide array of terms and measures used in this body of research, over 40 unique terms were identified. In addition to the most commonly used terms “executive function” and “effortful control,” the following terms emerged from our literature review:

Updating	Attention Control	Effortful Attention
Working Memory - Simple	Sustained Attention	Cognitive Control
Working Memory - Complex	Impulsivity	Lack of Control
Complex EF	EC - Focusing Attention	Persistence
Inhibition	EC - Shifting Attention	Grit
Inhibitory Control	Error Detection	Self-Regulation
Response Inhibition - Simple	Monitoring	Emotion Regulation
Response Inhibition - Complex	Plan Actions (Planning)	Hot EF
Response Control	Behavioral Regulation	Cool EF
Shifting	Delay	Delay EF
Set Shifting	Suppress/Initiate	Conflict EF
Attention Shifting	Mindfulness	Executive Attention
Cognitive Flexibility	Self-Control	Executive Control
Mental Flexibility	Self-Discipline	Problem Solving
Creativity	Delay of Gratification	Goal Setting

Focusing on how researchers operationalized these different terms (i.e., how they defined, described, and measured them) we identified a set of characteristics that can be used to differentiate individual

skills from one another. Drawing from this process, we generated a framework to help navigate EF and regulation-related research. We also created a map of terms – a visual tool to help stakeholders understand relationships between some of the most commonly used EF and regulation-related terms, and the specific skills to which they refer (see below for a simplified version of the map including only a small number of skills, and see pp. 12-16 for the full Map and its explanation). **The map is a tool designed to facilitate clear communication and translation among key stakeholders.** Please note this Report is not a stakeholder consensus document.

*Exhibit 1. Simplified Map of EF and Regulation-Related Skills*



#### **Key Take-Away Messages from the Map:**

This map provides an illustration of the distinction between EF and other regulation-related skills. See p. 13 for a more comprehensive map of skills.

- EF typically comprises the following simple skills (sub-components): working memory, attention shifting, attention control, and inhibition. These sub-components are simpler, smaller skills that work together to make up EF.
- Each of these individual skills could be referred to as *an* EF, but it is more precise and transparent to use the specific term associated with the discrete skill, for example attention shifting, when referring to only one component of EF.
- Regulation-related skills such as problem-solving and emotion regulation typically involve EF *and* other skills and knowledge, and are therefore more complex skills than EF.

We then summarized and shared our work with experts in the fields of child development and public policy, in order to gain feedback on the project's main findings and recommendations. Experts gave feedback on an earlier draft of this report through a group webinar, individual calls, and written emails. Our team then compiled feedback and revised the report and accompanying materials. In addition to this report, we are developing a Compendium of EF and Regulation-Related Measures (targeted toward researchers, program evaluators, and others interested in child assessment of EF and regulation-related skills) and a set of Policy Briefs written for other specific audiences.

**The primary audience for** this Report and the accompanying Executive Summary is ACF leadership and federal program staff as well as technical assistance providers. This report is a first step towards more transparent and accurate translations of EF and regulation-related research.

As a next step, we will work with key stakeholders to develop accessible resources for policymakers and early childhood program staff. We are also preparing an article for submission to a peer-reviewed journal that includes an in-depth description of the methodology and findings from our literature review. Researchers and other stakeholders interested in this article can contact us for more information.

**In this report,** we describe our process and present our findings. The remainder of the report includes the following sections:

- **II. A Map of Skills:** We present a visual map to illustrate relationships between key EF and regulation-related skills.
- **III. A Framework for Mapping EF:** We describe our proposed framework, which outlines differences between various skills in EF and regulation-related research. The purpose of the framework is to help stakeholders in early learning and child development to articulate research, programs, and policy recommendations with more accuracy and transparency.
- **IV. Project Findings:** We summarize key findings from our literature review, including gaps in the EF and regulation-related research, and challenges for effectively translating this body of research.
- **V. Implications and Considerations:** We close the report with a set of implications and considerations for stakeholders working in child development and education-related research, policy, and practice.
- **Three Appendices (A, B, and C)** include a detailed description of the project approach; definitions, measures, and research summaries of key EF and regulation-related skills; and a summary of recent meta-analyses of EF and regulation-related skills.

Note: When we use the term early childhood, we refer primarily to children ages 3-6 years old. This age group is particularly salient to EF-related research and interventions, as the foundational EF skills begin

to emerge around ages 3-4 and grow dramatically during the preschool period (Best & Miller, 2011; Garon et al., 2008). Additionally, most measures of EF are *not* suitable before 3 years of age, because the assessment tasks are not developmentally appropriate and/or they do not capture differences before age 3 years. Although the focus of the report is largely the early childhood period, particularly preschool-aged children, we note that EF and regulation-related skills are important from birth through adulthood.

### *A Note about Terminology: Untangling Terms and Skills*

We use the words “term” and “skill” in specific ways:

- By “term,” we mean the word used by researchers or other stakeholders to refer to developmental phenomena
- By “skill,” we mean the underlying phenomena itself, for example an observed behavior as opposed to the word used to characterize that behavior
- At times, we use “terms and skills” to refer simultaneously to both the words and the underlying developmental phenomena being described

The distinction between term and skill is one of the issues we aim to address: sometimes one EF-related term is used haphazardly to describe many different skills that actually have distinct terms that differentiate them. This is akin to using the word “car” to refer to a variety of objects including sedan, truck, van, etc. This may reflect conventional usage, but it is not technically correct – the best word to describe all of these is not the term “car” but the term “vehicle” or “automobile.” This may seem like a mundane point, but if you are an auto mechanic, salesperson, or a driver, the differences between these vehicles become important. Likewise, if you are a teacher, administrator, program director, or evaluator, it is important to know the terms that distinguish between different EF-related skills in order to operationalize them effectively.

This issue is bigger than just a mis-use of language, yet language is one confounding factor. Regardless of whether or not we have adequately refined language (“terms”), there are underlying distinctions in skills (e.g., whether or not I have vocabulary to name all the shades of blue on a paint swatch, they are all different). In this report, we attempt to clarify underlying distinctions between skills, and also propose use of specific terminology that will aid in communicating clearly about those skills.

## II. A Map of Skills

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### Organizing the Literature

In developing a map of key EF and regulation-related terms and skills, we started with two research traditions that are central to understanding regulation in early childhood: executive function (EF) and effortful control (EC) (see [Appendix B](#) for definitions of terms and skills referred to throughout the Report). We created a series of visuals intended to explore and illustrate the questions:

**What do the terms EF and EC mean?**

**How are EF and EC related to one another?**

*Executive Function.* The term *executive function* originates in the cognitive neuroscience literature. Cognitive neuroscientists generally define EF as a set of mental processes located in the pre-frontal cortex region of the brain used for goal-directed behavior. Specifically, executive functions are processes used to inhibit dominant responses, switch attention between multiple sets, and remember and update information (Fuster, 2008; Miyake et al., 2000).

**Executive Function (EF) is defined as** a set of mental processes, located in the pre-frontal cortex region of the brain, that are used to carry out goal-directed behavior. EF typically comprises the following sub-components:

- Response Inhibition
- Set Shifting (also called Attention Shifting or Cognitive Flexibility)
- Working Memory

Within this body of literature, researchers frequently use additional skills to refer to a broader concept of EF, including the skills of planning, problem solving, error monitoring, mental organizing, setting goals, decision-making, and occasionally, reflection and creativity.

These skills share a number of features:

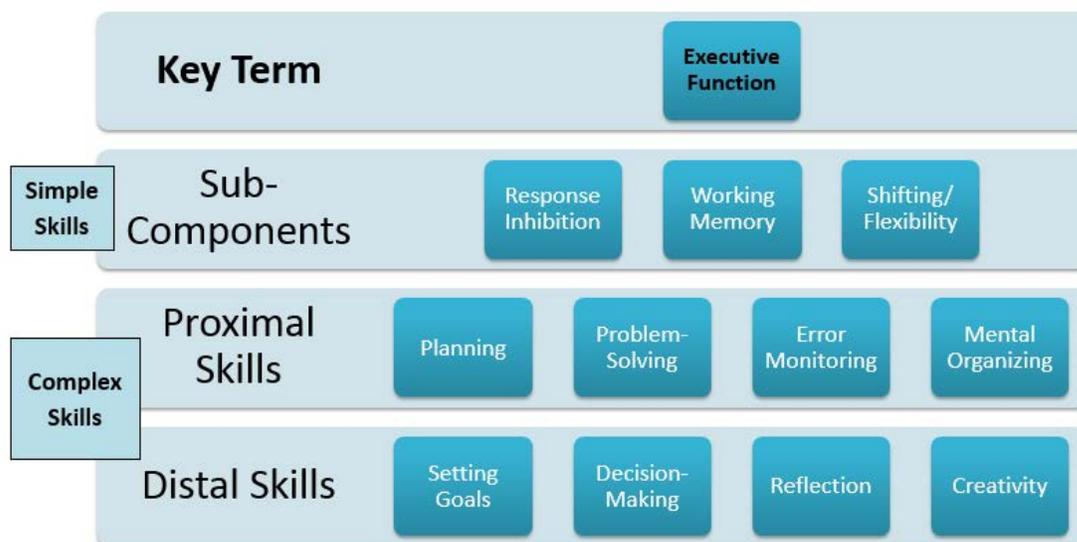
- The definitions and measures primarily reflect cognitively-oriented tasks (such as thinking, memory, and attention).
- They are assessed in emotionally-neutral contexts (not involving emotionally-salient stimuli).
- They typically involve internal, mental, and independent tasks (not involving social situations or interactions with others).
- The measures are primarily lab-based: many are computer-based tasks or other highly-structured activities in a controlled laboratory environment.
- They are frequently linked to academic achievement, in particular math, literacy and science.

The skills described here also represent some important distinctions. Inhibition, working memory, and shifting are usually presented as core processes or sub-components of EF – particularly during early

childhood. When other skills (such as planning or reflection) are included as part of EF, it is typically among older children or adults. Thus, we have organized these other skills not as direct sub-components of EF but as proximal and distal skills (Exhibit 2), based on the measures used to assess them. For example, we include planning and problem solving as proximal skill because they are measured in more closely related ways to the EF sub-components compared to reflection and creativity.

Another way to organize these terms is by thinking of the sub-components as “simple skills” that make up EF, and the proximal and distal skills as “complex skills” that are hierarchically more sophisticated than EF (defined as comprising the three core sub-components). For instance, planning likely involves the use of response inhibition, working memory, and shifting sub-components, but planning employs those sub-components in complex ways and may also involve the integration of other knowledge and skills (above and beyond the sub-component processes).

*Exhibit 2. Organizing Executive Function Terms*



Note: The intention of this exhibit is to show the distinctions between simple and complex skills. The skills in the rows could be in any order and we do not intend to imply any nesting of skills.

*Effortful Control.* Developmental psychologists, including many who are interested in children’s temperament or biologically-based dispositions and personality characteristics, use the term *effortful control* (EC) and define it as the ability to intentionally manage thoughts, attention, emotions, and behavior (Lengua, 2009). Both EF and EC include an emphasis on the ability to inhibit dominant responses, which suggests they are similar, parallel, or overlapping skills. However, it is important to note that EC researchers typically measure inhibitory control in tasks that involve managing strong emotions such as desire or frustration (sometimes in the context of social interactions such as taking turns or sharing with another child), whereas EF researchers typically measure response inhibition, the parallel component, in lab-based tasks that do not involve emotions or social interaction. See more below (on pp. 11-12) about the similarities and differences between EF and EC.

**Effortful Control (EC) is defined as** the ability to inhibit a dominant response in favor of a subdominant response, particularly in emotionally-driven situations such as those involving desire, frustration, or the potential for reward. EC typically comprises the following subcomponents:

- Inhibitory control
- Attention control
- Attention shifting

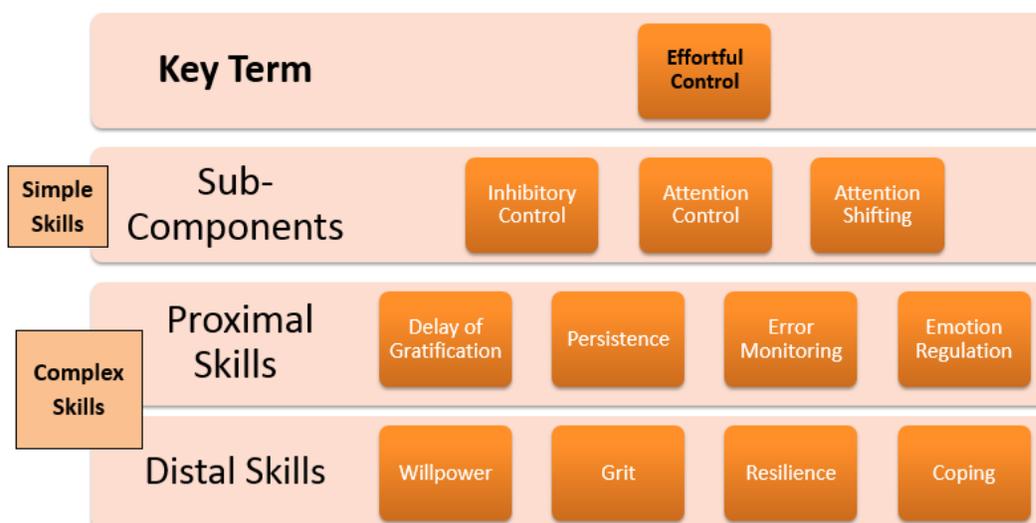
Some EC researchers also include additional skills such as error monitoring. Because of the close relationship within the temperament research tradition between effortful control and emotion regulation, we chose to include here additional skills that are frequently described in EF and regulation-related research, which involve emotionally-salient tasks and demands. For example, we have included delay of gratification, persistence, grit, emotion regulation, coping, and resilience.

As with EF, we have organized this set of skills by their proximity to the key sub-components of EC (Exhibit 3). For example, researchers often refer to and measure persistence in very similar ways to attention control, whereas researchers refer to resilience in broader ways, as a more sophisticated self-regulatory capacity to manage oneself in the face of challenge or difficult situations.

Key features shared by EC skills:

- The definitions and measures reflect both cognitive *and* emotion tasks.
- Most of the skills involve managing feelings such as desire, frustration, or motivation/arousal.
- Many of the measures include observations of daily behavior via teacher and parent reports.
- The skills are typically external, observable behaviors that occur in the context of social relationships and daily interactions with other people (natural settings such as home and school).
- The skills are frequently linked to social-emotional skills and mental health outcomes.

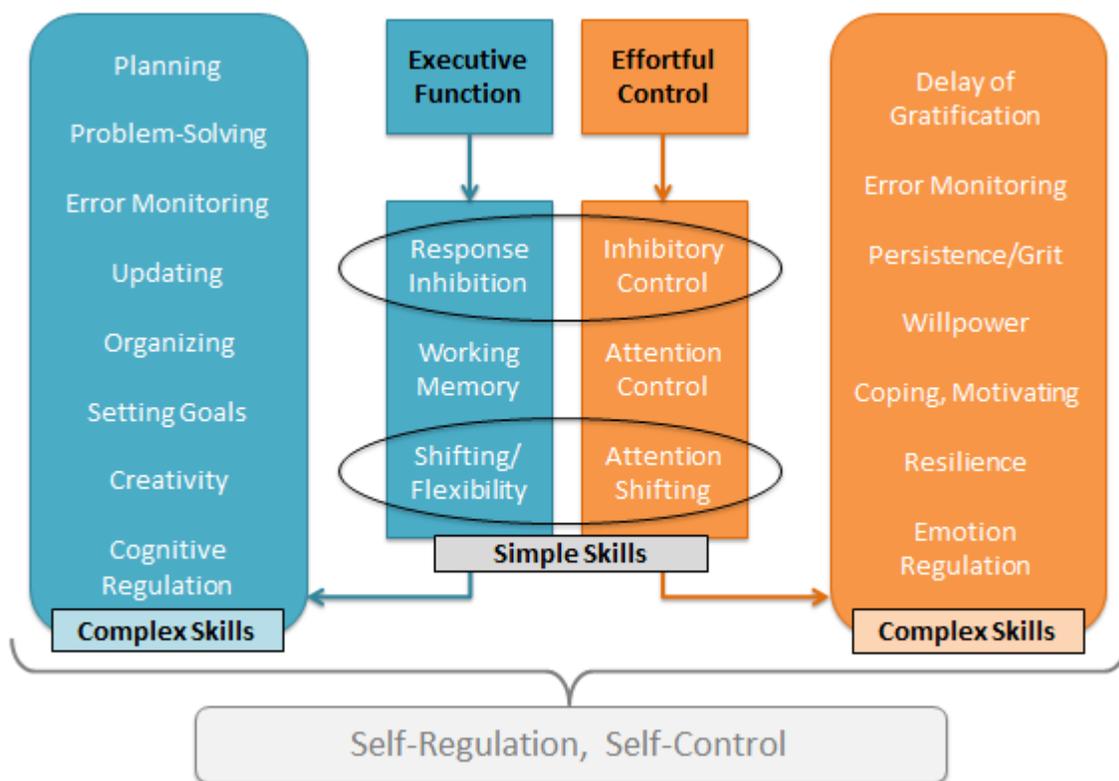
*Exhibit 3. Organizing Effortful Control Terms*



Note: As above, the intention of this exhibit is to show the distinctions between simple and complex skills. The skills in the rows could be in any order and we do not intend to imply any nesting of skills.

When we look at the organizational hierarchy of EF and EC skills side-by-side, we see parallel structures. EF and EC have a similar (but not identical) set of sub-components: they both comprise inhibition and shifting sub-components, and they both are related to a set of more complex skills. However EF and regulation-related skills are primarily in the cognitive domain, and EC-related skills are primarily in the emotion domain. Terms such as self-regulation and self-control often include multiple skills across both EF and EC, so we suggest that self-regulation and self-control are umbrella terms for the broad phenomena of children's developing regulation.

*Exhibit 4. The Parallel Structures of EF and EC*



*Untangling Executive Function and Effortful Control.* As suggested by the series of illustrations above, researchers studying EF and EC examine similar abilities in children, albeit with some important differences. Unfortunately, work from these two groups of researchers is increasingly being tangled together haphazardly, or at a minimum without clear rationale or intention, often under the header of EF. The resulting implications are two-fold.

First, important distinctions and key findings might be overlooked or misunderstood if the terms are used interchangeably for each other despite their key differences. For example, a number of important findings related to emotionally-salient regulation skills (e.g., findings related to self-control, effortful control, delay of gratification, and emotion and behavior regulation) might be misinterpreted as

cognitive terms and skills. Then when programs or policies aim to build these emotionally-salient regulation skills, they might rely on purely cognitive definitions, measures, and strategies and approaches to building children’s regulation skills – missing what may be the key feature of regulation that is tied to diverse long-term outcomes (e.g., see Mischel, 2014; Moffitt et al., 2011; Raver, 2002). Alternatively, researchers, practitioners, policy-makers, and other stakeholders may overlook or miss the opportunity to study and understand how cognitively-oriented aspects of EF (such as working memory or “cool” inhibition) influence emotionally-salient skills including grit, persistence, and resilience.

Second, the inconsistent use of so many overlapping terms, which appears to be relatively recent but increasingly problematic, could lead to the effective loss of meaning for the term EF. If the term EF is applied with wide variability and imprecision across different research, program, and policy efforts, it will no longer carry any specific or concrete meaning that can be useful to identify and enhance key EF and regulation-related skills or to accurately evaluate programs and policies that are intended to build EF.

Key Features of Research on Executive Function	Key Features of Research on Effortful Control
<ul style="list-style-type: none"> <li>• The terminology primarily reflects cognitive tasks</li> <li>• It is primarily measured in emotionally-neutral contexts</li> <li>• Tasks typically focus on internal, mental regulation</li> <li>• Measures are typically lab-based, many are computer-based</li> <li>• Frequently linked to academics (math and literacy)</li> </ul>	<ul style="list-style-type: none"> <li>• The terminology includes both cognitive and emotion tasks</li> <li>• Most measures include managing desire, frustration, motivation, and arousal</li> <li>• Measures include observations of daily behavior, such as teacher and parent reports</li> <li>• Measures are typically external and observable, sometimes in the context of relationships and daily interactions</li> <li>• Frequently linked to social-emotional skills and mental health</li> </ul>

As the research, practice, and policy communities begin to embrace the central importance of early childhood self-regulation, it is important to be accurate and transparent about the differences between EF and similar but distinct terms like EC. Without precisely and carefully aligning EF, EC, and other regulation-regulated skills, policy-makers, practitioners, and other stakeholders run the risk of generating incomplete or unrealistic approaches to skill-building and assessment, thereby undermining efforts designed to improve outcomes for the country’s most vulnerable children.

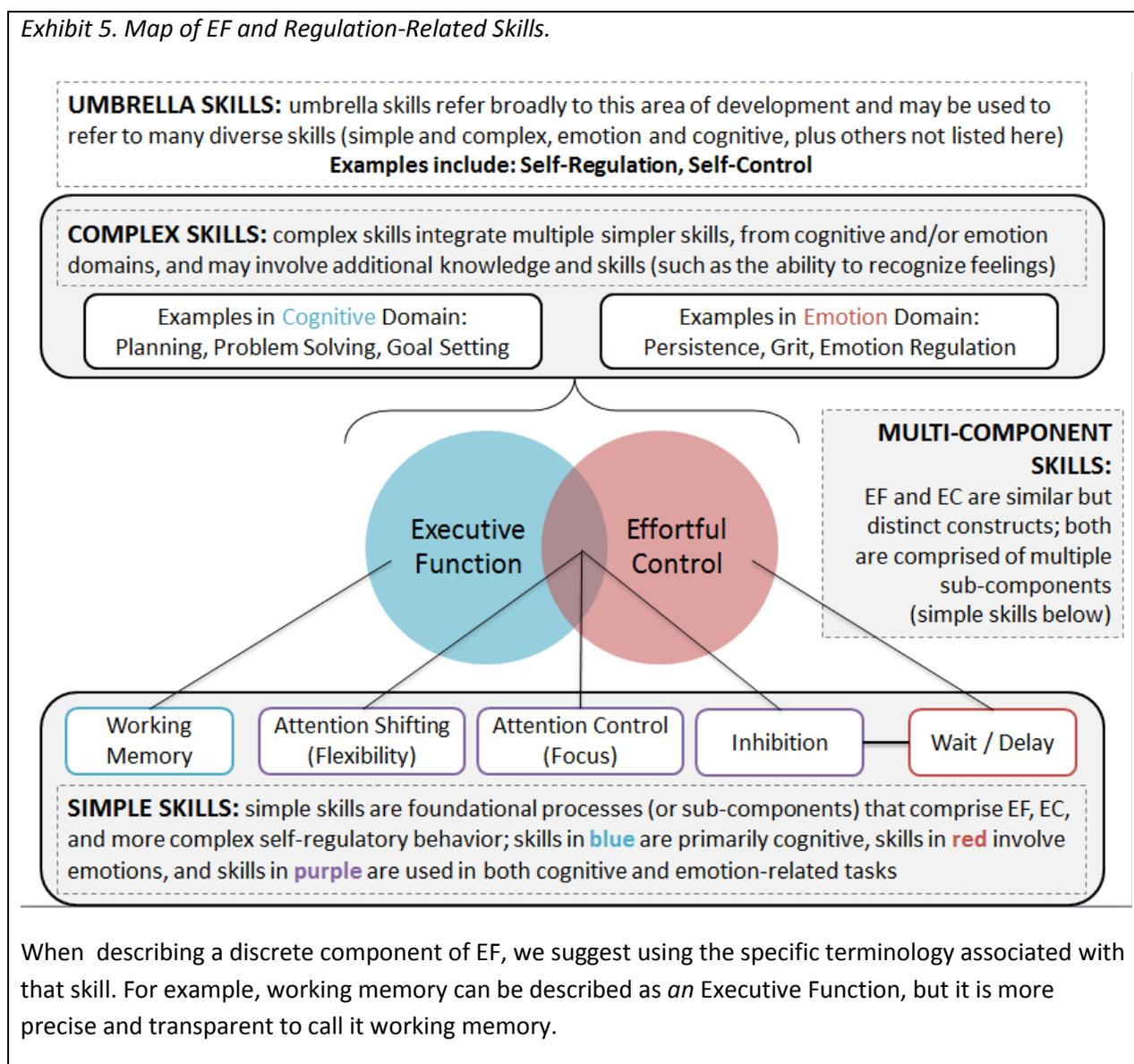
## Generating a Map of Key EF and regulation-related Skills

We present here a map of key terms that appear in EF and regulation-related research. The map is designed to bring together skills from multiple research traditions and to illustrate their relationships to one another, in order to highlight similarities and differences between various EF and other regulation-

related skills. This map is intended to be illustrative and not comprehensive – it is a conceptual tool that suggests a general structure for organizing key skills in this broad area of research.

We have organized the skills hierarchically: smaller, simple skills on bottom (sub-components of EF or basic processes that aren't typically broken down further; such as inhibition or attention); multi-component skills in the middle (such as EF and EC); larger, complex skills at the top (such as emotion regulation and problem solving); and broader umbrella terms at the very top (such as self-regulation or self-control, which encompass multiple skills in the map and may include additional skills such as conscientiousness; see more on pp. 17-20). The map does not illustrate developmental stage or measurement strategy; see the framework section for a description of those elements. However, it draws on developmental principles which suggest that smaller, simple skills (at the bottom of the map) serve as building blocks for more complex skills (at the top). See pp. 15-16 for more details.

Exhibit 5. Map of EF and Regulation-Related Skills.



### Notes about the map:

- While some researchers do not include attention control in their definition of EF (e.g., Miyake et al., 2000), many researchers who study EF during early childhood include attention control as a key component (e.g., Garon et al., 2008). Thus, attention control is included in the map above, and in our definition of EF (see p. 1).
- Delay is not typically described as a sub-component of EF or EC in the existing literature. However, based on our analysis of the measures used to assess delay, delay is a parallel process to inhibition, specifically in the emotionally-salient domain. For example, in delay tasks children must inhibit thoughts or behaviors in the context of a desire or temptation for reward – thus involving the regulation of strong feelings. The map, therefore, draws explicit attention to delay (rather than including it as part of the inhibition sub-component) because of research demonstrating robust links between delay of gratification and long-term outcomes across multiple domains of functioning (learning, behavior, and health).

### Key Take-Away Messages from the Map:

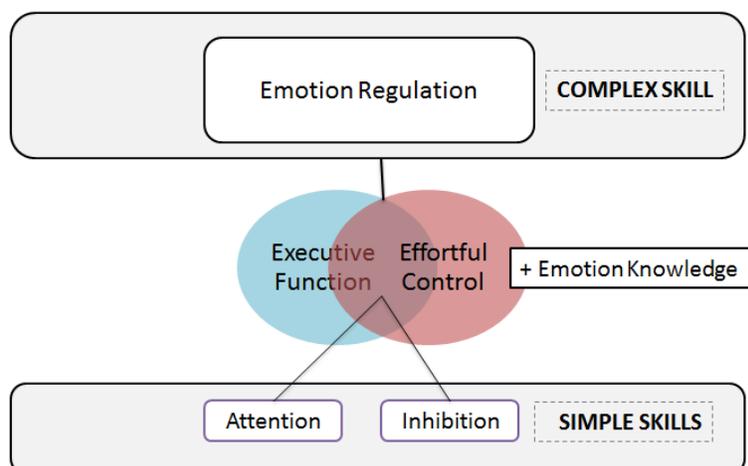
- **EF and EC are similar, but not identical.** The map emphasizes the overlapping nature of EF and EC and highlights key distinctions between them, in particular differences related to developmental domain.
  - EF is often defined as a **cognitive** skill and the simple skill **working memory** is most closely related to the cognitively-oriented study of EF.
  - EC is often associated with **emotion** skills and the simple skill **wait/delay** is more closely related to EC and other inhibition tasks studied in emotionally-salient contexts (i.e., involving desire, frustration, or high potential for reward).
  - EF and EC both draw upon **attention** and **inhibition** processes.
- The map highlights **multiple layers of complexity**.
  - At the bottom of the map are simple skills, also known as sub-components of EF and EC. When combined, simple skills represent EF (working memory + attention + inhibition) or EC (attention + inhibition + wait/delay).
    - While together these skills comprise EF, it can be misleading to use the term EF when referring to only one component. It would be more accurate to refer to a discrete component as *an* EF, or ideally to use the specific terminology associated with the skill, such as working memory or attention shifting.
  - At the middle of the map are EF and EC. EF and EC are terms of similar skill size and complexity. They draw upon simple skills, and are the basis of more complex skills.
  - At the top of the map are complex skills. Complex skills build on simple skills or emerge later in development. Complex regulation-related skills often include EF and/or EC.
  - At the very top of the map are umbrella skills – these terms are typically used to encompass many different terms and skills throughout the map.

- The map illustrates a **general concept in developmental theory**.
  - Simple skills are the building blocks for more complex skills. Across development, simple skills become increasingly coordinated and integrated, facilitating mastery of more complex skills gradually over time.
  - For example, a complex skill such as emotion regulation likely draws upon simple skills such as attention shifting and inhibition, as well as emotion knowledge (awareness of one's own and others' feelings) to produce emotion regulation.
  - It is important to note that, consistent with the map, targeting one simple aspect of EF/EC should not be expected to lead to the development of complex skills. Said another way, an individual may use EF as part of a complex skill such as planning, but targeting one component of EF will not necessarily make someone better at planning.

*The Role of Development.* While simple, foundational skills typically emerge first, and more complex skills emerge later in development, we do not intend to suggest that complex skills like emotion regulation (located in the top portion of the map) cannot be acquired and actively supported in young children. As children develop, they are constantly building and strengthening skills, both simple and complex. While children *can* start to build complex skills like emotion regulation at a young age, we want to emphasize that they still need adult support in the basic foundational sub-components of EF, because they haven't necessarily yet mastered simple skills like attention and inhibition that facilitate the development and emergence of emotion regulation. Over time, and through repeated practice, children are better able to integrate and automatically deploy both simple and complex skills to meet goals.

Exhibit 6 illustrates how simple skills may combine with other skills and knowledge to generate more complex skills such as emotion regulation, even in young children. For example, preschool-age children may use emotion-specific knowledge (e.g., awareness of feelings, ability to distinguish and communicate different feelings) in coordination with attention and inhibition skills in order to tell an adult when they are angry instead of impulsively hitting or perseverating on what is upsetting to them.

*Exhibit 6. Illustration of how the map reflects a core principle in development*



Another issue to consider is that skills in the map look different across development, as children mature and acquire more complex knowledge and abilities. For example, emotion regulation in a five-year-old will look different than emotion regulation in a ten-year-old. The same can be said for executive function and its component skills such as working memory or inhibition. This highlights that stakeholders will need resources that carefully define skills for a particular developmental stage and the strategies or assessments that are most relevant (see more on pp. 20-23).

## III. A Framework for Mapping EF

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Although there is no consensus use of the term shared by all researchers, it is possible to improve the accuracy and transparency with which findings are reported. **Researchers and other stakeholders in early childhood can support effective translation of EF and regulation-related research by being precise about the specific aspect(s) of EF and regulation-related skills being investigated.** Transparency when discussing children’s EF and regulation-related skills will allow for an accurate interpretation of findings, and can lead to the creation of policies, programs, strategies, and teacher recommendations grounded in the evidence-base for the skill or multiple skills of interest.

We have identified four issues that are important to consider across research, policy, and practice in order to improve communication about children’s EF and regulation-related skills:

- Skill Complexity
- Developmental Stage
- Developmental Domain
- Measurement Strategy

**These four issues represent characteristics of EF and regulation-related skills that stakeholders can use to distinguish these skills in meaningful ways.** Based on our literature review, these four issues characterize the most substantial variation that exists in how EF and regulation-related skills are defined, measured, and targeted. The four issues provide a guiding framework for comparing and contrasting different EF and regulation-related skills and associated findings, and for identifying the specific EF and regulation-related skills to target or the expected outcomes of a particular program or policy.

### Skill Complexity

Skill complexity is perhaps the most important characteristic to consider and be transparent about, because it has numerous implications for understanding the development and accurate measurement of EF and regulation-related terms, as well as for communicating clearly about them.

Across the literature, researchers describe EF and regulation-related skills using different levels of complexity. A **complex skill** is multi-faceted and involves the coordination of many sub-components or many smaller, simpler skills. A **simple skill** is a basic skill that cannot be broken down into smaller components. A simple skill may be one of many skills that together comprise a larger, more complex skill. Typically, simple skills can be thought of as “building blocks” for more complex skills.

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*Skill complexity refers to the relative size and complexity of a skill.*

For example, playing basketball is a complex skill, because it includes many simpler skills that have to be mastered first – such as dribbling, shooting, passing, defense, etc. These simpler skills can be broken down even further into basic components – such as running, hand eye coordination, and balance. Running and balance can be viewed as the building blocks for dribbling, shooting and passing; which in turn serve as the building blocks for playing basketball successfully.

Understanding skill complexity is an important part of translating research on children’s development because it helps practitioners and policy-makers to articulate learning trajectories and identify what small or simple skills need to be mastered first in order to build larger, more complex skills over time. As in the basketball analogy, efforts to build skills should accommodate children’s current abilities, but ideally should also help children get “the fundamentals” in place.

Stakeholders need to be able to identify skill complexity in the area of children’s developing self-regulation, but currently the terms are not used in a precise or consistent way. In our review, researchers sometimes used the term EF as a large and multi-faceted skill, comprising many other skills across different levels of complexity. In these instances, the term EF is being used as an umbrella construct for the broader field of self-regulation, encompassing diverse skills such as self-control, emotion regulation, and creativity (e.g., see Center on the Developing Child, 2011; Diamond, 2013; Diamond & Lee, 2011). For stakeholders to use these findings to inform their work, they would need to consult multiple research traditions, interpreting and synthesizing findings related to self-control and emotion regulation, for example, and targeting or measuring a variety of both simple and complex EF and regulation-related skills.

At other times, researchers used the term EF to refer to a more narrow aspect of children’s self-regulation. For example, cognitive neuroscientists typically use the term EF to refer exclusively to a set of mental processes situated in the brain’s prefrontal cortex: response inhibition, working memory, and set shifting or attention shifting (e.g., see Best & Miller, 2010; Garon et al., 2008; Miyake et al., 2000). In these instances, EF can be understood as a very specific set of smaller, simpler skills that likely serve as building blocks for more complex regulation-related skills. Basic processes such as working memory, while they are used for a variety of tasks (just as running and hand-eye coordination are used for a variety of activities), are relatively simple or fundamental skills.

Understanding EF and regulation-related skills according to their complexity helps stakeholders to design programs and strategies that support the development of basic building blocks as well as more complex versions of self-control; and to align assessments or expectations accordingly. For example, targeting simple skills such as working memory would not necessarily lead to improved outcomes in the same multi-faceted way that we would expect by targeting multiple, larger, and more complex skills – such as an umbrella skill like self-control (see Key Illustration on p. 38).

**Sometimes researchers use EF as an over-arching term that includes many complex skills such as planning, problem solving, emotion regulation, and creativity; other times researchers use**

**EF to mean simple skills like working memory or attention. These different meanings suggest different skills to target and measure in interventions and programs.**

We categorize EF and regulation-related skills according to their level of complexity, based on an analysis of the measures most commonly used to assess them.

### Simple Skills

- *Simple skills are small skills that are typically not broken down any further; they are the fundamental building blocks of EF and more complex regulation-related skills.* Simple skills include the sub-components working memory, attention control, attention shifting, and inhibition. Together, simple skills comprise the concepts of EF and EC as they are most commonly defined.
- Simple skills are the most commonly assessed EF and regulation-related skills during the early childhood period, and research tells us that these specific skills go through rapid growth and transformation during that time – making them important skills to target during preschool and early school years (Carlson, 2005; Center on the Developing Child, 2011; Garon et al., 2008; Kochanska et al., 2000).

### Complex Skills

- *Proximal skills are more complex than sub-components, and they draw upon them.* Without effective use of EF sub-components or simple skills, it would be difficult to master more complex skills like planning and problem solving. Many skills we categorize as proximal skills are EF and regulation-related skills that are most commonly assessed in middle or late childhood. As such, proximal skills may be understood as a progression of simple skills as they develop into more complex regulation-related skills over time.
- *Distal skills are even more complex than proximal skills. We refer to distal skills as higher-order skills, because they appear to represent the coordination and integration of many distinct regulation-related skills.* For example, it would be difficult to develop effective emotion regulation or persistence by simply practicing the basic components of EF; we suggest that distal skills likely require additional knowledge, skills, or experience (such as self-awareness, emotion knowledge, interpersonal knowledge and skills, etc.).

Please note there is limited research investigating the relationship between different EF and regulation-related skills, and therefore this hierarchy should be viewed as a theory-based organizing heuristic, not as an empirically derived model. More research exploring the relationships between EF and regulation-related skills is needed to confirm how these processes unfold in relation to each other over time.

However, by looking closely at the measures most commonly used to assess each of the skills, and the age of participants who are typically assessed using those measures, we were able to generate a general organizing heuristic for terms most commonly found in the literature.

### *Why does Skill Complexity matter?*

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Skill complexity is important for policymakers and program developers because it highlights the simple, fundamental skills that children need to practice before learning more complex skills. This is particularly relevant in early childhood, when children are just beginning to build the foundational components of EF. Programs or interventions that target complex EF and regulation-related skills without ensuring that children have first developed foundational skills, or doing it in a manner that doesn't reflect important foundational skills, may be ineffective for influencing targeted skills or outcomes.

Programs designed to build a single, simple skill should not be expected to have the same impact as programs designed to target multiple or more complex skills. For example, a program designed to build attention and working memory should not be expected to build more complex, multi-faceted skills such as emotion regulation or self-control. If a program or policy aims to impact broader skills like self-control, it should build skills of various complexities – for example, by including multiple types of activities designed to build working memory, attention, emotion and behavior regulation, etc.

### **Developmental Stage**

Developmental stage is a key issue to consider, because it can have serious implications for the accurate understanding and measurement of EF and regulation-related skills across development. Researchers study EF and regulation-related skills across the lifespan – starting in early childhood (typically around 3 years old, though sometimes earlier) and extending throughout adulthood (Best & Miller, 2010; Center on the Developing Child, 2011). Researchers assess EF and regulation-related skills in different ways at different times of development, which is appropriate, but can lead to inaccurate interpretation of findings if the age-relevant distinctions are not clearly stated.

*Developmental stage refers to the specific terms, measures, and findings that are most relevant for a particular age group.*

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Children's EF and regulation-related skills manifest in different ways across the lifespan (Best & Miller, 2010; Best, Miller, & Jones, 2009; Best, Miller, & Naglieri, 2011). Some EF and regulation-related terms and their associated findings are relevant for specific age groups but not for others – so stakeholders may benefit from an awareness of what terms and skills are most salient for the age group they are working with. These distinctions are often lost in translation.

Across the literature, we found three common pitfalls related to defining, measuring, and understanding EF and regulation-related skills across development:

**1. Some terms are used across development, but their meaning changes according to developmental stage. Other terms refer to age-specific manifestations of EF and regulation-related skills.**

For example, EF is a term used throughout development, however the *meaning* of the term changes to reflect changes in ability as children mature. In early childhood (ages 3-6 years), the key aspects of EF are inhibition, attention control, working memory, and shifting (Best & Miller, 2010; Garon et al., 2008). In middle childhood (ages 6-11 years), EF is measured using tasks that reflect additional aspects, such as planning, problem solving, and organizing (e.g., see Best, Miller, & Naglieri, 2011). In adolescence and adulthood, EF research often includes yet additional aspects such as reasoning, setting goals, and decision-making (e.g., see Diamond, 2013; Fuster, 2008).

In contrast, some researchers study EF and regulation-related skills in a specific developmental stage, and those findings should be approached carefully before being applied to a different age group. For example, the concepts of grit and self-discipline are studied among older children and youth (e.g., Duckworth et al., 2007; Duckworth & Seligman, 2005), but both terms are sometimes used to make claims about young children's EF skills. Using EF interchangeably with grit or self-discipline can be misleading and inaccurate. The measures used to assess grit and self-discipline involve self-reports of work habits and complex behaviors that are not appropriate or relevant for young children, due to age-related limitations in self-awareness, concept development, and other knowledge and skills. Given these different developmental and measurement considerations, policy-makers and other stakeholders should be wary of any claims that grit or self-discipline are important skills to build in early childhood. To date, there is no research to substantiate such a claim.

**2. Sometimes EF and regulation-related skills are very similar in particular developmental stages, but become differentiated over time.**

Two different EF and regulation-related skills can be distinct from each other in one developmental stage, but in another stage they are

identical. For example, researchers use the terms EF and EC across development.

While there are differences in how EF and EC are typically defined and measured, during the early childhood period researchers of EF and EC have often used the same measures to assess children's skills (see Carlson, 2005; Kochanska, et al., 2000). This may be a reflection of different

*It is important to articulate how EF-related skills change over time, and which terms refer to age-specific manifestations of EF.*

*In early childhood, how EF and EC are defined and measured overlaps, but in adolescence other specialized terms emerge such as grit and self-discipline.*

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research traditions or it may be a reflection of how regulation-related skills change over time. For example, children’s emerging regulatory skills may be undifferentiated during the early childhood period, such that actual differences between EF and EC only emerge later in development, when children’s skills become more specialized and multi-faceted.

This is important for stakeholders to understand so that findings can be interpreted and applied appropriately. For instance, it may make sense to synthesize studies of EF and EC into recommendations about how to build regulation-related skills during the early childhood period, but it may not be reasonable to combine EF and EC studies during other times of development if the two constructs are measured in distinct ways.

### **3. Some EF and regulation-related skills are especially salient during a particular developmental stage.**

Some EF and regulation-related terms have particular salience during one developmental stage, but are less relevant at other times of development. This may be because different aspects of regulation are needed to meet the changing demands that children face as they mature. For example, effortful control appears to be highly salient to the developmental tasks of early childhood (Lengua, 2009; Rothbart & Bates, 2006; Valiente et al., 2011). As young children make the transition to school and adjust to the demands of group learning environments, they must learn how to manage frustration, share and take turns, comply with adult caregiver requests, and get along with peers. In later school years, other EF and regulation-related skills may be more relevant to children’s success. For example, planning and problem solving appear to be closely tied to the academic tasks required of older children, such as writing a well-organized paper and solving multi-step equations.

Furthermore, some terms refer to assessment tasks that are relevant only during a particular developmental stage. For example, delay of gratification is typically assessed using the Marshmallow Test, in which a 3-5 year old child is presented with one marshmallow and told he/she can eat it right away, or wait and have two marshmallows later. How young children perform on this task has been shown to be predictive of important outcomes later in life – including SAT scores, college graduation, and other positive outcomes in adulthood (Shoda, Mischel, & Peake, 1990). But the task has only been used in the early childhood period, so there is no evidence to indicate whether this skill or task is relevant to target or assess among older children and youth.

#### ***Why is Developmental Stage important?***

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EF and regulation-related skills matter across development, but some aspects of regulation are most important during a particular developmental stage. For example, effortful control is highly salient during early childhood, whereas grit and self-discipline are not appropriate terms/skills for young children.

Furthermore, the terms used to measure and describe regulation-related skills can vary across development. The term EF is used across the lifespan, but it means different things based on the structure and complexity of the skill at different times of development. EF in early childhood often refers to the sub-components of EF which include working memory, attention (control and shifting) and inhibition, and also can refer to basic versions of emotion and behavior regulation. EF in middle childhood usually refers to more complex skills such as planning and problem solving. EF in adolescence sometimes refers to more complex skills like reflection, resilience, grit, and self-discipline.

It is important for stakeholders to consult the research findings that apply to the age group they are working with and to be aware of the skills, terms, and measures that are most relevant to that group.

## Developmental Domain

Sometimes researchers use EF to refer exclusively to mental skills such as working memory, attention, or planning (Miyake et al., 2000). These definitions of EF imply that EF belongs in the cognitive domain. At other times, researchers use EF to refer to skills that include aspects of emotion regulation and compliance with social norms, suggesting it fits within the social-emotional domain (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Carlson, 2005).

Another possibility is that EF comprises processes that do not inherently fit within a particular developmental domain, but instead is a set of skills that children use to meet demands across multiple domains – such that EF supports learning and the development of skills across cognitive, social, and emotion domains.

*Developmental domain refers to where a concept fits within broad areas of children’s learning and development.*

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Our review of recently developed state and national standards (e.g., Head Start Early Learning Outcomes Framework, various State K-12 Education Standards) suggests that educators and policy-makers take a variety of approaches to including EF and regulation-related skills in early learning frameworks. Some frameworks include EF components such as working memory and attention with cognitive skills, and other components such as inhibition with social-emotional skills; whereas others include EF in a separate “Approaches to Learning” domain, and others create new domains exclusively for EF and/or self-regulation skills.

In particular, in the Head Start Child Outcomes Framework (2015), the following domains and sub-domains include EF and regulation-related skills:

- Domain: Approaches to Learning
  - Sub-Domain: Emotional and Behavioral Self-Regulation
  - Sub-Domain: Cognitive Self-Regulation (Executive Functioning)
- Domain: Social and Emotional Development

- Sub-Domain: Emotional Functioning
- Domain: Language and Communication
  - Attending and Understanding

It is clear that both cognitive and emotion-oriented aspects of regulation are included in the Head Start Domains above. In addition, regulation-related skills support many of the social skills outlined in the framework. For example, to meet the goal of engaging in prosocial and cooperative behavior and to be successful at sharing and taking turns (Domain: Social and Emotional Development, Sub-Domain: Relationships with Adults), children need to be able to inhibit impulses and delay gratification. As a second example, to meet the goal of using basic problem-solving skills to resolve conflicts with other children (Domain: Social and Emotional Development, Sub-Domain: Relationships with Other Children), children need regulation-related skills such as problem solving and attention shifting that enable them to take another's perspective.

We think it is essential to **highlight how different research traditions tend to conceptualize EF and regulation-related skills within one developmental domain or another**. Researchers' approaches to measuring children's EF and regulation-related skills often reflect how they are conceptualizing the skills. This has important implications for how stakeholders interpret and act on research findings.

For example, research that describes EF as a cognitive skill suggests to stakeholders that cognitive strategies are best suited to building and assessing the skill. In contrast, research that describes EF as a social-emotional skill implies that the skill can be targeted and assessed using social-emotional strategies or approaches. This issue may also impact how stakeholders evaluate the impact of a program or policy. For example, a cognitive definition of EF might encourage stakeholders to expect that building the skill will lead to improvements in other cognitively-oriented outcomes such as academic achievement. In contrast, a social or emotional definition of EF might suggest that programs and policies aimed at building the skill will influence social-emotional outcomes such as behavior, mental health, and general well-being.

These assumptions are mostly un-tested: while there is a body of research documenting the importance of regulatory skills (often measured as one composite skill) on general student outcomes, there is not enough research looking at EF and regulation-related skills across multiple domains to indicate how *specific* EF and regulation-related skills influence outcomes in traditional cognitive, social, and emotional domains. This is an important area for continuing research and raises questions that each stakeholder will have to consider when operationalizing research:

- Where does EF fit within frameworks of children's learning and development?
- Is EF a cognitive, social, or emotional skill, or does it support skills across all three domains?

### *Why is Developmental Domain important?*

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If program developers and policy-makers intend to promote EF and regulation-related skills in ways that support children across multiple areas of development, stakeholders may benefit from an awareness of multiple research traditions that inform their work.

Based on our review of the literature, program developers and policy-makers seeking to operationalize research showing links between EF and regulation-related skills and long-term learning, behavior, and health outcomes (such as criminal behavior, job earnings, and mental health) would be most informed by drawing from research on (a) cognitively-oriented EF, such as attention skills; (b) emotionally-salient EF and regulation-related skills, such as delay of gratification and emotion regulation; and (c) aspects of regulation that are frequently required in social settings and relationships, such as sharing, taking turns, perspective-taking, and problem solving.

At a minimum, the field would likely benefit from stakeholders in early childhood being transparent when communicating about how they are using the term EF and thinking about its relationship to cognitive, social, and/or emotion-related development. This will help clarify what types of EF and regulation-related skills are being targeted in children, what strategies and supports are most relevant, and what measures are best suited for assessing them.

## Measurement Strategy

Different research traditions use different types of measures to assess EF and regulation-related skills, and these different approaches to measurement have implications for the way a skill is conceptualized (how we understand the meaning of the term) and can suggest how children use the skill in everyday behavior. In general, different measurement strategies have different pros and cons and may be used for different purposes.

Measurement strategies can vary by the type of activity and by the context in which children are assessed.

*Measurement strategy refers to the way in which a skill is assessed.*

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**Measurement Type:** The measurement type refers to *how* a skill is assessed. There are two key measurement types: direct assessments and reports.

- Direct Assessments
  - *Lab-based assessments* include computerized tasks or scripted activities like a specially designed card-sorting game given to participants in research settings. With lab-based assessments, what is measured is often a child's speed or accuracy when completing a task (Jacob & Parkinson, 2015).

- *Observational measures* include performance-based assessments where a child is observed while showing a specific behavior or skill. For example, children might be evaluated on their ability to follow multi-step directions when asked (e.g., Head-Toes-Knees-Shoulders (HTKS); McClelland et al., 2014).
- Reports
  - *Reports* can take the form of self-reports, teacher reports, parent reports, and peer reports. Reports typically involve rating a child’s likelihood to do something based on the reporter’s general knowledge of the child’s behavior in normal, every-day tasks (e.g., Children’s Behavior Questionnaire (CBQ); Rothbart, Ahadi, Hershey, & Fisher, 2001).

### *What are the pros and cons of measurement types?*

Direct assessments are typically seen as more objective evaluations of a child’s skills. One criticism of lab-based measures is that they are “strange situations with strange people for the shortest amount of time possible” (Bronfenbrenner, 1977, p. 513). In other words, lab-based measures may not be reflective of children’s EF and regulation-related skills in many everyday situations. A criticism of computer-based tasks is that they don’t capture how children use EF and regulation-related skills to deal with difficult social situations or exercise control when feelings like frustration and desire are involved, which are common in early learning and school settings.

Reports are subject to bias and can be less reliable than direct assessments. However, since reports are designed to describe children’s behavior in naturally-occurring situations, they can provide better information about how children use EF and regulation-related skills in their everyday lives.

**Measurement Context:** We use measurement context to refer to whether or not an EF and regulation-related task is assessed in the context of an emotionally-salient event. An emotionally salient event or situation involves strong feelings like frustration or desire (tasks that involve high potential for reward are emotionally-salient situations, especially for a young child). Wait/Delay tasks are inherently emotionally-salient measures of regulation-related skills, because they are designed to require children to wait for something highly desirable.



#### Emotionally-salient or "hot" measures:

- Tasks that involve feelings such as frustration, desire, or the potential for reward
- Reports that emphasize overt behaviors involved in social interactions that are emotionally-salient, such as the ability to calm down when upset



#### Emotionally-neutral or "cool" measures:

- Computer-based tasks that emphasize independently performed, internal or mental activities
- Other tasks or report questions that are not designed to elicit or explore emotions

The following are examples of two tasks that assess inhibition. One task is an emotionally-neutral or "cool" task and the other is an emotionally salient or "hot" task.

*Emotionally-neutral task assessing inhibition:* Stroop color/word test (Stroop, 1935) – A person is shown a series of color words in which each word is presented in the corresponding ink color (e.g., the word "red" is in red ink, "blue" is in blue ink, and so on).



The person is then shown the same words, but each word is in a non-corresponding ink color (e.g., the word "red" is in green ink, the word "blue" is in white ink, and so on). The person must resist the tendency to read the word, and instead say aloud the color of the ink. This is an emotionally-neutral task, because it is not designed to elicit specific feelings.



Note: Emotions such as frustration may arise for children during many of the “cool” or emotionally-neutral cognitive tasks. Children are encouraged to continue the measurement task until it is too difficult, which may elicit different levels of emotional response from different children.

*Emotionally-salient task assessing inhibition: Less is More* (Carlson, Davis, & Leach, 2005) – A child is presented with two piles containing unequal amounts of a set of desirable items (e.g., stickers, candy, or other preferred items) and told that one pile will be given to a puppet and the other pile will be given to the child. The child is then instructed to point to the pile that will be given to the puppet, and are told that they will receive the other pile. To get the larger amount of treats, the child must point to the smaller amount. The child must resist his/her temptation, or inhibit the impulse, to point to the pile with more treats. In this task, there is a reward attached to performance, making it a “high-stakes” or emotionally salient task, especially for young children. The Marshmallow Test is another classic test of inhibition (ability to wait) in the context of emotionally-salient conditions – the strong desire to have a treat.

Researchers are trained to disclose the measures used to assess skills, but they do not necessarily discuss what is implied by the use of a particular type or the context of the measures they have chosen. It may be helpful for researchers and stakeholders to be clearer about the measurement strategies used to assess EF and regulation-related skills in order to carefully align terms, chosen measurement strategies, and the outcomes of interest. In some cases, emotionally-salient tasks may be better measures of the real world outcomes that researchers, policymakers, and practitioners are interested in targeting.

### ***Key Illustration:***

#### ***Using the Framework to Interpret Findings***

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Sometimes researchers refer to other scholars’ work without using the same term as the original author, misrepresenting the implications of the findings. For example, it is common for EF researchers to cite a well-known longitudinal study about early childhood self-control (Moffitt et al., 2011) as evidence that EF predicts long-term outcomes in health, wealth, and criminal behavior (e.g., Barker et al., 2014).

**However, a closer look at the paper – using the four main issues of the framework – suggests that EF and self-control are not the same thing.**

In the Moffitt paper, self-control is *defined* in a variety of ways:

- “The need to delay gratification, control impulses, and modulate emotional expression”
- “An umbrella construct that bridges concepts and measurements from different disciplines (e.g., impulsivity, conscientiousness, self-regulation, delay of gratification, inattention-hyperactivity, executive function, willpower, intertemporal choice).”

The definitions and terms draw upon multiple research traditions including executive function, emotion

regulation, effortful control, and behavioral self-regulation. This indicates that self-control in the original study is an umbrella construct or *complex skill* that includes many regulation-related *skills across cognitive, social, and emotion-related domains*.

Self-control was also *measured* in a variety of ways:

- The study's authors used nine different measures of childhood self-control to create a composite score, including *diverse measurement types* and assessing skills across *more than one developmental stage*:
  - Observational ratings of children's lack of control
  - Parent and teacher reports of impulsive aggression
  - Parent, teacher, and self-reports of hyperactivity, lack of persistence, inattention, and impulsivity
  - Assessed at 3, 5, 7, 9, and 11 years of age

A reasonable interpretation of the findings in this study is that to improve outcomes in children's learning, behavior, and health, stakeholders would aim to promote a rich set of skills that span many different aspects of self-regulation across multiple developmental domains, stages, and contexts.

Based on these study findings, it is misleading to suggest that EF is predictive of these diverse long-term outcomes. While EF and self-control are related skills, EF and self-control differ substantially when considered from the perspective of each of the four possible issues of the framework.

#### **Why is this relevant to policymakers and other stakeholders?**

Policymakers and other stakeholders need to be aware of how studies define and measure skills in order to accurately interpret and use the findings. It is important to know whether a study and its findings are specific to a sub-component of EF (e.g., working memory), to EF as a composite of simple skills, or to a larger umbrella construct.

## IV. Project Findings

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Based on our literature review, we identified several trends in the growing body of research on EF and regulation-related skills. We have included below a summary of key findings that we believe are most relevant for various stakeholders working in early childhood education, public policy, and programs and services for low-income children and families.

Please note: a more detailed description of our findings is included in a forthcoming academic paper.

**Finding #1 – Executive function (EF) and other regulation-related skills are important areas of children’s development and are promising targets for interventions** that aim to improve outcomes for children and families living in poverty.

- A large body of research from multiple disciplines indicates that EF and other regulation-related skills are linked to school readiness and positive adjustment to school, academic achievement, and long-term health and well-being outcomes (e.g., Best, Miller, & Naglieri, 2011; Blair & Razza, 2007; Bull et al., 2008; Duckworth & Seligman, 2005; Eisenberg et al., 2004; Graziano et al., 2007; McClelland et al., 2007; Moffitt et al., 2011; Raver, 2002; Valiente et al., 2011).
- Many studies found that EF and regulation-related skills are better predictors of school and life success than IQ, socio-economic status, child gender, and other background characteristics (e.g., Duckworth & Seligman, 2005; McClelland et al., 2007; Moffitt et al., 2011).
- Research suggests that low-income children are more likely to have lower levels of EF and emotion and behavior regulation than their more affluent peers (e.g., Evans & Kim, 2013; Farah et al., 2006; Noble, Norman, & Farah, 2005; Raver et al., 2013).
- In particular, exposure to adverse life experiences such as trauma, abuse, neglect, or chronic exposure to other poverty-related stressors may impact the development and function of specific regions of the brain responsible for EF and emotion regulation (e.g., Bos et al., 2009; Kishiyama et al., 2009; Shonkoff et al., 2012).
- A number of studies have demonstrated that EF and regulation-related skills can be improved through training or interventions (Diamond & Lee, 2011). In particular, universal school-based social-emotional programs and teacher trainings can have positive impacts on children’s EF and regulation-related skills, as well as positive impacts on academic and behavior outcomes (e.g., Bierman et al., 2008; Diamond et al., 2007; Raver et al., 2011; Riggs et al., 2006); these programs show the largest effects among children at-risk for academic and behavioral problems (e.g., Jones, Brown, & Aber, 2011).
- Additionally, there is some evidence that regulation-related skills may serve as a protective factor for low-income children and youth. For example, among a low-income sample, children and adolescents with better EF and emotion regulation skills were more likely to have positive academic, social/behavioral, and mental health outcomes than children with lower self-regulation, despite similar life experiences (Buckner, Mezzacappa, & Beardslee, 2003; 2009).

**Finding #2 – The term EF is frequently used to describe findings that are linked to other skills, such as self-control, delay of gratification, and emotion and behavior regulation.**

Our literature review included 160 articles about EF and regulation-related skills. Within this small sample of EF and regulation-related research, we identified more than 40 distinct ways that researchers describe and measure this area of children’s development (see p. 54 of Appendix A for a complete list of terms/skills that appeared in our literature review). While many researchers define EF as three specific mental processes (working memory, inhibitory control, and attention/set shifting; e.g., Miyake et al., 2000), other researchers use EF to refer to a wide variety of other regulation-related skills.

For example, our review identified the following skills that are often described as EF:

- Attentional control or persistence (Eisenberg et al., 2004; Garon et al., 2008)
- Planning and setting goals (Best et al., 2011)
- Problem solving (Senn, Epsy, & Kaufmann, 2004)
- Creativity (Diamond, 2013)
- Self-regulation (Blair & Diamond, 2008; Calkins, 2007)
- Self-discipline (Duckworth & Seligman, 2005)

In particular, during the early childhood period, the following regulation-related skills are often used synonymously with EF:

- Effortful control (Eisenberg et al., 2009; Kochanska et al., 2000)
- Self-control (Moffitt et al., 2011)
- Delay of gratification or willpower (Metcalf & Mischel, 1999; Mischel, Shoda, & Rodriguez, 1989)
- Emotion regulation (Graziano et al., 2007; Howse et al., 2003; Raver, 2002)
- Behavior regulation (McClelland et al., 2007; Morrison, Ponitz, & McClelland, 2010)

Although EF and these regulation-related skills share common features, they differ in ways that have implications for the design and evaluation of programs. Without more transparency and precision in how stakeholders communicate about EF and regulation-related research, these differences may be lost, important areas of skill development may be overlooked, and key findings may be mis-understood.

- **Finding #3 – Rigorous research has shown that EF along with other regulation-related skills has broad influence on child outcomes.** Some of the strongest evidence about the importance of this area of development comes from studies that assess regulation-related skills involving multiple aspects of children’s thinking, feeling, and social behavior.
  - For example, one of the most commonly cited studies about the importance of EF is actually about self-control (Moffitt et al., 2011). In this study, defined in detail on pp. 28-29, self-control is defined as an “umbrella skill” encompassing many other skills, such as impulsivity, conscientiousness, self-regulation, delay of gratification, inattention-hyperactivity, executive function, will power, and intertemporal choice. In this study, self-control was assessed using

nine different measures including parent-, teacher- and self-reports, at multiple time points (over the span of nine years; from ages 3 to 11). Researchers found that children’s self-control predicted a wide range of important outcomes across the life span, including adult physical health, substance dependence, personal finances, and criminal behavior.

- Similarly, a recent study of young children’s social skills – including the abilities to share, take turns, and cooperate with others – were predictive of diverse long-term outcomes, including attaining higher levels of education, greater likelihood of having a full-time job, and lower likelihood of being arrested or needing public housing assistance as an adult (Jones, Greenberg, & Crowley, 2015).
- In contrast, although there is growing research documenting the links between EF and children’s school readiness and academic achievement, there is limited evidence about the predictive role of young children’s EF on long-term health, behavior, or mental health outcomes.

Programs and policies that aim to influence a broad set of learning, behavior, and health-related outcomes may consider targeting EF as well as other regulation-related skills. Stakeholders could also benefit from resources that articulate these distinct regulation-related skills, and how these skills change and grow over time, in order to understand and target them effectively.

Furthermore, some research indicates that even when children show gains in EF and regulation-related skills as a result of an early intervention, children often lose those gains when they move into traditional kindergarten and school settings (Zhai, Raver, & Jones, 2012). This finding suggests it may not be sufficient to build regulation-related skills at only one point in time. Instead, continued support in EF and regulation-related skills across multiple years and/or settings is likely necessary to maintain positive impacts on learning and behavior over time. This is consistent with many long-term follow-ups of early interventions. Thus, programs and policies that target EF along with other regulation-related skills, and that continue to support these multiple skills over time, may have broad impacts on child outcomes.

**Finding #4 – Particularly in early childhood, research suggests that regulation-related skills that involve managing emotions and social interactions** are especially important for children’s success in school and other positive outcomes. This includes specific regulation-related skills like the ability to manage frustration, desire, and anger/aggression, and the ability to share, take turns, and comply with teacher or caregiver requests.

As illustrated in the findings above, some of the most rigorous research about the importance of this area of development comes from studies that look at how children use regulation-related skills to manage their own emotions and social interactions (e.g., Mischel, 2014; Moffitt et al., 2011; Raver, 2002). For example:

- Numerous studies of social-emotional learning (SEL) programs and interventions designed to improve classroom quality and teacher caregiving practices (such as emotional support and positive behavior management) have demonstrated positive impacts on children’s EF and regulation-related skills (e.g., Bierman et al., 2008; Diamond et al., 2007; Raver et al., 2011).

- Two recent meta-analyses (for a combined total of almost 300 studies) indicate that children participating in high-quality SEL programs also demonstrate better academic performance, improved attitudes about school, more positive self-image, better classroom behavior and social skills (reduced aggression, noncompliance, and antisocial behavior), fewer disciplinary referrals, and reduced emotional distress (Durlak et al., 2011; Sklad et al., 2012).
- SEL programs tend to build skills such as the ability to identify and communicate feelings, resolve conflicts effectively, and generally support positive behavior in the classroom.

These findings are obscured when they are lumped under the header of EF and then described in purely cognitive terms. In contrast, studies of computer-based training in cognitive EF skills (such as working memory or inhibition) have shown some evidence of improved academic performance but limited transfer to other skills, classroom-relevant behaviors, or other non-academic outcomes (e.g., Melby-Lervag & Hulme, 2013; Thorell et al., 2009; Titz & Karbach, 2014).

**Finding #5 – EF and other regulation-related skills can be distinguished from one another using four different features: skill complexity, developmental stage, developmental domain, and measurement strategy.** Across the different definitions and measures that we came across in our review of EF and regulation-related research, we identified four characteristics that distinguish specific skills from each other:

- Skill Complexity – some skills refer to simple processes or single skills, while others refer to complex, multi-dimensional skills made up of many smaller skills
- Developmental Stage – some skills are relevant to the early childhood period, whereas others are used to refer exclusively to the regulation-related abilities of older children or adolescents
- Developmental Domain – some skills refer to purely cognitive processes, while others refer to social or emotional processes, or some combination of these three domains
- Measurement Strategy – some skills are assessed via computer-based or laboratory tasks, whereas other skills, or the same skills at other times, are assessed via observations or reports of children’s daily classroom or home behavior

These features provide a guiding framework for articulating distinctions between EF and regulation-related skills, and the findings associated with specific skills, in order to support more evidence-based policy and programmatic efforts.

## Gaps in the Literature

Important research and programmatic work is still needed to build a robust body of knowledge about the development of EF and regulation-related skills and to determine which skills are most closely tied to various outcomes. Based on our literature review, we identified a number of questions and assumptions that researchers have not yet addressed or answered on children’s EF and regulation-

related skills. These questions suggest cautions for how research is interpreted by the field, and point to future directions for EF and regulation-related research.

We identified the following gaps in the literature, organized by major question for the field:

**1) How are *EF and other regulation-related skills related to one another?***

Throughout the body of research, EF is often used to refer to a diverse set of regulation-related constructs such as persistence, grit, delay of gratification, emotion regulation, self-control, and other complex regulatory skills. However, **there is very limited research that investigates whether and how EF is actually linked to these other regulation-related skills.**

Our analysis of the measures used to assess EF and regulation-related skills suggests they are similar, yet distinct, although some of the hypothesized relationships seem to be more closely related than others. Little research directly explores the relationships between skills, and more research is needed to provide empirical support either for or against these claims. This research will likely need to be longitudinal in order to address questions related to developmental stage – given that the terms used to define, assess, and measure these constructs and skills vary across development and are often designed for different age groups (i.e., early childhood versus middle childhood versus adolescence).

**2) Are there *associations between EF and non-cognitive or non-academic outcomes, and between EC and academic achievement?***

There is limited research in the EF and cognitive neuroscience traditions that explores EF and non-cognitive or non-academic outcomes, such as self-regulation and other social-emotional skills. Because of this, little is known about how EF, as measured by emotionally-neutral tasks, is linked to social-emotional skills, mental or physical health, everyday behavior such as aggression or number of expulsions, or longer-term outcomes such as adolescent delinquency, criminal behavior, and adult income, etc. This may indicate that specific aspects of regulation are more salient for some outcomes and not others, or it may be because some important relationships have not yet been thoroughly investigated.

In contrast, the EC and emotion and behavior regulation literatures show consistent links between emotionally-salient or social-behavioral aspects of regulation and non-cognitive outcomes, but there are fewer studies exploring the relationships between these specific skills and academic achievement. As others have noted (Morrison & Grammar, 2016; Zhou et al., 2012), this may be a reflection of historical and methodological differences between different research traditions, rather than a difference in how aspects of regulation are related to specific outcomes. More research is needed to better understand the relationship between EF and non-cognitive skills, EC and academic achievement, and what aspects of regulation can be targeted

to achieve impacts in specific outcome areas or policy platforms (i.e., educational versus economic versus non-cognitive versus health).

### 3) Are EF and regulation-related skills *causally related* to behaviors or academic performance?

Throughout the body of research, the associations between children's EF and regulation-related skills and key outcomes are primarily derived from correlational studies. **There are very few rigorous studies from which causal inferences can be made providing evidence that EF and regulation-related skills are responsible for children's performance in either academic or behavioral domains.** This claim is supported by a recent meta-analysis that examined the relationship between EF and math and reading abilities and found that the existing research base supports a correlational but not a causal association between children's executive function skills and academic abilities (Jacob & Parkinson, 2015) (see Appendix C for a summary of this meta-analysis).

It is unclear whether some other skill is underlying both EF and academic performance; or whether children's advances in academics and behavioral development pave the way for changes in executive functioning and regulation-related skills; or some combination of these different pathways and directions of influence. The lack of causal research can make it difficult for researchers, policymakers, and practitioners to target aspects of EF to improve behaviors or academic performance.

### 4) Can *lab-based EF tasks accurately predict outcomes* in real-world contexts?

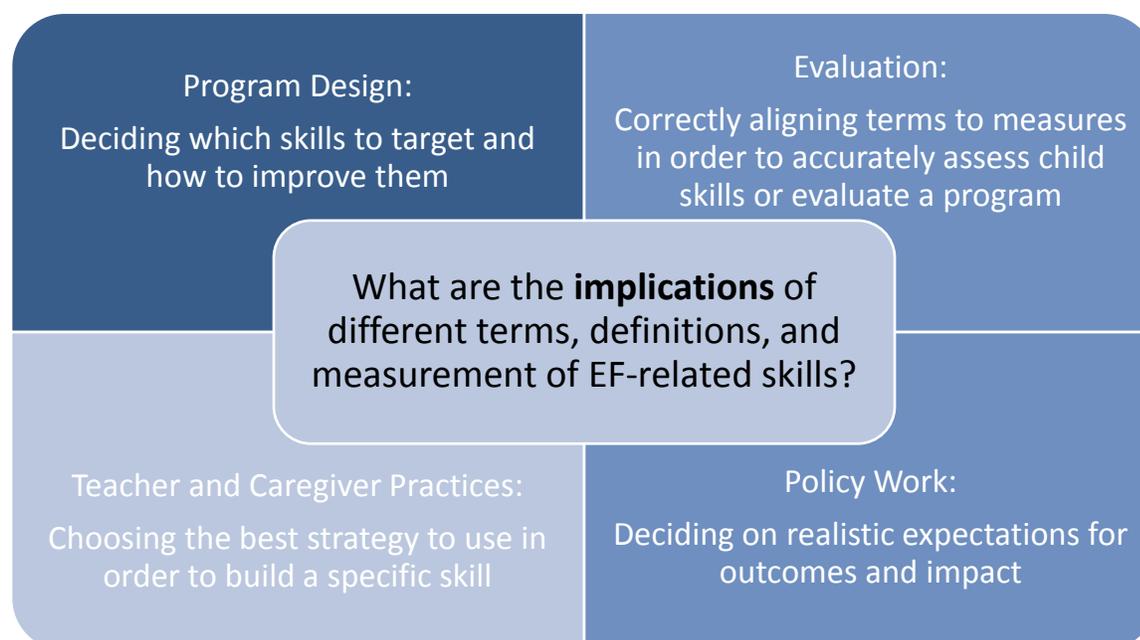
Many studies that stakeholders refer to when highlighting the importance of EF use lab-based tasks, such as a child's performance on a computer-based attention game or the ability to sort cards correctly in the presence of a researcher. However, there is limited evidence that lab-based EF tasks predict children's everyday behavior in home and school. For example, there is little research demonstrating that children's EF as assessed by lab-based tasks is related to their abilities to wait in line, to follow-through with multi-step instructions, to refrain from interrupting others, to resist acting out when angry, to comply with care-giver requests, and to sustain attention or persist with learning activities, daily chores, etc.

While some researchers have created measures that more closely mimic the classroom environment (Ponitz et al., 2008), it remains unclear whether children's performance on this measure is correlated with their performance on traditional, lab-based EF tasks. It is important that we understand whether these lab-based tasks capture children's everyday behaviors and skills in school in order to determine how to accurately measure EF in important contexts, such as the classroom.

## Challenges for Translation

Based on our findings and gaps in the literature, we identified potential challenges for translation for each stakeholder that may result as a consequence of the different terms, definitions, and conceptualizations of EF. Such challenges arise because substantial confusion and mis-alignment in the field can lead to a poor understanding of the key skills, what works to enhance them, and how to appropriately measure them or evaluate program impact. In light of growing interest in targeting EF as a way to address poverty-related gaps in school readiness, academic achievement, and other aspects of healthy development, these challenges have the potential to undermine efforts to improve outcomes for the country's most vulnerable children.

*Exhibit 7. Translational challenges for design, evaluation, practice, and policy.*



**Challenges for Program Design:** It is important to understand how and where students develop EF skills in order to design effective programs. However, different bodies of research suggest different targets and approaches to skill-building, and different contexts in which children are likely to build or practice emerging skills. Due to this lack of consensus, it is difficult to establish “best practices” related to the EF construct, and to design programs or interventions that will achieve optimal EF outcomes.

**Challenges for Program Evaluation:** Different bodies of research suggest different assessment strategies and different expectations for programmatic outcomes and impact. For example, the differences between the research traditions (EF and EC) and measurement styles can make the evaluation of programs and the clear communication of findings problematic. Different assessment

strategies of the same concept may also present a challenge. Sometimes EF is used to refer to skills assessed by computer-based tasks, other times to skills measured by emotionally-salient tasks (tasks that take the real-world context into consideration), and other times it refers to skills assessed by teacher or parent reports. These different measurement strategies may capture different aspects of the same construct or skill, and may emphasize different contexts in which children use EF skills.

**Challenges for Teacher and Caregiver Practices:** Different bodies of research suggest different supportive practices and recommendations for teacher training. It is important to provide teachers with clear recommendations and suggestions about the different strategies and practices that support the development of specific EF skills. Such guidelines will allow teachers to be more intentional in their practices when targeting a specific skill, and will help them better support children as they build EF skills.

**Challenges for Policy Work:** Different bodies of research suggest different policy levers and platforms for intervention, different federal or state standards or guidelines, and different expectations for outcome and impact; for example, because it is so embedded in early relationships and environmental experiences, effortful control might be ideally targeted in the home environment before kindergarten entry. Working memory, on the other hand, is so central to the basic tasks of early schooling (e.g., remembering a sequence of steps or a classroom routine), it may be more effectively targeted in later years via school-based interventions.

## How does terminology cause confusion for applied efforts?

### Imagine these two situations:

- A. A state policy-maker and team of advocates are working to integrate recent research on EF into existing services for low-income children and families. The team compiles a research summary suggesting that EF can be targeted to improve a wide range of children's short- and long-term outcomes, which is used to build buy-in with stakeholders from health and early learning sectors. The team operationalizes their work by focusing on mindfulness and emotion regulation skills. The team measures the impact of their work by assessing children's EF skills using the Dimensional Card Change Sort and backward digit span, two standardized and commonly-used EF measures for childhood EF. These measures tap a cognitively-oriented definition of EF. The team finds no evidence that children did better on these measures, but they find some evidence that their academic performance improved. The team is unsure how to describe the impact of their efforts. **This group probably would have benefited from a broader definition of EF and regulation-related skills and different types of measurement, for example teacher and parent reports of everyday focus and emotion management behaviors.**
- B. A preschool teacher is concerned about some of her students who are struggling with behavior. She looks at her summer training materials and sees a section that was new to her about children's executive function and self-regulation skills. The section describes specific skills such as working memory, attention, inhibitory control, flexibility, persistence, and coping with difficult emotions. She is able to identify different, specific areas that are particularly challenging for each child, and she uses the training materials to make a plan for how she will help each student practice that skill in the upcoming weeks. **This teacher likely benefited from having careful, distinct descriptions and information about multiple types of EF and regulation-related skills.**

It is likely that different efforts related to supporting children and families with the EF literature will be best met by different combinations of the various skills and findings related to each. Some efforts will require comprehensive approaches to EF that operationalize and target multiple skills. Other efforts may only require an understanding and ability to target or measure certain aspects of EF. But without a guiding framework of what the skills are and how they are related to different outcomes, age groups, and issues of interest, it will be difficult or impossible for decision-makers to know.

## V. Implications and Considerations

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The following implications and considerations for stakeholders emerged from a synthesis of our literature review, our guiding framework that is based on our analysis of EF and regulation-related terms and skills, and the gaps we identified in the literature. Our findings suggest cautions for the interpretation of current research and its application to real-world problems.

### Implications and Considerations for Stakeholders

Our findings and proposed framework have practical implications for multiple stakeholders, including program developers, service providers, researchers, evaluators, educators, practitioners, and policy-makers. The implications and considerations below, broken down by stakeholder, demonstrate the framework's usefulness for understanding and generating research on EF and regulation-related skills. In addition, they allow each stakeholder to consider their own role in communicating and operationalizing EF and regulation-related efforts with more accuracy and transparency.

**Need for more precision, clarity, and careful alignment between term, measurement, and recommendation.** The biggest message of this report is that people use different EF and regulation-related terms to mean the same thing, or the same terms to mean different things. Such conceptual confusion makes it difficult to draw clear, accurate conclusions about the research or recommendations and what to do in early childhood settings. This matters for different stakeholders in different ways.

- **For Program Developers.** Program developers and program directors must think carefully about the EF and regulation-related skill or set of skills they want to target, how they define those skills, and how they will evaluate the effectiveness of a program in improving those skills. When deciding what skills to target, program developers and directors should look at the specific literature for the age group, developmental domain (i.e., cognitive, social, emotional), and skill complexity (i.e., complex or simple/foundational) of interest.
- **For Program Evaluators.** Evaluators need to understand the specific EF and regulation-related skills a program is trying to improve and how to best measure them in order to accurately assess the effectiveness of a program or policy effort. For example, it would be unwise to use a computerized EF task to evaluate the effects of a program designed to improve children's regulation-related skills such as following multi-step directions or waiting patiently in line. It is important for program evaluators to select measures that are age appropriate as well as aligned to skill complexity, developmental domain, and the context of how children are expected to use the targeted skills.
- **For Policy Makers.** While most policy-makers do not need detailed knowledge about the nuances between EF and regulation-related skills, they should have a general understanding of

the broad ways that EF and regulation-related skills are studied and what is known about them. This will allow policy-makers to communicate accurately and to facilitate work related to developing, assessing, and funding various EF and regulation-related efforts across different sectors at the state and national levels.

- **For Teachers and Caregivers.** Early childhood and K-12 educators may not need details about terms and their associated research traditions, but they will need information about how to identify needs and the best strategies for supporting children in specific skill areas. When choosing programs, strategies, or developing best practices, teachers will need access to information that is specific to the skill complexity, developmental stage, domain, and the context of interest.
- **All Stakeholders.** We suggest that all stakeholders in early childhood – researchers, practitioners, policy-makers, funders, and others – use the guiding framework to better operationalize EF and regulation-related terms in their work. In our framework, we have identified four issues to facilitate articulating salient differences between EF and regulation-related skills: (a) skill complexity, (b) developmental stage, (c) developmental domain, and (d) measurement strategy. Use of the framework will promote increased accuracy and transparency about the specific skills stakeholders are studying or targeting.

**Need for more rigorous research.** The field needs more rigorous research investigating causality, relationships over time, and links to real-world outcomes.

- **Causality.** Research to address questions of causality should ideally be designed around interventions and training studies. Intervention studies need to include evidence- and theory-based covariates, pre- and post-training measures of key skills and outcomes (to show how *change* in skills is related to *change* in outcomes), and ideally be large enough to use multi-level modeling and control for children’s nesting in classrooms, centers/schools, and neighborhoods/communities.

Without causal research, we do not know if changing EF can *cause* changes in academic outcomes or if EF and academic outcomes are both influenced by other factors, such as demographic characteristics. This research is a crucial next step because without it we cannot be sure that investing in programs that build EF will lead to improvements in the targeted outcomes that interest policymakers and program designers.

- **Relationships Over Time and With Varied Outcomes.** Research to address questions of relationships over time can investigate relationships between multiple regulation-related processes and skills (i.e., whether and how executive function and emotion regulation are related over time), or relationships between regulation-related skills and specific outcome areas (i.e., whether and how the relationship between working memory and academic achievement changes over time). Given the claims and interest in targeting early childhood regulation as a

means of addressing later disparities, studies to explore relationships over time should ideally follow children from early childhood through adolescence and into adulthood when possible.

Without this research, we do not know how the relationship between regulation-related skills and specific outcomes changes across the developmental trajectory. It is important to know which skills to target at each stage of development, and how these skills build on each other and align across development.

- **Research in Diverse Populations.** Research to address questions of the distribution of EF skills in children should look across populations with varying demographics – specifically those populations that policy-makers and service providers are most interested in supporting, including low-income and vulnerable children and families. Most of the current research is limited to upper and middle class populations, resulting in little knowledge about how EF and regulation-related skills develop in diverse populations. It is often unclear whether high or low levels of EF are due to programs and interventions or unobserved child characteristics, such as IQ and key demographic variables (Jacob & Parkinson, 2015).

Further, key demographic variables should be statistically controlled for in all analyses in order to gain a better understanding of the true relationship between EF and outcomes of interest, such as academic achievement.

- **Links to Real-World Outcomes.** Research to investigate the links between EF skills and real-world outcomes should include observational data about children’s everyday behavior in school, home, and other settings. Due to reporter bias inherent in observational reports, research should aim to include multiple reporters – such as parent, teacher, and outside assessor. This type of data can be combined with other measures (including lab-based tasks) in order to provide a rich and context-relevant picture of children’s skills.

The effortful control and emotion and behavior regulation literatures have many such measures that have been standardized and validated in large population samples. However, there is a need to develop new measures and indicators of additional aspects of regulation (such as working memory) that are not already included in existing observation-based assessment tools.

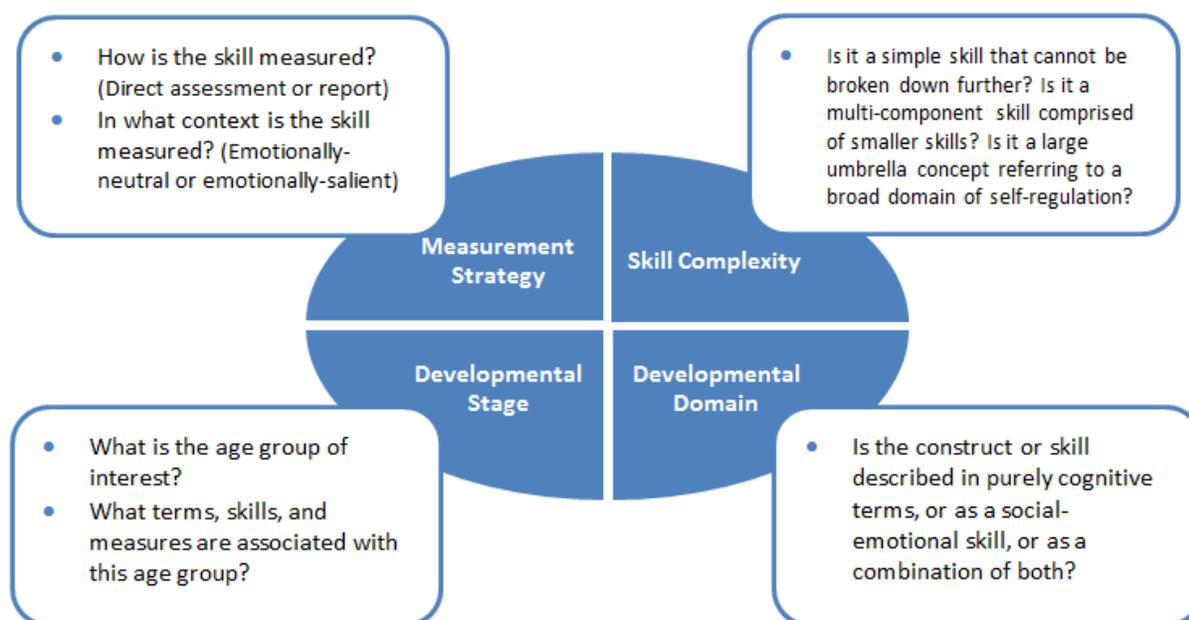
**Need to bridge different research traditions and disciplines.** The field would benefit from efforts to bridge different research traditions that study the development of EF and regulation-related skills (for example, using measures and approaches from cognitive neuroscience in the same studies as approaches from developmental, temperament, or clinical psychology). Multi-disciplinary, multi-method approaches are needed in order to address many of the remaining questions about how regulation impacts children in diverse ways and what can be done to most effectively promote children’s healthy development.

**Looking Forward** – Finally, we suggest the field needs additional resources that allow users to (1) search a specific EF and regulation-related skill, (2) locate key research tied to that skill, (3) identify assessment and teaching strategies associated with that skill, and (4) synthesize relevant findings for policy and practice recommendations. Policy recommendations and best practices are built on coherent bodies of research, but the current body of EF and regulation-related research reflects many different skills with unique findings tied to each, and is muddled by a lack of consistent or clear terminology that can articulate distinct skills.

Economists, funders, or policy-makers who wish to look across diverse studies to assess the impact at-large of EF and regulation-related interventions have no tools to articulate the differences between various programs and policy efforts, which makes it difficult to determine why some EF and regulation-related efforts produce positive impacts while others do not. Without a guide to how different research, program, and policy efforts operationalize the term EF (e.g., how they define, measure, or target it), it is impossible to compare the impact of these diverse efforts. An interactive online resource would allow studies that have similar terms and measures to be compiled based on an overarching framework. Aggregating findings into larger, more robust bodies of evidence would support broader policy work and provide a more accurate understanding of the science of EF.

**We have summarized the four key issues of the framework in the figure below, including sample questions stakeholders can ask to understand and describe EF and regulation-related skills with more clarity and precision.**

*Exhibit 8. Questions to consider when using the framework*



## Cautions

- **EF risks losing its specific and important meaning.** Without more clarity, consensus, or consistency in how it is used, the term EF is not likely to be understood accurately or operationalized in evidence-based and effective ways.
- **EF is not a silver bullet.** While EF is an important skill, particularly for low-income and vulnerable children, supporting EF development is not a magic solution for closing poverty-related gaps in learning, behavior, and health. Policy-makers and other stakeholders should be careful not to over-estimate or over-promise what can be realistically accomplished through efforts to build EF or other related skills.
- **Emotions Matter.** Policy-makers and other stakeholders should be aware that promoting or measuring children's skills in contexts that involve emotion such as reward, frustration, and desire might be more relevant to what children can actually do, and need to be able to do, in school and everyday environments. This type of measurement strategy is in contrast to how EF is often portrayed or described as a purely cognitive skill assessed via computer-based tasks, but may be a better predictor of important real-world outcomes.
- **Programs and strategies could be designed for the wrong skills and outcomes.** Without more transparency and precision in how EF and regulation-related research is communicated and operationalized, we risk designing programs for the wrong processes, leaving out important processes, or targeting skill areas in the wrong contexts or at the wrong time in development.

## Conclusion

There is strong evidence from multiple disciplines that executive function and other regulation-related skills matter for the healthy development of children and youth. Our review highlights that different research traditions approach regulation-related concepts in meaningfully distinct ways, and yet we identify a growing trend in both research and applied settings in which distinct terms are used as if they are synonyms with one another. Our concern is that by combining the diverse bodies of EF and regulation-related research without careful precision and transparency, stakeholders are likely to miss-out on important distinctions and ultimately misunderstand key skills and the findings associated with them.

The various bodies of research on children's EF and regulation-related skills provide different perspectives on what regulation is, how it manifests in everyday behavior, and how it can be targeted in policy work, school-based interventions, and other applied efforts. Because each body of research offers unique advantages and disadvantages for translation, we suggest that those working in this field take special care to consult multiple research traditions to understand distinctions that are relevant to their work and to maximize the likelihood of positive influence on children's outcomes.

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## Appendix A: Project Approach

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To understand the current landscape of EF and regulation-related research, we organized our work around the following questions:

**What are the key skills and terms identified in the EF and regulation-related literatures? How are they defined, described, and measured? What do we know about their development and their links to important outcomes?**

To investigate these questions, we engaged in the following activities:

- First, we conducted a *literature review* of conceptual papers, review papers, and recent studies about EF and regulation-related skills, focusing primarily on the early childhood period, but sometimes extending into middle childhood and adolescence in order to highlight issues related to the development of EF and regulation-related skills over time.
- Second, we compiled a *database* of these studies (n=160) and coded each study based on a list of observed differences in how the term EF was defined, described, and measured, plus the main findings of each study. From our literature review and database, we generated a list of commonly used EF and regulation-related terms and the discrete skills to which they refer.
- Third, we analyzed the differences between terms and skills and their relationships to each other in order to develop a *guiding framework* and an accompanying visual *map of key terms*. The purpose of the framework is to articulate distinctions between EF and regulation-related skills, so that findings tied to specific skills can be communicated with more accuracy and transparency.
- Fourth, we identified additional documents (such as working papers intended for a policy audience, books and popular writing on EF and regulation-related skills, and other materials including early learning and K-12 state standards) to provide real-world illustrations of how EF and regulation-related skills are being applied in decision-making contexts.
- We used these multiple sources to refine our guiding framework and visual map, to identify *challenges for translation and gaps in the literature*, and to generate a *set of implications and considerations* for research, policy, and practice. The guiding framework, map of key terms, and considerations are designed to drive a better understanding of EF and regulation-related research, in order to support more evidence-based and effective translation of research into policy and programmatic efforts.

We summarized this work in a written report and shared the information with a group of experts in child development and public policy. Experts provided feedback about the findings, implications, and considerations of the project, and we refined our report to incorporate their comments and suggested revisions.

## Literature Review

We started our literature review by identifying key articles in the broad traditions of executive function (EF) and effortful control (EC). We chose to begin with these two terms because there is a great deal of research on EF and EC during the early childhood period. Additionally, researchers have been using EF and EC in increasingly interchangeable ways (Carlson, 2005; Kochanska, Murray, & Harlan, 2000; Liew, 2012; Zhou et al., 2012). Although these skills may overlap, research provides evidence that EF and EC tap distinct developmental phenomena. For example, most studies of EC involve measuring children's abilities to manage strong feelings in order to complete an activity, whereas many studies of EF measure a purely cognitive aspect of self-regulation. Some of the most compelling findings about the influence of early childhood regulation on long-term health and behavioral outcomes are tied to emotionally-salient aspects of regulation (Mischel, 2014; Moffit et al., 2011). This may suggest that skills involving the explicit management of emotions, such as EC, are particularly important.

**A lack of precision and transparency in communicating these unique features of EF and EC may undermine efforts to improve outcomes for children.** If EF and EC are incorrectly assumed to be synonyms, then findings from EF and EC studies that are lumped together will give stakeholders the misleading impression that targeting one skill (EF) may lead to outcomes that, in reality, have been tied to the other skill (EC). This may result in stakeholders overlooking a body of research that has important implications for children's positive development.

This use of EF and EC as interchangeable skills – as well as the use of many other terms such as self-regulation, grit, persistence, and self-discipline – may give policy-makers and other stakeholders an inaccurate view of what is known about these specific skills. Researchers have begun to describe this problem and attempt to address it using various methods (see Burman, Green, & Shankar, 2015). The objective of our literature review was to untangle key EF and regulation-related terms by identifying the unique features of each skill, as well as the findings tied to its development.

Our review extended to EF and regulation-related terms and skills that authors cited in key EF and EC studies. A process of following reference lists and identifying the terms and measures used by commonly-cited authors led us to investigate additional skills including self-control and emotion and behavior regulation, in particular (i.e., what one author describes as a finding related to EF, the original author calls self-control and measures it in a substantially different way than EF).

We also examined articles written for diverse audiences about the importance of executive function. Based on our own work with policy-makers, program developers, and PreK-5 educators, we selected articles and resources that we knew stakeholders were using in popular discourse about what EF is and why it matters for children's development. Since the purpose of our project is to support effective translation for non-researchers, we were particularly interested in understanding how these broad-audience publications were defining, describing, and measuring EF. We identified the following publications and resources:

- The Center on the Developing Child at Harvard University (Working Paper #11, *Building the Brain's "Air Traffic Control" System: How Early Experiences Shape the Development of Executive Function*, and related Training Module, Activities Guide, and InBrief materials).
- Building Better Programs (online collection of materials about EF, including expert webinars).
- Research-based books and popular writing that we encountered when working with educators and policy-makers in PreK-5 settings (including *Mind in the Making* by Ellen Galinsky, *The Marshmallow Test* by Walter Mischel, and *How Children Succeed* by Paul Tough).
- Head Start Child Outcomes Framework, also known as the 2015 Head Start Early Learning Outcomes Framework: Ages Birth to Five (which includes specific skills such as Emotional and Behavioral Self-Regulation, and Cognitive Self-Regulation/Executive Function within the Approaches to Learning and Social and Emotional Development Domains).
- State early learning and K-12 standards (including standards for Social and Intellectual Habits, Social-Emotional Skills, Approaches to Learning, and Self-Management Domains).

## Database and Coding System

We entered findings from the literature review into a database of 160 articles spanning a range of disciplines, including cognitive and affective neuroscience, stress neurobiology and neurophysiology, and developmental psychology; and including the sub-fields of temperament, cognitive development, social-emotional development, clinical psychology, educational research, and prevention science. In our database, we documented the following information for each study:

- How is the EF and regulation-related skill defined and described?
- How is the EF and regulation-related skill measured?
- How is the EF and regulation-related skill linked to academic, social-emotional, or other key outcomes?
- How does the EF and regulation-related skill develop across childhood?
- How is the EF and regulation-related skill linked to socio-economic status or other risk factors?
- How does intervention influence the development of the EF and regulation-related skill? Has intervention been shown to be effective? If so, what kinds of interventions, strategies, or programs are effective?

**Our primary goal was to capture how different researchers were using the different terms – how they operationalized the term or skill under investigation.** For example, Miyake and colleagues (2000—a commonly-cited landmark publication about the nature of EF) break down the term EF into four sub-components, provide distinct definitions for three of the four sub-components, and use multiple measures for each – a total of 14 measures to assess EF. As you can see below in a screenshot of our database, we coded the following information:

- **Key Developmental Construct (Author)** – this is the term used by the author; it is the author's way of identifying the target in the study (in the example below, the author uses the term EF).

- **Key Developmental Construct (Definition/Description)** – this is the way the author defines or describes the term or skill; we included actual text from the article.
- **Sub-component (Author)** – these are the terms used by the author to identify any sub-components of the skill/term being studied; it is the author’s way of saying what they think is included in the meaning of EF (in the example below, the author uses Shifting, Updating, Inhibition, and Complex Executive Tasks).
- **Sub-component (Definition/Description)** – these are the definitions provided by the author for each sub-component; it is the way the author describes the terms/skills that collectively comprise EF.
- **Measures** – these are the actual measures used to assess each skill or sub-component (in the example below, these include Plus-Minus, Number-Letter, Local-Global, and 11 other tasks).

*Exhibit 9: Partial screenshot of an article in the EF Mapping Project Database*

<u>Article:</u>	<u>Key Developmental Construct (Author):</u>	<u>Key Developmental Construct (Definition/Descr.):</u>	<u>Sub-component (Author):</u>	<u>Sub-component (Definition/Descr.):</u>	<u>Measures:</u>
Miyake et al. (2000)	Executive function	"general-purpose control mechanisms that modulate the operation of various cognitive subprocesses and thereby regulate the dynamics of human cognition" (pg. 50)	Shifting	Mental set shifting	plus-minus number-letter local-global (details pg. 62)
Miyake et al. (2000)	Executive function		Updating	Information updating & monitoring	keep track letter memory tone monitoring (details pg. 63)
Miyake et al. (2000)	Executive function		Inhibition	Inhibition of prepotent responses	Stroop Antisaccade Stop-signal (details pg. 64)
Miyake et al. (2000)	Executive function		Complex executive tasks		WCST TOH RNG Operation span Dual (details pg. 64-66)

Note: additional columns of the database contain more information for each study, including: Age of Participants, Assessment Context (lab-based, school-based, etc.), and any findings related to the Development of EF, Risk Factors, Links to Outcomes, and/or Intervention Results (such as whether and how much skills were improved, and what, if any, specific strategies were identified as effective or promising for enhancing EF and regulation-related skills). Since each study varied with regard to which specific categories of information it included, we did not show those columns in the example above.

Due to the inconsistent use of EF and regulation-related terminology across studies, we primarily coded how the author operationalized each term and skill by carefully examining the measures. Below is a list

of the key developmental constructs (main term used in a study) and the sub-component category (distinct skills or processes that comprise the main term) that emerged from the database. There are 45 total terms and skills identified in this list.

**The number and variety of terms authors used in EF-related research illustrates the potential for confusion and inaccuracy or lack of transparency in interpreting findings tied to a particular skill.**

Updating	Attention Control	Effortful Attention
Working Memory - Simple	Sustained Attention	Cognitive Control
Working Memory - Complex	Impulsivity	Lack of Control
Complex EF	EC - Focusing Attention	Persistence
Inhibition	EC - Shifting Attention	Grit
Inhibitory Control	Error Detection	Self-Regulation
Response Inhibition - Simple	Monitoring	Emotion Regulation
Response Inhibition - Complex	Plan Actions (Planning)	Hot EF
Response Control	Behavioral Regulation	Cool EF
Shifting	Delay	Delay EF
Set Shifting	Suppress/Initiate	Conflict EF
Attention Shifting	Mindfulness	Executive Attention
Cognitive Flexibility	Self-Control	Executive Control
Mental Flexibility	Self-Discipline	Problem Solving
Creativity	Delay of Gratification	Goal Setting

### Grouping Key EF-Related Terms and Skills

Based on our literature review and database, we began to group terms and skills that are closely related or identical both conceptually (based on authors' definitions and descriptions) and operationally (based on measures or tasks used to assess them). For example, researchers often use executive function, executive control, executive attention, and cognitive control in closely related or identical ways. While there is variation, researchers and other stakeholders defined, described, and measured these terms in similar ways across many studies: as multi-dimensional constructs comprising three or four key processes (inhibition, attention, working memory, and shifting). Although sometimes the focus of the term is slightly different, for example emphasizing working memory versus attention as the "coordinating" factor, we suggest they form a meaningful and cohesive group, and can serve as a placeholder for a type of EF-related skill that is measured in fairly consistent ways (when assessed as a composite of the processes identified above).

We propose grouping other key terms as follows:

- Inhibition, inhibitory control, response inhibition, response control, simple and complex inhibition, conflict EF, suppress (though not initiate), as well as impulsivity and lack of control (as inverse measures of inhibition).

- Working memory (WM), simple WM (though not complex because it typically involves additional elements), and sometimes updating and monitoring (depending on how they are measured).
- Shifting, set shifting, attention shifting, cognitive flexibility, and mental flexibility.
- Sustained attention, focusing attention, effortful attention, and attention control.
- Delay (wait tasks), delay of gratification, delay EF, and some hot EF tasks.

The remaining terms/skills share features with one or more of these groups. However, they also typically involve additional elements such as dealing effectively with emotions (i.e., involving deliberate self-soothing or regulating the duration or intensity of emotional expression), managing behavior in socially-appropriate ways (i.e., involving understanding social cues and/or norms), or explicit consideration of possible future-oriented steps or alternatives (in the case of planning and problem solving, for example).

### Developing a Guiding Framework and Visual Map

Building on our work to identify key EF-related terms and the skills they refer to, we next analyzed the unique or defining characteristics of each set of terms and the relationships between them. Since there is limited empirical evidence about the relationships between distinct skills, we looked carefully at definitions and measurement tasks in order to develop a theory-based framework for organizing the skills in a meaningful way.

#### **Our goal was to articulate what we observed to be the major similarities and differences between skills that appear in EF and regulation-related research.**

We identified a set of four issues, or four organizing principles that can be used to describe how various EF and regulation-related skills are connected to one another.

#### **The four organizing principles of our proposed framework are:**

1. **Skill complexity** – the relative size or complexity of a skill (i.e., whether a skill is complex, multi-faceted, and comprises multiple skills; or small, simple, and less complex)
2. **Developmental Stage** – the relevant stage for a skill, or age-specific manifestations
3. **Developmental Domain** – the social, emotional, or cognitive orientation of a skill
4. **Measurement Strategy** – the approach to assessing or observing the skill

EF and regulation-related skills vary along each of these four dimensions, and they have implications for the accurate interpretation and effective application of research. **We suggest these four issues should be used as a guiding framework for communicating about EF and regulation-related skills and findings with more clarity and precision.**

The framework can help researchers to situate their work in the broader landscape of EF and regulation-related research. The framework can also help program developers, evaluators, policy-makers and other stakeholders accurately interpret findings that may be specific to a particular EF and regulation-related skill. This honed ability to interpret findings may aid stakeholders in identifying the most important skills

to target at a particular age/stage, promising strategies for enhancing a particular skill, reliable ways to assess a particular skill or the impact of a program, or long-term outcomes that may be realistically anticipated as a result of a program or policy. Without accurate information about skill complexity, developmental stage, developmental domain, and measurement strategy, the implications of a scientific study will be unclear. Findings could be specific to skills that are simple (such as a single construct) versus complex, large and multi-dimensional, or skills that develop during early childhood versus those that emerge later in middle childhood or adolescence, skills that involve exercising control in emotionally-charged situations, or skills that are best measured via teacher report versus computer-based tasks.

*The framework can help researchers situate their work transparently in the broader landscape of EF-related research and can help other stakeholders accurately interpret findings that may be specific to a particular EF-related skill.*

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The map is a visual illustration of how key EF and regulation-related skills are related to one another. It most closely reflects the principles of skill complexity and developmental domain. To keep the map simple and useful as a heuristic (i.e., as a general conceptual organizing device; it is not intended to be a comprehensive or exact representation of empirical relationships, since there are few studies directly investigating how EF and regulation-related skills are related to each other), we did not attempt to reflect developmental stage or measurement strategy. We plan to address development and measurement strategy explicitly in future products, such as the compendium of EF and regulation-related measures.

### EF Mapping Report and Expert Webinar

In January 2015, a group of experts reviewed our project's main findings and recommendations through document review and a group webinar. Participants included nationally recognized experts in executive function and self-regulation research, child development and public policy, and key personnel from research and policy organizations such as the National Governors Association, the National Head Start Association, and the Office of Planning, Research, and Evaluation at the federal Administration for Children and Families. Special thanks to Cybele Raver, Phil Fisher, Deborah Phillips, Danielle Ewen, Albert Wat, Martha Zaslow, Aleta Meyer, Lindsey Hutchison, Christine Fortunato, Kathleen Dwyer, and other ACF federal staff members for reviewing draft materials and providing critical feedback.

# Appendix B: Definitions, Measures, and Research Summaries of Key EF and Regulation-Related Skills

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This section is a snapshot of the definitions, measurement, and a brief summary of research for the EF and regulation-related terms and skills included in our map (see Exhibit 5). An upcoming Measures Compendium will provide a more comprehensive list of measures used to assess EF and regulation-related skills. As with many areas of research, information was sparse and findings are sometimes conflicting or difficult to assign to one specific term - due to the very issues this report is intended to address. Based on our review, we have included here the most consistent and reliable information available.

## Simple Skills:

**Working Memory** is defined as the ability to maintain and manipulate information over short periods of time. The core feature of working memory is the requirement to hold information in mind and actively use it to guide thinking and behavior (Wiebe et al., 2011). Children use working memory to remember to put their socks on before their shoes and to follow multi-step directions. Even before children enter preschool, working memory may be an important predictor of school success, particularly mathematics achievement (Fitzpatrick & Pagani, 2012; Epsy et al., 2004). In a 5-year longitudinal study, researchers found that Pre-K measures of working memory predicted academic achievement at the end of first grade and again at the end of 3rd grade, including on measures of general cognitive, math, and reading abilities (Bull et al., 2008). Further, a recent review of working memory training programs for school-age children found some evidence that these programs may improve academic outcomes, particularly reading abilities (Titz & Karbach, 2014) (see Appendix C for a summary of this meta-analysis).

**Inhibition** (sometimes referred to as *inhibitory control* or *response inhibition*) is defined as the ability to inhibit or suppress a dominant response in favor of a subdominant response. When inhibition is used as a sub-component of EF, it is typically measured in an emotionally-neutral context via computerized or observational tasks. Common direct assessments include the Stroop and Tower of Hanoi, and a common observational task requires children to walk a line as slowly as possible.

When measuring inhibition as a sub-component of EC, researchers typically use observational measures that involve moving an object as slowly as possible, whispering, following rules only

some of the time, or teacher and parent-reports of children's behavior. To assess inhibition in the emotionally salient domain, many researchers use tasks that are typically characterized as wait/delay tasks. Delay is a parallel process to inhibition, and in these tasks children inhibit thoughts or behaviors in the context of a desire or temptation for reward, thus involving the regulation of strong feelings.

Studies indicate that inhibition is also related to academic and social-emotional outcomes. For example, inhibition measured during the Pre-K year was found to be associated with mathematics knowledge in one study (Epsy et al., 2004) and math and reading ability in both pre-K and kindergarten in another (Blair & Razza, 2007). In a recent meta-analysis, Allan et al. (2014) found that there is an association between inhibitory control and academic skills in pre-K and kindergarten children, however the strength of the relationship varied by measurement strategy (i.e., direct assessment vs. report-based measure, "hot" vs. "cool" task) (see Appendix C for a summary of this meta-analysis).

Inhibition is also related to emotion regulation in this age group. For example, in a study of preschoolers, inhibition levels at either the extreme low-end (under-controlled) or the extreme high-end (over-controlled) were related to lower levels of emotion regulation when compared to moderate inhibition levels (Carlson & Wang, 2007). This inverse-U relationship suggests that children who are highly un-inhibited (i.e., impulsive) or highly inhibited (i.e., anxious) may have a harder time regulating their emotions compared to children who can flexibly manage their inhibition.

**Attention Shifting** (sometimes referred to as *set shifting* or *cognitive flexibility*) is defined as the ability to transfer focus from one object or task to another or to willfully move from one activity to the next (Wiebe et al., 2011). A common attention shifting task is a card sorting game in which children first sort cards according to the color of the card (e.g., red or blue), and then sort the same set of cards according to the shape on the card (e.g., rabbits or boats). Children must be able to switch from paying attention to the color of the card to paying attention to the shape on the card. For children aged 7-8, attention shifting is linked to academic outcomes (Bull & Scerif, 2001). This is consistent with a meta-analysis that showed that the performance on shifting tasks is correlated with both math and reading skills in pre-school through middle-school children (see Appendix C for a summary of this meta-analysis). However, it is worth noting that none of the early childhood studies (children 2-5 years) we reviewed showed links between preschool-age children's attention shifting and academic outcomes. This lack of attention shifting in young children may be explained by theory and other research suggesting that inhibition may be more relevant than attention shifting during the preschool years (Epsy et al., 2004).

**Attention Control** is the ability to voluntarily focus or sustain attention on a given task. Children need to be able to maintain their focus on a given task without succumbing to

distractions in order to follow through with instructions, complete an activity, and positively interact with peers in social situations (NICHD, 2003). Attention control can be measured using parent- and teacher-questionnaires of children's behaviors, such as the Children's Behavior Questionnaire (CBQ), or through computerized assessments including the Continuous Performance Task (CPT), Child Attention Network Test (ANT), or the Spatial Conflict task. The key feature of attention control is the requirement to maintain attention on a specific activity or piece of information. In a cross-sectional study, attention control skills were strongly related to academic performance at 54 months of age, including reading, math, and linguistic abilities (NICHD, 2003). These findings suggest that attention is particularly important during the transition to school and that children's attention skills in kindergarten help to lay a foundation for long-term academic success.

**Monitoring.** Some researchers include in descriptions of EC the ability to detect and correct errors. For example, from the EC tradition, Rothbart & Bates (2006) reference error detection as one aspect of a child's effortful control. Other EC researchers have also described EC as involving the ability to detect errors, yet there is little research that specifically measures this ability in children (Zhou, Chen, & Main, 2012). One measure that does seem to tap the ability to detect errors is the Maze subtest from the Wechsler Intelligence Scale for Children-Revised for children ages 6 to 16, which is described as assessing forward planning and monitoring of performance (McCrea et al., 1999).

**Wait/Delay (Delay of Gratification)** is defined as the ability to voluntarily postpone immediate gratification and persist in goal-directed behavior for the sake of later outcomes (Mischel et al., 1989). The classic delay of gratification measure is the Marshmallow Test in which children – typically during the early childhood period – are given the choice to eat one marshmallow immediately, or receive two marshmallows after waiting for some time. In a longitudinal study, longer wait times among four-year-olds predicted higher SAT scores and lowered likelihood of behavior problems, drug addiction, and obesity as adolescents (Mischel et al., 1989; Shoda et al., 1990). Additionally, preschoolers who performed well on the delay of gratification task were more likely to be rated by their parents as able to cope with social and personal problems in middle-to-late childhood (Mischel et al., 1989).

## **Complex Skills in the Cognitive Domain:**

**Planning and Setting Goals.** Best and colleagues (2011) studied what they term “complex, higher-order executive function” and describe it as involving planning, goal-setting, and monitoring. These researchers used three tasks to assess complex EF: Matching Numbers, Planned Codes, and Planned Connections. Another common measure of planning is the Tower of Hanoi task. In this task, children must plan strategic moves while following rules, and in some cases minimize the number of moves that are made. Researchers have found that complex EF is

positively related to both math and reading achievement (Best et al., 2011). That is, children who scored higher on the complex EF tasks tended to also score high on academic achievement tests, and vice versa. Interestingly, the measures used to assess complex EF have been used across the school-age years (e.g., 5-17 years). Although the strength of the relationship between complex EF and academic achievement varies slightly at different ages, complex EF was found to be continuously related to academic performance in both math and reading across this 12-year time span (Best et al., 2011). One implication of this finding that is consistent with previous research is that EF may be an overarching cognitive process that is linked to multiple types of academic achievement (i.e., reading and math).

**Problem Solving.** In addition to planning and goal setting, the Tower of Hanoi task is also described as a problem solving task. For example, Senn, Espy, and Kaufmann (2004) state that the Tower of Hanoi task requires multiple executive function abilities, and that it likely reflects problem solving abilities more than planning in preschool children since children at this age do not yet demonstrate overt planning behaviors. Furthermore, these researchers found that 3- to 6-year old children's performance on inhibition and working memory tasks contributed to their performance on the Tower of Hanoi task. Inhibition was found to contribute to problem solving ability more than working memory in younger children, while working memory was found to contribute to problem solving ability more than inhibition in older children (Senn et al., 2004).

**Creativity.** Some researchers also include creativity in EF and regulation-related research. For example, Diamond (2013) suggests that EF and creativity are closely related because creativity likely involves using core EF processes such as working memory and cognitive flexibility. Diamond uses the illustration that should one's goal-directed strategy be ineffective, they must exercise flexibility to think outside of the box to formulate a new strategy. In this case, cognitive flexibility is facilitating the ability to exercise creative thinking. Measures that appear to tap creativity include design fluency and verbal fluency. In both of these measures, children must generate as many specific examples as they can of a given category or topic. For example, children are instructed to name as many uses as they can for a table.

## **Complex Skills in the Emotion Domain:**

**Emotion Regulation** is the ability to manage, modulate, inhibit, and enhance emotions to facilitate adaptive functioning. Emotion regulation is important for children's successful adaptation to school (Raver, 2002). Parents' ratings of preschool children's emotion regulation (using the Emotion Regulation Checklist), but not their performance on emotion regulation laboratory tasks including Attractive Toy in a Transparent Box and Impossibly Perfect Circles, were found to be positively related to math, literacy, and listening achievement in Kindergarten (Howse et al., 2003). Additionally, in a study of 8 to 17 year olds, those with greater emotion regulation skills (author used the term resilience) were more likely to score higher on measures

of comprehensive emotional well-being and mental health, after controlling for other variables such as negative life events and chronic stress (Buckner, Mezzacappa, & Beardslee, 2003).

**Persistence** is defined as the ability to sustain effort in a challenging situation. Persistence and attention control share many features. Both imply continued focus and concentration, but the defining characteristic of persistence is the deployment of attention and effort in the face of frustration or difficulty. Persistence has been measured using the Puzzle Box Task (Eisenberg et al., 1996; 2004) and the Yarn Tangle (Sulik et al., 2010). In these studies, elementary and preschool aged children were observed completing the task and rated on their ability to continue working despite frustration. These kinds of measures are often used alongside numerous other measures in studies of EC, but these specific studies do not report findings for persistence separate from the global constructs of EC.

**Grit** is defined as the tendency to sustain interest in and effort toward very long-term goals. Grit can be measured using the parent-, teacher-, or self-report questionnaire developed by Duckworth, Peterson, Matthews, and Kelly (2007). The questionnaire is designed for late childhood through adulthood, and includes 8 or 12 statements that participants are asked to rate themselves on using a 5-point Likert scale. Among middle school age children, research has shown that scores on this scale are predictive of various measures of success including greater standardized test gains between grades 4 and 8, fewer school suspensions, and National Spelling Bee Rankings (Duckworth et al., 2007; West et al., 2015).

## **Umbrella Skills**

**Behavior Regulation** is measured in different ways, but generally includes multiple EF and regulation-related skills which is why we have included it as an umbrella construct. Some researchers measure behavior regulation using tasks such as the Head-to-Toes task, in which children are supposed to do the opposite of what that are instructed by the experimenter (e.g., touch their head when the experimenter instructs them to touch their toes)—here, it is defined as a set of skills which include the ability to deliberately control behavior by paying attention, following instructions, and inhibiting inappropriate actions (McClelland et al., 2007). Other researchers measure behavior regulation using a questionnaire called the Instrumental Competence Scale for Children (COMPSCALE), which measures children’s behavioral self-regulation and motivation in various settings, such as the home and classroom (Howse et al., 2003). Researchers found that children’s performance on the Head-to-Toes task in the fall of pre-K predicted growth over the course of the year in literacy, vocabulary, and math scores (McClelland et al., 2007). Similarly, teacher-rated behavior regulation in kindergarten was significantly related to literacy, math, and listening achievement (Howse et al., 2003).

**Self-Control** is described as an umbrella term that reflects other regulatory constructs such as impulsivity, conscientiousness, self-regulation, delay of gratification, inattention-hyperactivity, executive function, and willpower (Moffitt et al., 2011). Moffitt and colleagues reported on data from the 32-year longitudinal Dunedin Multidisciplinary Health and Development Study. Self-control was measured at five time points between the ages of 3 and 11 years old using a combination of parent-, teacher-, and self-reports and psychiatric interviews. Findings revealed that childhood self-control predicted adult physical health, wealth, and crime convictions, after accounting for social class origins and IQ. Furthermore, improvement in self-control over the course of childhood to adulthood was associated with better adult outcomes despite initial levels of childhood self-control.

**Self-Discipline** is defined as the ability to make choices that require sacrificing short-term pleasure for long-term gain; in other words, the opposite of instant gratification (Duckworth & Seligman, 2005). Self-discipline is commonly measured among older children and adolescents using self-reports (e.g., the Eysenck I.6 Junior Impulsiveness Subscale and the Brief Self-Control Scale) and a parent- and teacher-report (e.g., the Self-Control Rating Scale). Students with higher levels of self-discipline were more likely to achieve higher grades, watch less TV, and manage their time more effectively than students with low levels of self-discipline (Duckworth & Seligman, 2005).

## Appendix C: Recent Meta-Analyses of EF and Regulation-Related Skills

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Meta-analyses are helpful for policymakers and other stakeholders because they look across multiple studies to identify the trends that are emerging in a body of research. Below are summaries of recent meta-analyses about EF and regulation-related skills.

### **Executive Function Interventions and Academic Achievement (Jacob & Parkinson, 2015)**

In an extensive review of 67 studies that have examined the relationship between executive function performance and math and reading abilities among children and youth aged 3 to 18, Jacob and Parkinson (2015) found an average correlation of roughly 0.30 that is relatively consistent across age, executive function and academic measures, and both concurrent and predictive designs. The researchers made an important point of recognizing, however, that in most studies the associations were much weaker and often not statistically significant when background characteristics and IQ were controlled for. Furthermore, they also noted that among the five randomized control studies designed to improve EF that were included in the meta-analysis, there was no evidence that gains made in executive function corresponded to gains in academic achievement. Thus the authors concluded that existing evidence supports correlational, not causal, associations between children and youth's executive function and academic abilities.

### **Mindfulness-based interventions for children and youth (Zenner, Herrnleben-Kurz, & Walach, 2014; Zoogman, Goldberg, Hoyt, & Miller, 2014)**

In recent years, mindfulness-based interventions for children and youth, ranging from breath- and body-practices to group discussions and psycho-education, have risen in popularity due to their potential to improve attentional and emotional regulation, as well as social and cognitive skills. A meta-analysis of 24 studies in elementary, middle, and high schools found significant, moderate to large effects of mindfulness training—both in pre- and post-intervention and in randomized control trial comparisons—on cognitive performance and measures of stress, coping, and resilience (Zenner et al., 2014). Similarly, a meta-analysis of 20 studies also identified significant, small to moderate overall effects of mindfulness intervention on social skills, well-being, attention, and psychological symptoms (Zoogman et al., 2014).

### **Social Emotional School-Based Interventions (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Sklad, Diekstra, Ritter, Ben, & Gravesteyn, 2012)**

A meta-analysis of 213 school-based SEL programs found that program participation was associated with improved social and emotional skills, fewer conduct problems, and higher academic performance (Durlak et al., 2011). Furthermore, the overall effect sizes across the programs they examined are comparable, or larger, to those of other psychosocial or educational interventions in similar populations and settings. A slightly smaller meta-analysis of 75 school-based social, emotional, and/or behavioral programs further supports these results (Sklad et al., 2012). This meta-analysis found significant, positive

overall effects of participation on social skills, antisocial behavior, substance abuse, positive self-image, academic achievement, mental health, and prosocial behavior, both in immediate and follow-up assessments (Sklad et al., 2012). These findings suggest that school-based social-emotional interventions have the potential to positively impact a wide range of outcomes for children and youth.

#### **A Review of the Effect of Working Memory Training on Academic Achievement (Titz & Karbach, 2014)**

Working memory (WM) training programs have been shown to improve performance on trained WM tasks as well as non-trained tasks of inhibitory control and attention (Titz & Karbach, 2014). However, few studies have examined whether WM training effects transfer to children's academic achievement. Titz and Karbach (2014) reviewed a limited number of studies that addressed the issue of transferability to mathematics and reading achievement. The studies included in the review were focused on school-age children (between ages 7-14), contained a variety of WM training sessions, and assessed either reading or mathematics achievement. Findings suggest limited evidence that training programs may enhance school performance, particularly in reading. Additional research is needed to extend the evidence-base that supports this conclusion.

#### **Measures of Inhibitory Control and their Association with Academic Achievement in Preschool and Kindergarten (Allan, Hume, Allan, Farrington, & Lonigan, 2014)**

Allan et al. (2014) analyzed 75 studies and found a moderate, positive, statistically significant association between inhibitory control and academic skills in preschool- and kindergarten-aged children. They noted, however, that across studies these associations varied based on measurement: behavioral measures had stronger associations with academic performance than did parent- and teacher-reports of inhibitory control; among behavioral tasks, associations were stronger for "cool" as opposed to "hot" tasks; and associations with all predictors were stronger for math skills compared to literacy skills. These findings reveal that even among young children, inhibitory control skills are related to academic performance, but the strength of this relationship is dependent on measurement.

#### **Measures of Shifting Ability and their Association with Math and Reading Performance (Yeniad, Malda, Mesman, van Ijzendoorn, & Pieper, 2013)**

While there is only a small body of research examining the association between performance on shifting tasks and academic performance, a meta-analysis conducted by Yeniad et al. (2013) suggests that shifting ability is moderately, significantly, and positively correlated with math and reading performance among preschool-, elementary-, and middle-school students. Though there are stronger associations between intelligence and math and reading abilities than there are between shifting task performance and these academic outcome measures, this meta-analysis confirms that performance on shifting tasks, like that for other executive function tasks, is correlated with both math and reading skills.