Self-Regulation and Toxic Stress:

Foundations for Understanding Self-Regulation from an Applied Developmental Perspective

OPRE Report # 2015-21

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OVERVIEW

This is the first in a series of four inter-related reports titled *Self-Regulation and Toxic Stress*, with subtitles specifying the focus of each report. This report, subtitled *Foundations for Understanding Self-Regulation from an Applied Developmental Perspective* (1) provides a comprehensive framework for understanding self-regulation in context, using a theoretical model that reflects the influence of biology, caregiving, and the environment on the development of self-regulation. The second report, *A Review of Ecological, Biological, and Developmental Studies of Self-Regulation and Stress* (2) provides a cross-disciplinary review on research of the relationship between stress and self-regulation. The third report, *A Comprehensive Review of Self-Regulation Interventions from Birth through Young Adulthood* (3) describes the strength of evidence for interventions to promote self-regulation for universal and targeted populations across development. The fourth and final report, *Implications for Programs and Practice* (4) considers implications of findings from the prior reports for programs supported by the Administration for Children and Families (ACF). In the present report, we introduce and describe a set of seven key principles that summarize our understanding of self-regulation development in context.

1. **Self-regulation serves as the foundation for lifelong functioning** across a wide range of domains, from mental health and emotional wellbeing to academic achievement, physical health, and socio-economic success. It has also proven responsive to intervention, making it a powerful target for change.

2. **Self-regulation is defined from an applied perspective as the act of managing cognition and emotion** to enable goal-directed actions such as organizing behavior, controlling impulses, and solving problems constructively.

3. **Self-regulation enactment is influenced by a combination of individual and external factors** including biology, skills, motivation, caregiver support, and environmental context. These factors interact with one another to support self-regulation and create opportunity for intervention.

4. **Self-regulation can be strengthened and taught like literacy**, with focused attention, support, and practice opportunities provided across contexts. Skills that are not developed early on can be acquired later, with multiple opportunities for intervention.

5**. Development of self-regulation is dependent on "co-regulation" provided by parents or other caregiving adults** through warm and responsive interactions in which support, coaching, and modeling are provided to facilitate a child's ability to understand, express, and modulate their thoughts, feelings, and behavior.

6. **Self-regulation can be disrupted by prolonged or pronounced stress and adversity including poverty and trauma experiences**. Although manageable stress may build coping skills, stress that overwhelms children's skills or support can create toxic effects that negatively impact development and produce long-term changes in neurobiology.

7. **Self-regulation develops over an extended period from birth through young adulthood** (and beyond). There are two clear developmental periods where self-regulation skills increase dramatically due to underlying neurobiological changes– early childhood and adolescence – suggesting particular opportunities for intervention.

UNDERSTANDING SELF-REGULATION IN CONTEXT

This report will describe the seven key principles that formed the foundation for our comprehensive framework for self-regulation development, with each principle highlighted in a text box. We begin by defining self-regulation from an applied perspective within a normative developmental context and describe cognitive, emotional, and behavioral domains of self-regulation and how they interact. Next, we consider how stress and adversity may impact self-regulation. We then describe the developmental tasks of self-regulation from birth through young adulthood, with particular attention to contextual factors that may impact development. Within this framework, we propose a model of "co-regulation" for conceptualizing caregivers' roles in supporting children's self-regulation development, providing examples across the age span.

Principle 1

Self-regulation serves as the foundation for lifelong functioning *across a wide range of domains, from mental health and emotional wellbeing to academic achievement, physical health, and socio-economic success.* ***It has also proven responsive to intervention, making it a powerful target for change.***

The importance of self-regulation for long-term functioning across a wide range of domains, from psychological and social to academic and health, has now been clearly established [1-4]. Poor self-regulation is associated with major societal problems such as violence and substance use [5, 6], mental health concerns [7], and health problems such as excessive weight gain [8]. Dysregulated behaviors such as impulsivity are also a core feature of several clinical diagnoses such as attention-deficit/ hyperactivity disorder, autism, and eating disorders. Moreover, self-regulation predicts socio-economic success as defined by income and financial planning (e.g., managing money, saving for things like home ownership, and avoiding credit problems) [3]. The impact of self-regulation in childhood on such long-term adult outcomes is notable even when IQ and social class are taken into consideration [4]. Indeed, self-regulation has been identified as the foundation for lifelong physical and mental health [9].

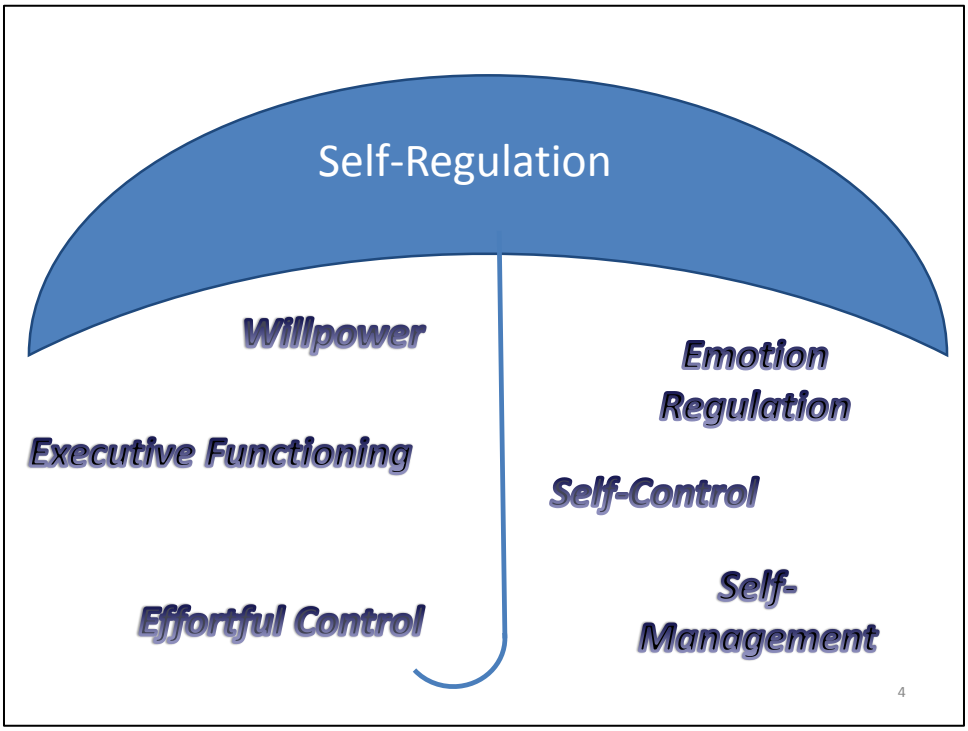
There is also evidence that self-regulation is malleable, and thus a meaningful target for intervention. For instance, preschool attendance has been associated with self-regulation related outcomes such as rates of delinquency and welfare dependence in adulthood as well as educational achievements [10]. In addition, a large empirical literature demonstrates the effectiveness of interventions that target self-control [11], executive function [12], and social-emotional outcomes [13], which each overlap with self-regulation. Thus, in addition to its substantial societal impact, self-regulation appears to be responsive to intervention, highlighting its relevance for program developers and policy makers.

Definition, Domains, and Processes of Self-Regulation from an Applied Perspective

Many different terms have been used to describe one's ability to manage emotions, impulses, and behavior. These include "willpower", "grit", "self-control", "executive control", "effortful control" and

"self-management". Figure 1 presents a graphical representation of self-regulation as an umbrella term that encompasses many constructs that may be used to describe similar skills and processes. *Self-regulation* is the term used in this series of reports because it has application across disciplines, implies a broad range of abilities beyond simply controlling impulses, and suggests flexibility and adaptability in response to situational demands and social norms [1].

Figure 1. Self-Regulation Terms



Self-regulation has received increased attention in both the scientific literature and public media in recent years, with over 10,000 peer-reviewed papers published in the past 15 years [14] and an abundance of popular multimedia material on the web. Therefore, it is important to define self-regulation for use in this series of reports. As the primary aim of the present work is to facilitate understanding of intervention approaches that may have large-scale programmatic relevance, our definition of self-regulation is intentionally broad and applied.

Principle 2

Self-regulation is defined from an applied perspective as the act of managing cognition and emotion to enable goal-directed actions such as organizing behavior, controlling impulses, and solving problems constructively.

This definition highlights that self-regulation is an action intended to achieve goals across broad domains of functioning. It captures key constructs considered important across academic disciplines: specifically, it includes both cognitive and affective components and goal orientation [4, 7, 15]. Although this

definition is informed by basic neuroscience, it may not map directly onto specific neurocognitive processes; rather, it provides a translational framework that applies neuroscience to self-regulation interventions. For further consideration of varying terminology, definitions, and assessment tools across theoretical, technical, and applied domains, the reader is referred to ACF Report # X (Jones et al., 2015).

Domains of Self-Regulation

As specified in Box 1, self-regulation is conceptualized as comprising three overlapping domains: cognitive, emotional, and behavioral, with the first two domains serving as building blocks for regulated behavior or actions. Although we are distinguishing these facets conceptually, we recognize that they inter-relate in complex ways, and it may be difficult to disentangle the separate domains empirically when measuring self-regulation in children[16].

Box 1. Domains of Self-Regulation

Cognitive self-regulation includes focused attention, executive functioning (i.e., cognitive flexibility, mental shifting), goal-setting, self-monitoring, attributions and appraisals, problem-solving, perspective taking (i.e., theory of mind and future orientation), and decision-making.

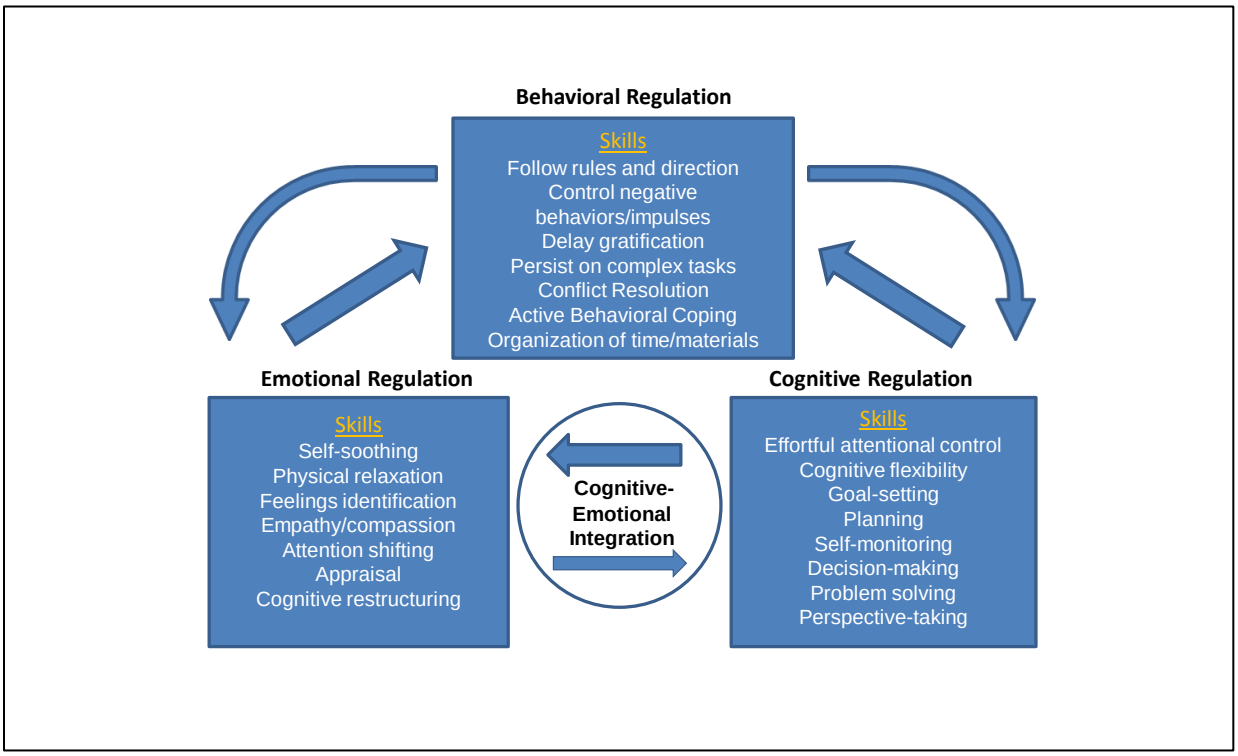
Emotional self-regulation involves actively managing strong and unpleasant feelings and results in adaptive functioning in emotionally arousing situations. It requires awareness and understanding of feelings and involves self-calming strategies and tolerance or management of internal distress. It also supports empathy and compassion for self and others.

> ***Integration of cognitive and emotional processes*** is the essential work of self-regulation. This integration enables 1) attachment and compassion to influence goal-setting and behavior in prosocial ways and 2) allows cognitive regulation skills to effectively manage emotion in a process sometimes referred to as "effortful coping".

Behavioral self-regulation includes following rules, delay of gratification, persistence, impulse control, conflict resolution, enactment of active coping strategies (e.g., doing something like physical activity, deep breathing, or seeking support), and goal-oriented behaviors (e.g., organizing time to complete tasks). Lack of self-regulation may result in a range of mental health difficulties; in children and youth it is most observable in impulsive, aggressive behavior, attentional difficulties, withdrawal, self-harm, and engagement in risk behaviors such as substance use.

Figure 2 depicts the interaction among the three domains of self-regulation. As can be seen, cognitive and emotional regulation serve as building blocks for behavioral regulation, enabling individuals to organize behavior to achieve goals. Cognitive and emotional regulation also interact and influence each other in a bi-directional manner, as described by Blair and Ursache [17]. Cognitive regulation skills, including executive functioning, are often described as having a "top-down" influence on self-regulation in a process that is considered effortful or intentional. A concrete example of this type of *effortful coping* is when a young child remembers rules and anticipates consequences so as to make positive behavior choices when experiencing frustration or anger [4]. However, self-regulation can also be influenced in both helpful and unhelpful ways by less intentional and more reactive "approach and avoidance" processes related to emotion, sometimes called "bottom-up" influences. An example of the negative impact of strong emotions would be when arousal associated with anger or distress prevents children from considering alternative perspectives and utilizing appropriate behavioral coping strategies (e.g., a child hits a peer who knocked over his/her blocks). Similarly, strong positive "approach" emotions may derail efforts to delay gratification in favor of a long-term goal (e.g., a teen blows off homework to go out with friends).

Figure 2. Self-regulation Skills and Processes



On the other hand, emotion can also serve to foster effective self-regulation. Feelings of attachment and empathy can support the initiation and maintenance of prosocial goals. For instance, the values of fairness and social justice are driven by feelings of emotional connectedness and community. Likewise, emotional "gut checks" can aid in assessing the accuracy of our thought processes. Examples of the positive influence of emotion on cognitive and behavioral regulation might be when a child feels concerned about a friend's well-being and decides to share a favorite toy, or when an adolescent

realizes by her emotional discomfort that a peer is being sarcastic rather than supportive and seeks out different friends without taking the peer's comments personally.

Being able to integrate cognitive and emotional regulation and maintain a balance of these processes through *effortful coping* is essential for effective self-regulation, and is considered a major self-regulation development task [18]. This may be particularly challenging during developmental periods when emotional arousal is stronger than cognitive controls, such as early childhood and adolescence [19] . Although the influence of cognitive and emotional regulation is bidirectional, cognitive regulation is believed to have a stronger impact on effortful coping in that it is more logical and goal-directed. This relationship is depicted by a larger arrow from cognitive to emotional skills than from emotional to cognitive in our figure. Moreover, effective emotion regulation is dependent on cognitive regulation skills such as attention-shifting, appraisal, re-appraisal (or cognitive restructuring) and suppression. We have included these cognitive skills in our emotion regulation skill domain in Figure 2 to enhance understanding of intervention approaches, again recognizing that this depiction may be different from a neuro-biological model of self-regulation processes.

Building on the foundation of emotional and cognitive regulation, our model depicts bidirectional arrows from these fundamental constructs up to behavioral regulation and back. As noted, behavioral regulation is supported by successful regulation of emotion and cognition, implying that these components need to be addressed in any intervention targeting functional behavioral outcomes. At the same time, use of behavioral regulation skills can create a positive feedback loop, calming emotions and providing a different perspective on a situation. Thus, all three components of self-regulation are inextricably linked, and each warrants consideration in comprehensive self-regulation interventions.

It is important to note that this conceptual model as described is based in normative development, where children and youth experience manageable and developmentally typical self-regulation demands. Later in this report we will describe the impact of severe stressors and adversity on self-regulation processes. In a situation where stress is overwhelming or a child may not be safe, he or she would not be expected to cope with the stressor or self-regulate independently. Indeed, the key self-regulation skill in this context is seeking help from a caregiver or other trusted adult.

Case Example: Self-Regulation Domains and Interaction

To understand how these self-regulation domains and processes interact, it is helpful to consider their application to a specific case.

Box 2. Case Example of Self-Regulation Domains and Processes

Consider a 16-year-old teenager, "Janine", who has a long-term goal of attending college. In the short term, she has several upcoming deadlines for schoolwork along with a busy social life. She worries about doing well academically and often feels overwhelmed in completing multiple tasks, but also likes to have fun and sometimes makes poor decisions around prioritizing her time. The behavior regulation required in this case is timely completion of multiple school tasks to support her goal of attending college. Successful regulation of this behavior will require Janine to engage both cognitive and emotion regulation skills. She will need to form a plan for completing her work on time, perhaps breaking it down into steps and prioritizing the different tasks (cognitive regulation). She will need to manage feelings of anxiety about time pressures and performance (emotion regulation). She may also need to make a decision not to meet her friends after school at their usual hang-out so she can complete some of the assignments on her list.

Strong emotional arousal (e.g., excitement about the social activity, presence of a love interest) will make successful self-regulation more challenging, as emotions may distort priorities and cause Janine to overlook the consequences of this decision (influence of emotion on cognition). Let's assume that she decides to socialize, and then experiences significant distress when she gets home late and realizes she may not meet her school due dates. Janine may feel like a failure in following her academic goals and have very self-critical thoughts. At this point, to successfully regulate her behavior, Janine will need to again use cognitive and emotion regulation skills (e.g., thought stopping, deep breathing, cognitive restructuring to remind herself that she can still do her best during the time she has left) in order to calm herself and focus on her work without excessive rumination (effortful coping). This example illustrates the complexity of self-regulation and the inter-connection of cognitive, emotional, and behavioral regulation processes.

Distinguishing Self-Regulation from Related Constructs: Resilience, Coping, and Stress Management

Resilience is a concept related to self-regulation that has been defined as "positive or protective processes that reduce maladaptive outcomes under conditions of risk" [13]. Resilience refers to an individual's capacity to cope with chronic or severe stress, adversity, and trauma, and function successfully [20]. Self-regulation has recently been identified as an important factor in children's resilience [21], particularly among samples of low-income, homeless, and maltreated children [22-24]. Although more resilient youth have been found to have stronger self-regulation skills [24], these constructs have historically been considered theoretically and empirically separate [21].

Coping is a common term that is discussed in connection with self-regulation, although the empirical literature in this area is somewhat limited. Several definitions of coping include self-regulation

processes such as problem-solving, flexibility, positive reframing, and adaptation [25]. Although lay language about "coping" sometimes suggests that it can include involuntary emotional and behavioral reactions to stress, we agree with Eisenberg et al. (2009) that coping is an active, volitional response to adapt or meet a certain goal in a specific context. Indeed, our model of self-regulation includes the term "effortful coping" to indicate such a process.

Stress management is also referenced in the intervention literature, often with no explicit connection made to self-regulation, and with highly variable definitions of what it means to "manage" stress. According to our theoretical model, stress management requires self-regulation across cognitive, emotional, and behavioral domains. We suspect that this definition is much broader and more comprehensive than is typically thought of in programs that teach stress management strategies.

Each of these related constructs would seem to have potential to inform our understanding of self-regulation and therefore were considered in our literature reviews in Reports 2 and 3.

A Comprehensive Model of Self-Regulation in Context

The act of self-regulating is dependent on several different factors, those that are individual to the child or youth as well as those that are external or environmental.

Principle 3

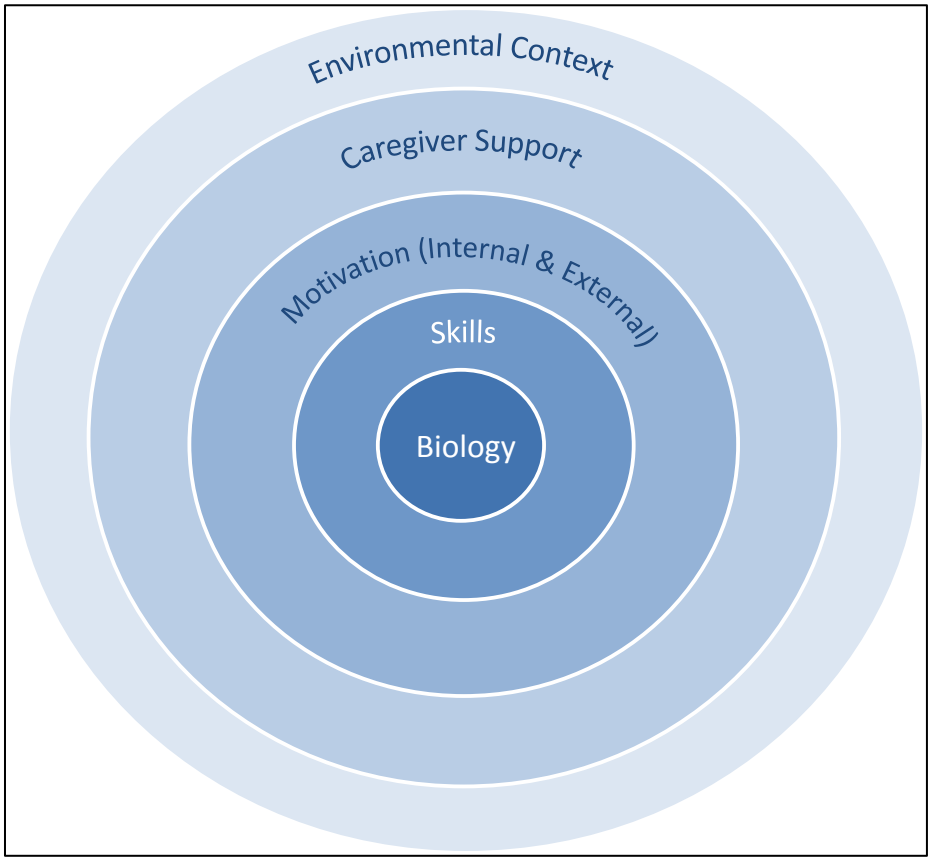
Self-regulation enactment is influenced by a combination of individual and external factors including biology, skills, motivation, caregiver support, and environmental context. These factors interact with one another to support self-regulation and create opportunity for intervention.

In Figure 3 below, we present a comprehensive model of self-regulation enactment which graphically presents the range of factors that influence whether and how well a child or youth may self-regulate in any given situation. Each of these will be described in detail in the sections to follow, with only a broad overview provided here. The most internal factor influencing a child's capacity for self-regulation is comprised of the child's *biology, genetics, and temperament*, which contributes to individual differences in self-regulation. The next major influence depicted is the *self-regulation skills* that the child or youth has developed over time, which have often served as a target for interventions. Next is an individual's *motivation* to self-regulate [26], which can be derived from either external sources (e.g., rewards and consequences) or internal goals and values (e.g., intrinsic motivation). *Caregiver support* (provided by parents, teachers, or mentors) is the next layer in our model, which serves to strengthen children's self-regulation skills and also buffer them from adverse experiences in the larger environment. Finally, the *environmental context* including the demands or stressors placed on an individual as well as the external resources available also have a significant influence on one's ability to self-regulate.

It should be noted that, although the concentric circles begin with those factors that are most internal and extend outward to those that are most external, each of these factors may interact with and

influence the others. For example, environment may influence a child's biology by shaping brain circuitry, and biology or temperament may influence how a caregiver interacts with a child. Motivation is the point at which internal and external factors most clearly connect as motivation can be either internal or external. Importantly, each of these layers may serve as a point of intervention. Considering both ends of the spectrum, medications may be used to address biological factors, and environmental changes like providing greater resources in a poor neighborhood or enrolling a child in preschool may alter experiences, supports, and skills to impact how well a child is able to self-regulate in different situations.

Figure 3. Factors Contributing to Self-Regulation Enactment



Biological Influences on Self-Regulation

Even at very early ages, children can be identified as having different thresholds of responsiveness to stimuli that may result in dysregulation as well as different styles reacting to negative stimuli and regulate emotion [27]. This is often referred to as "temperament", and encompasses different levels of need for regulatory skills as well as different response styles. One common way of understanding these styles is a distinction between children who primarily respond and react in ways that disrupt and bother others, and those who primarily respond and react in ways that increase their own personal distress. The former group is often referred to as *under-controlled* in emotion regulation style, while the latter is described as *over-controlled.* These patterns parallel clinical patterns of aggressive and anxious behavior, respectively [28]. Other children may be more balanced in their response styles. Self-

regulatory style appears to be relatively stable across childhood (e.g., ages 4-12 years), consistent with other temperamental differences seen in children [16]. Indeed, children's ability to delay gratification on simple laboratory tasks during the preschool years has been found to predict social-emotional and educational outcomes into adulthood [29].

Another factor with biological origins that has been explored as a contributor to self-regulation is child sex. Some studies show that boys score lower on measures of executive functioning than do girls [30, 31], consistent with higher ratings of dysregulated behavior such as attention problems and aggression in boys [32]. However, these sex differences tend to be small and are not found consistently [33]. They also do not seem to reflect differences in the pattern of growth in self-regulation over time [16]; that is, self-regulation seems to develop similarly for boys and girls. We will nonetheless examine sex as a potential variable influencing individual differences in self-regulation development and response to self-regulation interventions in Reports 2 and 3.

Behavioral genetics and molecular genetics research have also demonstrated a substantial genetic component to self-regulation [34]. Indeed, there is indication that some of the most genetically heritable brain regions are regulatory structures such as the dorsal prefrontal cortex, orbital frontal cortex, superior parietal cortex, and temporal lobe [35, 36]. This research suggests that some variance in children's abilities to self-regulate is related to individual differences defined by genetics. It does not mean, however, that other factors and influences such as the environment are not important. Indeed, self-regulation is clearly malleable and responsive to intervention.

Self-Regulation as a Set of Skills that can be Strengthened (like Literacy)

The skills construct is based upon several well-controlled intervention studies demonstrating improvement in self-regulation through instruction and practice [37, 38]. Specific skills that form the building blocks of self-regulation are enumerated in the boxes of Figure 2. A metaphor that we find helpful in understanding self-regulation is that of literacy.

Principle 4

Self-regulation can be strengthened and taught like literacy, with focused attention and support provided across contexts. *Skills that are not developed early on can be acquired later, with multiple opportunities for intervention*.

Literacy is a set of skills developed over time in a sequential manner that ultimately enable an individual to read and comprehend a range of texts. Literacy starts with building blocks like phonemic awareness and letter-sound relationships and progresses to fluency and comprehension of complex ideas. Likewise, self-regulation requires a series of sub-component skills that build upon one another to enable effective coping and adaptability in complex situations. As with literacy, these skills require developmental scaffolding across time to achieve long-term competence. Also similar to literacy, an individual's ability to self-regulate is determined by not only biological and temperamental factors, but also by the structure, support, instruction, and reinforcement that one has received from the environment.

Just as literacy develops earlier when young children are immersed in rich literacy environments, self-regulation skills will develop earlier in environments with a stronger foundation of support, i.e., nurturing, stability, security, structure, and modeling. However, just as a child who struggles with literacy for any number of reasons may later become literate when provided with effective instruction in a supportive environment, we believe that children who have early self-regulation difficulties are capable of acquiring these skills at later ages. This metaphor has applied implications in that it suggests that there may be multiple opportunities for intervention across development. It also suggests that: (1) universal supports for healthy self-regulation development are necessary, (2) instruction and coaching over time are needed to build the sophisticated skills required in adulthood, and (3) some children may need more intensive, targeted interventions to overcome biological or environmental adversity that have disrupted their self-regulation abilities. Although no metaphor can have absolute application to something as complex as self-regulation, we believe the model of literacy has considerable value in informing intervention design and implementation.

Motivation

Motivation is sometimes an overlooked factor in determining whether an individual will enact self-regulation skills; however, evidence suggests that it plays an important role [26]. Motivation is broadly defined as the drive to obtain wants or needs; in the context of self-regulation, it refers more specifically to the drive to achieve a goal following recognition that one's behavior is not currently aligned with the goal achievement. For example, reminding a young child that he will have to leave circle time if he cannot keep his hands to himself may motivate him to use behavior regulation skills (e.g., sitting on his hands) in order to enjoy the circle time activities. For the adolescent in our case example, remembering that she is trying to get good grades for college (a cognitive regulation skill) may motivate her to study instead of going out with friends. Thus, the extent to which an individual is motivated to achieve a certain goal can make it easier or harder for them to self-regulate. Although motivation and skills are considered separate constructs [39], they are often combined when being assessed and many self-regulation interventions target both.

Children and youth can be motivated by a wide range of factors that can be either internal or external. Internal motivation may come from basic needs such as food and safety or from more advanced needs for such things as attention, social acceptance, intimacy, or control. It may also reflect the drive to obtain more peripheral desires, which may at times conflict with rules and social/cultural expectations and require self-regulation to resolve. External motivation is provided by rewards and consequences, which take different forms based upon the individual's age. For children and youth, this is often caregiver approval (or disapproval), tangible incentives, or punishments. Indeed, behavior management systems are based in the logic that behavior can be changed when such external motivators are manipulated. Caregivers can also provide specific support to encourage children and youth to identify goals (particularly long-term goals), which can enhance internal motivation.

Role of Caregivers in Self-Regulation

Although child factors clearly play a role in self-regulation, the environment or context in which a child lives also appears to have a profound influence on that child's ability to self-regulate. A critical factor in

the caregiving environment is the extent to which parents and other caregivers including teachers and mentors are warm and responsive in interacting with the child, utilize positive behavior management strategies, and provide a positive climate for growth and development. We call this interactional process between caregivers and children or youth "co-regulation", defined in Principle 5 below.

Principle 5

Development of self-regulation is dependent on "co-regulation" provided by parents or other caregiving adults *through warm and responsive interactions in which support, coaching, and modeling is provided to facilitate a child's ability to understand, express, and modulate their thoughts, feelings, and behavior.*

More specifically, caregivers provide nurturing environments by supporting and scaffolding the self-regulation skills of children and youth in a way that strengthens the development of these skills [40]. Where families experience adverse events such as domestic violence, substance use, and divorce or high levels of partner conflict, children experience a number of negative developmental outcomes that are associated with poorer self-regulation [41]. Caregivers can act to buffer children and youth from the negative impact of these types of stressors and adversity in the family and wider community [40]. In addition to reducing actual stressors in the environment, caregivers can support children and youth in keeping their emotional arousal in balance with their cognitive regulation skills so they can cope with the stressor. Such caregiving factors have been identified as important in children's demonstration of resilience despite immersion in a clear risk environment [24], and, at least for young children, the ability to cope with stress is related to caregiver support [42]. As such, our model of self-regulation development also takes into consideration caregivers' own abilities to self-regulate and therefore provide the co-regulation that their children need.

Role of the Environmental Context in Self-Regulation

One contextual factor that may influence self-regulation beyond the family is relationships with friends and other peers, particularly as youth enter and traverse adolescence. Peers can both support and interfere with self-regulation enactment. In some situations they may serve in a co-regulation role, building the youth's skills within a "developmental relationship" [43] in which a caring peer challenges and expands positive development through encouragement, modeling, guidance, and advocacy. Engaging in such proactive and cooperative relationships may build adolescents' interpersonal skills in a way that supports future relational success. However, adolescents should not be expected to provide co-regulation for their friends given their own developmental state and the complexity they face in navigating their own contexts and managing their thoughts and feelings. Indeed, peers may have a negative influence on self-regulation by reinforcing risk taking, poor decision-making, and emotional/behavioral dysregulation. Caregiving adults should therefore assume responsibility for monitoring and facilitating peer relationships in a way that best supports self-regulation development.

In the larger contextual environment, available supports and resources in schools and communities influence children's self-regulation, as do the level of stress, adversity, and demands that are present. Within the classroom, positive student-teacher relationships and positive behavior management provide caregiving support similar to that provided by parents [44]. Such support helps students of all backgrounds feel safe and secure, and provides scaffolding for important social and academic skills [45]. At the school level, factors such as bullying, violence, and harassment negatively affect the climate, which can translate into academic failure and antisocial behavior [46]. In schools that have limited resources and supports for students, and where teacher turnover rates are high and teachers have fewer skills, self-regulation development is less likely to be supported. Similarly, neighborhoods with high crime rates and lack of resources for healthy child development such as safe play spaces, access to fresh foods, medical care, libraries, and economic stability create conditions of adversity that are likely to impair the development of self-regulation [9].

Poverty is a specific environmental factor with a well-established link to self-regulation development [30], which likely exerts influence on children through the chronic pressure present in families, schools, and communities. One proposed mechanism of this link is the "psychology of scarcity," which suggests that a lack of money, food, time, or even companionship may reduce one's "mental bandwidth" or ability to focus, plan, and problem-solve [47]. The stress, fatigue, and worries that can accompany living in poverty reduce the energy and resources available for self-regulation and co-regulation. Evidence of this effect from natural and laboratory experiments [48] suggests that individuals who appear to struggle with self-regulation under conditions of scarcity (e.g., living in poverty) may be just as capable as others when they have more wealth [49]. Poverty also appears to account for some of the few differences that have been found in self-regulation among children from minority backgrounds. Specifically, although some studies [50] have suggested delays in inhibitory control and cognitive flexibility in African-American and Hispanic preschoolers, controlling for poverty appears to account for these differences [51].

To illustrate the impact of co-regulation and the environment, we elaborate on our case example in Box 3.

Box 3. Illustration of the Role of Environment in a Case Example

One can imagine that Janine, our teen from the previous example, may have made a better decision if she had a parent or caregiver with whom she had shared her dilemma and was supported in thinking through her choices in a collaborative way. This caregiver could help her prioritize her tasks, activate coping skills when needed, and monitor her behavior to keep her on track. Moreover, if a caregiver had helped Janine establish good organizational routines that encouraged her to start projects with enough time to complete them, she may have avoided the distress of conflicting deadlines and any negative consequences of poorly completed work. Alternately, if Janine's caregivers were unavailable, unsupportive, or unable to regulate themselves, this could make it more difficult for her to learn good decision-making skills. This could also create conflict in their relationship, which would increase the emotional demands on Janine, widening the gap between the regulatory demands of the situation and Janine's regulatory capacity to respond effectively.

Broadening our consideration of context, if Janine attended a school with high rates of bullying and violence and her classes had many students who were disruptive or disengaged, she would likely feel less connected and supported and may have less academic motivation. Within such a setting, a caring teacher or mentor could play a buffering role and encourage her to set positive long-term goals for herself and develop positive work habits. If her community were transient and unsafe, it may be harder for her to access resources for completing her work (e.g., visit a library). Such negative school and community influences are often compounded for families living in poverty, which itself creates stress that can overwhelm a child's ability to cope and self-regulate. In other words, she may be so preoccupied with basic needs and safety that she has little cognitive energy for studying. This example highlights the need to consider a child's self-regulation within the context of his or her environment.

Self-Regulation and Stress

Our interest in this inter-connected series of reports is in understanding how self-regulation is impacted by stress associated with early adversity and how it might be strengthened, particularly for vulnerable populations of children and youth. As such, it is important to consider how stress and self-regulation interact. On the one hand, stress is a normal part of development and serves a role to teach children and adolescents to problem-solve and cope with typical developmental challenges. When faced with stress, challenging emotions are evoked that make it difficult for individuals (of any age) to respond deliberately and effectively, rather than reactively. Effective self-regulation in the context of stress requires regulatory skills across all three domains. In managing stress emotionally, one must manage strong feelings, tolerate distress, and regulate emotionally-driven behavior [52]. Cognitively, one must anticipate stressors, appraise them accurately, identify strategies to avoid or moderate their impact, and plan how to implement the strategies selected [53]. Ideally, this problem-solving process would be followed by later evaluation to improve coping in the future. The behavioral manifestation of coping is

enacting behavioral solutions selected through problem-solving, hopefully solutions that are socially appropriate. As implied, the most effective coping strategies likely involve an integration of emotional and cognitive regulation, which is very much under development in children [54]. Clearly, learning to cope with stress is an important developmental task, and shielding children from all such learning experiences would not seem useful. However, when stress exceeds what is tolerable because it is not buffered by caregivers or a given child lacks the requisite self-regulation skills, it can have toxic effects [9].

Principle 6

Self-regulation can be disrupted by prolonged or pronounced stress and adversity including poverty and trauma experiences. Although manageable stress may build coping skills, stress that overwhelms children's skills or support can create toxic effects that negatively impact development and produce long-term changes in neurobiology.

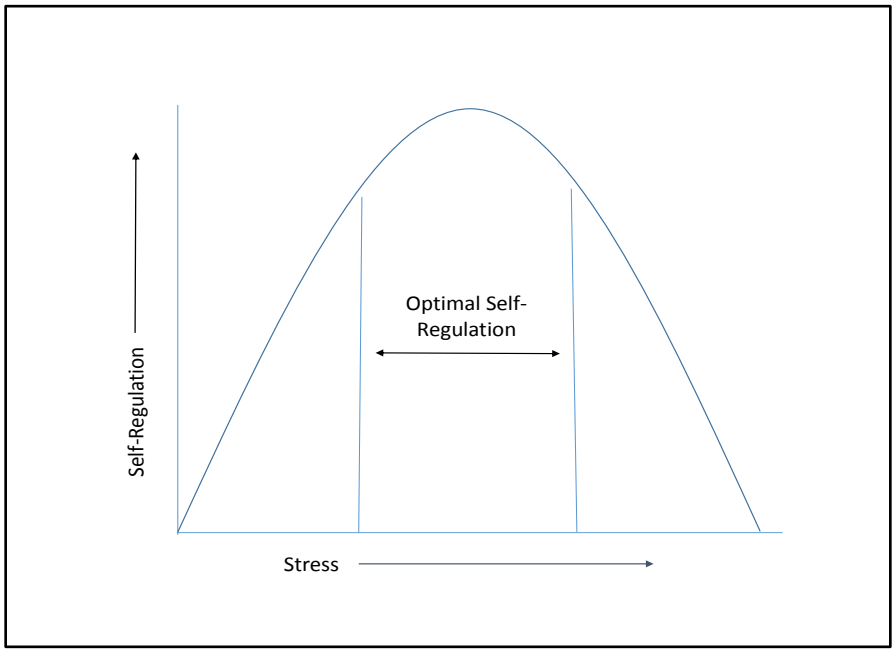
A *toxic stress response can occur when children experience strong, frequent, and/or prolonged adversity that overwhelms their skills or support*—such as physical or emotional abuse, chronic neglect, caregiver substance abuse or mental illness, exposure to violence, and/or the accumulated burdens of family economic hardship (i.e., poverty)—whereby their stress response system stays activated for extended periods of time (DHHS6). Such stress alters an individual's baseline level of stress and ability to return to a calm state, making one more reactive to changes in the environment and normal stressors. More specifically, this may lead to a quicker or more intense reaction to a stressor, or may produce a reaction to a lower level stressor which may not have previously occurred. This then increases the need to self-regulate while simultaneously making it more difficult to do so. Stressors may be chronic or acute, and we expect that their effects are magnified when combined. For children whose stress systems are continually activated, long-term disruptions in developing brain architecture may occur, with lifelong detrimental effects on health and wellbeing [9]. More specifically related to self-regulation, it has been hypothesized that toxic stress contributes to impaired inhibitory control and delay of gratification, excessive or blunted emotional reactions, and impulsive, disorganized thinking [55, 56]. These impairments will likely further reduce children's abilities to cope effectively with stressors. Although this is a well-accepted conceptual understanding, a critical review of empirical data on stress and self-regulation is needed, such as is provided in Report 2.

There are different theoretical views of how stress and self-regulation interact. On the one hand, some suggest that stress may deplete one's future self-regulation capacity in what is called a "limited resource" or "strength" model of self-regulation [57]. However, there are data that contradict this claim and suggest that depletion may have more limited effects than initially thought [58]. A model that is well-accepted in the child development literature is that stress and self-regulation have a curvilinear relationship (like an inverted U). As can be seen in Figure 4 below, some stress may increase arousal, focus, and goal-orientation in a way that enhances self-regulation, while too much stress may decrease it. Indeed, mild and intermittent stress within a child's abilities to cope might actually support the

development of self-regulation skills. However, as the level, intensity, or duration of stressors exceeds a child's coping skills and support, self-regulation is expected to decrease.

Context is also believed to play an important role in an individual's response to stress. More specifically, when stress response systems are activated for extended periods of time by stressors in the environment, self-regulation capacity may begin to diminish at a lower stress threshold (i.e., the zone of optimal self-regulation in Figure 4 is truncated). This is often described as *stress reactivity* or the extent to which an individual reacts quickly and with a stronger emotional, behavioral, and neurobiological reaction than expected. Not surprisingly, this can lead to negative developmental outcomes in contexts without adequate support [59]. On the other hand, being more reactive to stress and less reflective (which is generally considered poorer self-regulation) could be adaptive in unpredictable or conflictual environments [60]. For example, acting quickly to secure scarce resources or avoid danger may be beneficial.

Figure 4. A Curvilinear Relationship between Stress and Self-Regulation



We hypothesize that self-regulation is optimized for children who experience manageable levels of stress and have an array of resources (including self-regulation skills and environmental supports) that serve as protective factors to balance any risk factors. With regard to implications for interventions, the negative impact of stress could be moderated by either decreasing the stressors in the environment (through environmental modification or caregiver buffering) or by increasing a child's self-regulation skills.

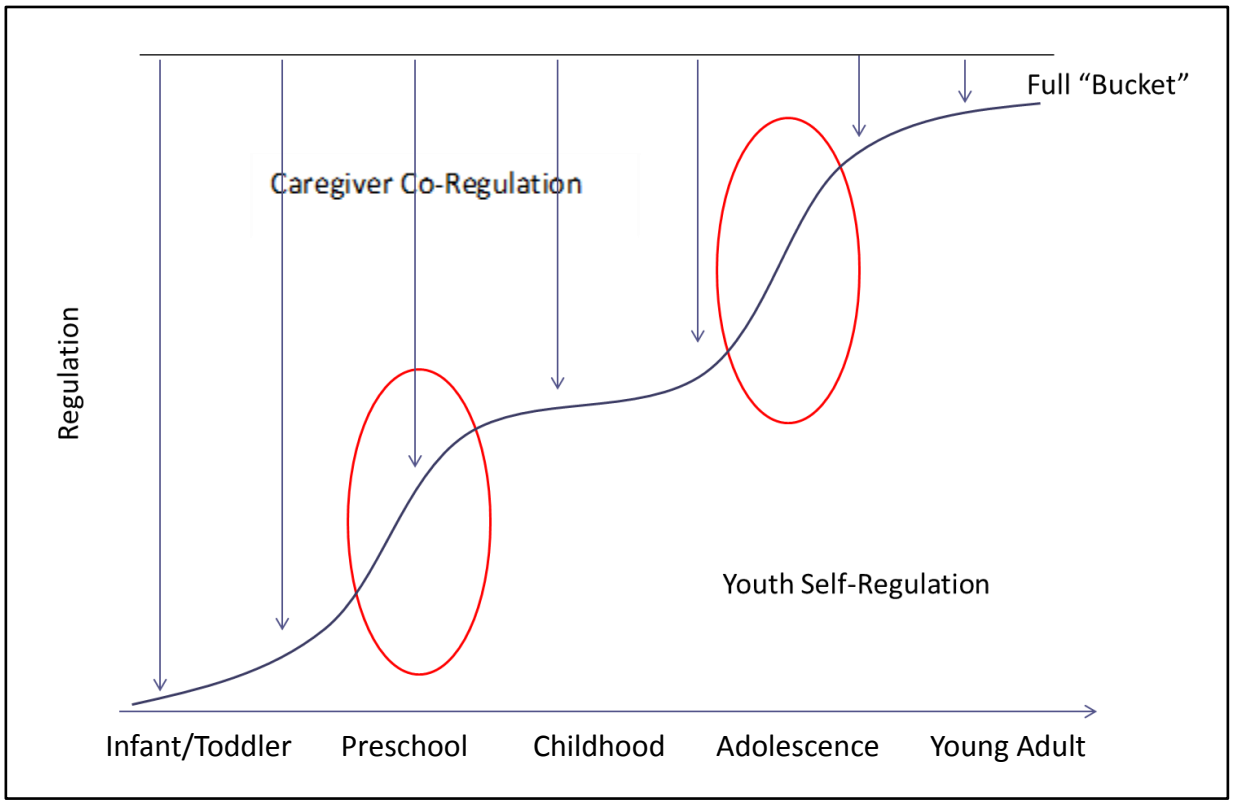
DEVELOPMENT OF SELF-REGULATION FROM BIRTH TO YOUNG ADULTHOOD

In order to understand how stress impacts self-regulation development and how self-regulation interventions may have different effects at different ages, it is first necessary to consider how self-regulation develops normatively. Because so much brain maturation and growth occurs after birth, self-regulatory processes based in the brain are very much influenced by the environment and a child's experiences, consistent with our comprehensive model of self-regulation in context. For instance, children's trajectory of self-regulation development may be impacted by the self-regulation demands they encounter across developmental contexts such as in the transition from preschool to elementary or elementary to middle school [30]. Another implication of this developmental model is that different intervention approaches may be needed across developmental periods. For example, there is some evidence that parents' specific interaction strategies that work well at one age may actually be problematic at another age [61]. This is consistent with work showing that parenting style and children's coping do not have a clear linear relationship as children age [62]. Thus, our intervention review in Report 3 will examine intervention characteristics and outcomes at different developmental stages.

Co-Regulation

As described in the section on caregivers above, a critical component of our understanding of children's self-regulation development is the concept of "co-regulation". In co-regulation, caregivers provide the nurturing, instruction, coaching, and support that will promote optimal self-regulation by the child, while simultaneously buffering against environmental stressors that might diminish regulatory capacity. In Figure 5 below, we present a theoretical model of child self-regulation relative to co-regulation provided by caregivers across different ages. We are not specifying the exact ratio of child to caregiver regulation, as this varies for different children at different times. Rather, we are describing a normative trajectory in child capacity vis-à-vis need for caregiver support. One way of thinking about this ratio is that, for optimal development, children and youth need to have their self-regulation "bucket" filled. For this analogy, imagine that regulation of emotion, cognition and behavior can only be successfully enacted if a "bucket" holding accumulated biology, skills, motivation, caregiver support, and environmental support is filled to the top.

Figure 5. Co-Regulation between Caregivers and Youth across Development



Depending on developmental stage, environmental circumstances, and individual differences, children themselves have the capacity to fill their self-regulation bucket to varying levels. However, for optimal functioning, they require caregivers to provide co-regulation that fills the remainder of the bucket. It is expected that greater external regulation by caregivers is needed at younger ages (as indicated by the blue arrows), and as a child's ability to self-regulate increases, less caregiver regulation is required. Importantly, however, we believe that at least some external support is needed through young adulthood (at least), which may be well beyond the time that this is typically considered necessary. For children with self-regulation difficulties (due to individual differences, stress environments, etc.), greater levels of caregiver support may be needed for optimal self-regulation. This does not imply that a lack of caregiver support is the cause of children's self-regulation difficulties, but without co-regulation a greater burden is placed on the child's own skills and capacities to achieve an adaptive level of regulation. To the extent that either child skills or caregiver support are limited, the "regulation bucket" may be only partially filled, which will directly affect child emotions, cognitions, and behavior. Indeed, where regulation continually falls short, functional challenges will be evident, and may manifest as behavioral or physical health concerns.

Developmental Nature of Self-Regulation

In addition to depicting co-regulation, Figure 5 also illustrates the developmental changes in self-regulatory capacity over time. As with literacy, this developmental aspect of self-regulation suggests that ongoing and increasingly sophisticated instruction and coaching may be beneficial to scaffold growth.

Principle 7

Self-regulation develops over an extended period from birth through young adulthood (and beyond). *There are two clear developmental periods where self-regulation skills increase dramatically due to underlying neurobiological changes—early childhood and adolescence—suggesting particular opportunities for intervention.*

Developmental research indicates that self-regulation significantly increases across childhood [16], through adolescence [63], and into early adulthood [64]. There are two clear developmental periods (circled in red in the figure above) where children's abilities to self-regulate increase dramatically: early childhood and adolescence. As will be described further below, research has demonstrated rapid changes in areas of the brain associated with executive functioning during the first five years of life [65], and again during adolescence [66]. This suggests particular opportunities for intervention, consistent with the proposed "one-two punch" model of providing interventions during early childhood and adolescence suggested by Moffitt et al. [3]. It is certainly also possible that intervention investments during other developmental periods may have equivalent or even latent protective impacts – questions our literature review in Report 3 will examine.

Early Childhood (Birth to ~3 years)

Emotion regulation during infancy is almost entirely reactive, characterized by a quick stimulus-driven response with physiological effects [54]. For example, a baby responds to loud noises by crying, which would not typically be considered evidence of self-regulation. However, there are very early indicators of cognitive self-regulation such as an infant's ability to orient attention away from a stressor (i.e., look at his/her mother's face when there is a loud noise) and thereby modulate the impact of sensory-motor stress. Re-orienting also appears to be effective for toddlers in reducing distress, and may represent the primary regulatory system until executive functions develop [67]. In addition, self-soothing behaviors such as thumb-sucking may support emotion regulation in that they reduce distress and frustration [68]. The capacity to focus attention, considered foundational for cognitive self-regulation, becomes more voluntary between 9 and 18 months of age [69]. Young children use this skill in self-regulating by looking at their attachment figures for cues to respond to novel or ambiguous situations, a phenomenon called 'social referencing' [70]. Co-regulation at this age primarily involves caregivers modifying the environment to maintain manageable arousal levels and providing external regulation to calm and reassure children when upset through warm and responsive interactions (see Table 1).

Between two and three years of age (toddlerhood), growing self-regulation skills are manifested in children's increased ability to adjust behavior to achieve goals. Cognitive self-regulation is seen in understanding of behavioral expectations and performance on attention switching and response inhibition tasks [67]. During this time period, children demonstrate the ability to delay gratification in laboratory activities such as those where they are asked not to peek during a gift-delay task [71] and in Mischel's classic marshmallow test [29] where they can earn two marshmallows rather than one for waiting. An increased sense of self, i.e., "knowing that I know" and "knowing that I feel"; [72] and understanding of the connection between action and goals also appear to contribute to self-regulation at this age [73]. However, young children have strong experiences of and reactions to affect and the cognitive abilities that could help with self-regulation (e.g., effortful attentional control) are only just emerging. As a result, they have limited control over their emotions and typically require adult support to manage frustration and other upsetting emotions [1]. A more deliberate manifestation of emotion regulation emerging at this age is the young child who actively engages his/her parents in dealing with potentially fearful or frustrating situations [74]. Co-regulation at this age may occur when a parent removes a child who is upset to a quiet area, uses a reassuring voice and calm touch, which should help the child learn to regulate.

Table 1. Self-Regulation and Co-Regulation Supports across Development

Developmental Stage	Characteristics of Self-Regulation	Caregiver Co-Regulation Supports
Infancy (birth to ~age 1)	Orient attention away from stressors; use self-soothing behaviors like sucking fingers.	Interact in warm and responsive ways; anticipate and respond quickly to child's needs; provide physical and emotional comfort when child is stressed; modify environment to decrease demands and stress
Toddlerhood (~1-2 years)	Begin to select and shift attention (attentional control); adjust behavior to achieve simple goals; delay gratification and inhibit responses for short periods when there is structure and support; emotions stronger than cognitive regulation	Reassure and calm child when upset by removing child from situations or speaking calmly and giving affection; model self-calming strategies; teach rules and use consequences to regulate behavior
Preschool-aged (~3-5 years)	Focused attention increases but is still brief; begin to use rules, strategies and planning to guide behavior appropriate to situation; delay gratification and inhibit responses for longer periods; perspective-taking and empathy emerge; language begins to control emotional responses and actions; tolerate distress apart from caregiver	Model, prompt, and reinforce (or "coach") self-calming strategies when child is upset; instruct and coach use of words to express emotion and identify solutions to simple problems; coach rule-following and task completion; provide external consequences to support emerging self-regulation skills
Middle Childhood (~6-10 years)	Use cognitive strategies and internal speech to control behavior; increased cognitive flexibility, attentional control, and more accurate appraisal of situations; emerging ability to manage emotion "in the moment"; social problem-solving emerges; increased ability to organize behavior in complex ways	Teach problem-solving; model conflict resolution strategies; provide time, space, and support to manage emotions; model, prompt, and reinforce ("coach") organization and time management skills; encourage independence in task completion while providing external consequences as needed

Developmental Stage	Characteristics of Self-Regulation	Caregiver Co-Regulation Supports
Early Adolescence (~11-14 years)	Increased focus and task completion; more goal-oriented behavior and self-monitoring; organize more complex behaviors and manage time more independently; use strategies to manage distress; emotional arousal stronger than cognitive controls; strong reward-seeking with relatively low fear; poor decisions made "in the moment"	Monitor task completion; continue to coach organizational skills; teach planning and prioritization; collaboratively problem-solve social and academic issues; coach healthy stress management; encourage decision-making when less emotional; review future goals; set limits to reduce risks related to increased reward-seeking; reduce the emotional intensity of situations exceeding coping skills
Late Adolescence (~15-17 years)	Focus and persist on complex and challenging tasks; more complex and independent planning, time management, and prioritization; future orientation may influence behavior; consider others' perspectives in goal-setting; make less emotional decisions; manage distress more effectively with support	Monitor achievement of goals; provide problem-solving support as needed; prompt and reinforce effective time management and goal completion; help anticipate difficult decisions before they arise; encourage future perspective; prompt and support healthy stress management; reduce risks that may exceed coping skills or provide "safe" risks
Emerging Adulthood (~18-25 years) and beyond	Persist on long-term projects; manage time independently; self-monitor, self-reinforce, and overcome challenges to goals; delay gratification to achieve goals; future orientation begins to guide behavior; make decisions with broader perspective and compassion for self and others; organize complex behaviors in context and independently; manage frustration and distress independently	Provide consultation on important decisions; provide guidance for complex problem-solving; provide support in coping with significant stressors and negotiating more complex life situations

Preschool Age (~3-5 years)

Between 30 and 48 months (preschool-age), dramatic development occurs in children's cognitive self-regulation, during what is considered the greatest period of brain "plasticity" (defined further in Report 2). During this time period, children's performance on a range of executive functioning tasks assessing working memory and response inhibition greatly increases. A critical foundation for these abilities is selective attention, the ability to focus on a task and ignore irrelevant information [75], which increases dramatically between 7 and 31 months [76]. In addition, being able to shift attention between internal representations and the environment allows for increased cognitive flexibility and perspective-taking [77]. Integration of these two attentional systems (selective and set shifting) is considered an important milestone in cognitive self-regulation as it allows children to resolve conflicts between different types of information. This further supports emotion regulation, allowing children to provide more deliberate, reflective and context-specific responses [54] when faced with emotionally demanding situations (e.g., waiting for a toy or favorite treat). Laboratory work [75] demonstrating enhancements in delay of gratification with introduction of strategies to "cool" emotional reactivity (e.g. labeling or verbalizing that it's good to wait) has clear intervention implications.

Behaviorally, preschoolers' higher-order cognitive capacities and growing language skills allow them to inhibit responses during simple games such as Simon Says. They become increasingly able to use rules, strategies, and plans to guide their behavior. They are better able to match their behavior to the context because their thinking now allows them to integrate conflicting knowledge into a more complex rule system [78]. However, preschoolers have limited abilities to multi-task, so coping strategies and problem-solving must involve linear steps such as stopping, looking and listening [72]. Moreover, the duration of their focused attention, even during play, is very short [79], constraining cognitive interventions that might be considered.

From a more social-emotional perspective described by Kopp [72], children around age four develop the cognitive capacity to acknowledge their parents' preferences and goals and become more inclined to accommodate requests because of their emotional relationship with their parent. Their development of "theory of mind" (i.e., the ability to attribute beliefs, intention, desire, etc. to oneself and others and to recognize that others may have different mental states) allows them to take others' perspectives, which encourages feelings of empathy and motivates prosocial behaviors with peers as well as parents. As a part of co-regulation, parents play an important role in teaching emotion regulation at this age through direct instruction, modeling and coaching. For example, parents may provide labels for observed emotions, demonstrate taking deep breaths or self-talk to calm down, and prompt and reinforce the child for doing the same in specific situations. Through this process, children learn to experience, express, and manage strong feelings in a more adaptive manner. Undoubtedly, the influence of social interaction – particularly between a parent and child – is very influential in a child's self-regulation development [80].

The role of language in the development of self-regulation is also worth elaborating. Through language exchange in social interactions, children learn knowledge and strategies that can be used to develop self-regulation. When caregivers explain rules and talk through problems, children learn vocabulary to mediate their behavior [81]. As children's verbal skills develop, they move from using verbal self-instruction to internal speech, and later, inner thoughts, to manage their thoughts, feelings and behavior. When young children verbally label their emotions, it helps them more accurately appraise those experiences and then react in adaptive ways. Language skills allow children to not only understand directions and rationales for desired behavior, but may also facilitate self-reflection which in turn supports self-regulation [82]. Moreover, language development supports interpersonal communication as a strategy to negotiate parental demands and avoid disputes with peers. There is a wealth of data demonstrating that expressive and receptive verbal abilities are significantly related to children's executive functioning and impulse control [83], although this may simply reflect general cognitive abilities. There is also indication that parenting predicts verbal skills, which later predict impulse control [83], again underscoring the importance of social interactions in the process of self-regulation development.

Middle Childhood/Elementary Aged (~6-10 years)

Notable growth in self-regulation continues until around age seven [77], with more of a leveling off during middle childhood. As summarized in Berger (2011), early elementary-aged children demonstrate

increased control of their emotions and behavior, with further neurocognitive maturation and integration of affective and cognitive neural systems. This can be seen in a six year-old's use of cognitive strategies to inhibit responding to an appealing stimulus (e.g., a novel toy) rather than having to keep the stimulus out of sight as a preschooler might [84]. Critical to this increased regulation is the use of internal speech and the development of meta-cognition or the ability to reflect on one's own thinking processes. Being able to recognize self-thoughts gives children the ability to then modify those thoughts. This also increases self-awareness and allows children to be more conscious of their behavior and make more deliberate decisions. Increased cognitive flexibility, inhibition, and attentional control contribute to the ability to reason, manage emotions "in the moment", organize behavior for simple, routine tasks, and exhibit socially appropriate behavior in more complex situations. Such self-regulation appears to be relatively stable through childhood and across school environments, with little evidence of growth in self-regulation during the age period between 8 or 9 and 12 or 13 years [16], at least as typically measured. There is, however, also evidence of malleability [30], suggesting that interventions may continue to be helpful during this developmental period. For children who have had delayed self-regulation up to this point, this may even be a time for compensatory development with intervention support.

The social context of middle childhood is also important in understanding self-regulation development. During elementary school when peer interactions become more complex, children must be able to understand and respond to others' goals, perceptions, and beliefs, to self-monitor and inhibit inappropriate behavior, and to plan and change their behavior based upon feedback if they are to be socially competent [85]. Such social problem-solving requires integration of numerous executive functioning abilities, which is a developmental task that continues well into adolescence. Middle childhood has also been identified as a period during which children's self-regulation becomes more independent from parental influence, or when mechanisms of parental influence may change [86], suggesting new possibilities for intervention. However, co-regulation remains important in helping children learn to manage challenging emotions, problem-solve social situations, and learn organization and planning skills needed for school. Developmentally, it is also important for caregivers to begin to allow children time and space to make some decisions and self-monitor, while providing structure and consequences as needed.

Early Adolescence (~11-14 years)

Adolescence is becoming recognized as a second critical period of developmental plasticity with dramatic neurobiological restructuring and opportunity for intervention. Although less is known about self-regulation during adolescence as compared to early childhood, recent methodological advances in the field have allowed for research that is demonstrating profound brain maturation changes during this age period related to regulatory and motivational processes and their neural mechanisms [87]. By about age 11, gray matter in the prefrontal cortex reaches its peak [88] and pruning in this region begins, dramatically increasing functional efficiency [66]. Adolescents also appear to be more reactive to stress than are younger children and older adults [64]. Relatedly, there is an increase in reward sensitivity and sensation seeking during adolescence along with reduced avoidance behavior that leads to increased novelty seeking, exploration, and emotionality [89]. Simultaneously, adolescents' social

contexts are changing in that they are spending increasing time with peers, and the structure of their time is changing with new school routines and activities and decreased monitoring from parents. Society expects youth of this age to identify long-term goals for themselves and to begin paths to pursue these successfully.

During early to mid-adolescence, youths' reward-seeking emotional systems are stronger than their cognitive regulation system (just as during the preschool years), and impulse control is relatively low [90], with the largest gap between the arousal and control systems is seen at ages 14-15 [63]. This can be seen in laboratory tasks where adolescents' executive functioning is disrupted when emotional stimuli are introduced [91]. In addition, the presence of peers when adolescents make risky decisions seems to increase activation of the reward centers [89]. To use a metaphor from Steinberg, teens' neurobiological functioning results in them "pushing the gas before their brakes are fully installed". As such, self-regulation is out of balance, leading to increased vulnerability to psychiatric disorders and risk behaviors during this developmental period [90]. Parental monitoring to reduce youths' exposure to risk situations and continued parental support for the development of coping skills is believed to be quite important at this age.

Later Adolescence (~15-17 years)

By age 15-16 years, cognitive maturity as measured by many indicators is comparable to that of adults [92]. As a result, adolescents demonstrate increased abilities to focus and engage in goal-oriented behavior [90]. They begin to set longer-term goals with more complex plans of action, to prioritize goals, consider the impact of their goals on others, solve problems that arise, and self-monitor their progress. They are capable of organizing their behavior to achieve desired goals and take more intentional actions to create their personal future. External demands and expectations become increasingly internalized and guide decisions. However, the emotional and psychosocial maturity of older adolescents is not aligned with their cognitive maturity, and they continue to benefit from some amount of structure and adult support (i.e. "co-regulation") to create plans for longer-term goals, guide important decision-making, support healthy stress management, and monitor risky behavior.

Emotionally, older adolescents are able to delay gratification for longer periods of time, which may be related to an increased future time perspective, i.e., the ability to think about the future. They become capable of coping with frustration and using strategies to manage internal distress independently, although not always effectively. For example, distress management could include obsessive rumination or mood enhancement through substance use, neither of which would be considered particularly adaptive [92]. Older adolescents also become better able to cognitively and emotionally manage complex social relationships, although peers may continue to undermine adolescents' self-regulation skills by increasing arousal and changing their perceptions of risk and reward [93].

What is unclear is whether adolescents have adequate strength of inhibitory control to manage the high level of emotional arousal and reward-seeking that they experience. The insufficient brain maturation hypothesis, which has some empirical support, suggests that they do not [63]. Alternately, it has been proposed that adolescents can learn control through experience such as can be gained with driving [64].

These different views suggest very different intervention approaches. Unfortunately, much of the literature in this area is theoretical at this time, providing limited data to inform interventions. Given the potential neurocognitive vulnerabilities and opportunities during adolescence, a critical review of all available intervention data seems indicated, with particular attention to the empirical grounding of theories of change for different interventions. One specific area of interest is how external strategies such as parental monitoring and providing external constraints on risk behaviors impact youths' self-regulation skill development, and what form co-regulation activities might take. Another very pertinent question is whether interventions at this age can provide a compensatory function for youth from chronic stress environments who have increased risk-taking behaviors.

Young (Emerging) Adulthood (~18-25 years)

Although neurocognitive plasticity decreases during adulthood, there is evidence that brain maturation of the frontal cortex is not complete until the third decade of life [63]. Some such as Steinberg [92] have noted that as adolescence has become extended over the past several decades, the age of full self-regulation development may also be extending upwards, providing a potentially longer window for intervention. It therefore seems appropriate to consider this a period of "emerging adulthood", defined by Arnett [94] as "18-25 year olds who do not yet have children, live in their own homes, or have sufficient income to be fully independent and who are often completing their education, finding a career, and are not yet married". Unfortunately, little is known about neurobiological development during this period, limiting the empirical basis for informing intervention approaches.

Considering the social context of young adults may, however, suggest potentially fruitful directions for interventions. This is an age when there are numerous demands on self-regulation including the need to become self-supporting and ideally live independently either in some type of post-secondary educational setting or while working. Successfully completing a technical or post-secondary degree and starting a career certainly requires considerable executive functioning skills, which must be implemented with much less structure and co-regulation/contingency modification from caregivers than youth have had up to this point. The workplace also has less clearly defined behavioral regulations than school and requires more sophisticated knowledge of social norms, demands which could create difficulties for youth with delayed self-regulation skills. This is the age when many young adults also enter the military, facing sometimes extreme stress and self-regulatory challenges. Finally, many at-risk youth begin having children of their own at young ages, and must learn to parent when their own development is not yet complete, creating unique demands and complexities in managing the competing demands of work and parenting. In a recursive pattern, those who are most developmentally vulnerable appear to experience the most stressors (e.g., school or job failures), further exacerbating their self-regulatory functioning.

According to our developmental model, self-regulation in emerging adulthood is demonstrated by planning and persisting on complex tasks and long-term projects, self-monitoring and self-reinforcing progress towards goals, and effectively problem-solving barriers to goals. Delaying gratification to achieve these goals and considering others' perspectives in goal-setting and planning is also important. Ideally, young adults are able to manage frustration and distress independently, although we recognize

that emotion regulation continues to exist in a relational context with peers and intimate partners in adulthood. However, many young adults from at-risk backgrounds and chronic stress environments may not fully demonstrate all these skills. Unfortunately, young adulthood is a time when co-regulation by parents and teachers typically ends and youth become fully responsible for their behavior just at a time when there are increased consequences for self-regulation failures (e.g., criminal charges for engaging in risk behaviors). Moreover, adults such as post-secondary educators and employers have generally not been trained to identify or intervene in social-emotional concerns of individuals in this group. A broad review of interventions during this time period appears warranted, including critical examination of job training or "soft skills" programs which appear to share some goals with self-regulation interventions. In addition, because some young adult parents may not be capable of supporting their children's self-regulation development, we will also consider "dual-generation" interventions which simultaneously provide intervention support to young children at risk and to their parents (who may be young adults needing further self-regulation development in multiple domains of functioning).

Summary of key points about self-regulation and its development

In reviewing the additional reports in this project, it will be helpful to consider some of the key points highlighted in this introduction about self-regulation and its development. First, self-regulation involves inter-related domains, specifically cognitive and emotional dimensions, which interact to provide the foundation for behavioral regulation, the area with perhaps the greatest policy relevance. Self-regulation can be defined from an applied perspective as the act of managing one's thoughts and feelings to engage in goal-directed actions such as organizing behavior, controlling impulses, and solving problems constructively. The act of self-regulating is dependent on several different factors that interact with each other, those that are individual to the child or youth as well as those that are external or environmental, including biology, skills, motivation, caregiver support, and environmental context. In contexts with chronic or severe stressors, self-regulation may be negatively impacted, creating tremendous challenges for youth who live in adversity to develop and achieve optimal self-regulation within normative developmental expectations. As such, at-risk youth are vulnerable to a range of negative, lifelong health and mental health difficulties with significant social and economic consequences.

Self-regulation can be considered similar to literacy in that it can be taught at different ages, with multiple potential opportunities for intervention from birth through young adulthood. We would argue that instruction for self-regulation is important like instruction for literacy given self-regulation's lifelong, far-reaching consequences. The goal of self-regulation interventions should be to support development of increasingly sophisticated integration of emotional regulation with cognitive regulation across more complex social situations with less and less external support. This review suggests two important intervention approaches that should be applied across all developmental stages: 1) direct instruction in self-regulation skills and 2) co-regulation supports from parents, teachers, or even job coaches or mentors. Although more or less co-regulation support may be needed for different children at different ages and in different contexts, we believe that developmentally-appropriate and contextually-sensitive co-regulation is necessary from birth through young adulthood.

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