Summer 2019

Preschool Self-Regulation: A Predictor of School Readiness

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PRESCHOOL SELF-REGULATION: A PREDICTOR OF SCHOOL READINESS

A Thesis
Presented to
The Faculty of the Department of Psychological Sciences
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
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August 2019
Date recommended 7/10/2019

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I dedicate this thesis to my parents Christy M. Wade and Marty A. Geiger, who were of great support during the process of completing my graduate work.
ACKNOWLEDGEMENTS

I want to thank my friends and family for their support and belief in me when I did not believe in myself. I would not be here if I did not have a strong foundation with you all in my corner supporting me as a student.

I also want to thank Dr. Elizabeth Lemerise, who provided me with exceptional research, academic, and professional guidance for the past two years. I really appreciate the critical and necessary feedback she has provided to help mature me as a scholar.

Additionally, I want to thank all of the students within the Social Development Laboratory who assisted with this project: Jordan Gregory, Jasmine Ernst, Sam Fugate, Hannah Martin, Gopika Gopan, Cynthia Williams, Valentina Pinilla, and Andrea Bravo. You all were of tremendous help, and I wish all of you continued success in your future endeavors.
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Substantial evidence from previous research has supported the idea that greater self-regulation in the form of “cool” self-regulation or executive functioning and “hot” self-regulation or effortful control is associated with higher academic achievement within the preschool years and school readiness in the kindergarten years (Anaya, 2016; Carlson, 2005). However, there are only a few studies that assess the prediction of school readiness through validated cool and hot self-regulation tasks (Carlson, 2005; Krain, Wilson, Arbuckle, Kastellanos, & Wilham, 2006; Rothbart, Ellis, Rueda, & Posner, 2003; Thompson & Giedd, 2000). There also few studies examining to what extent cool and hot-self-regulation tasks predict socio-emotional (Blair, 2002) and academic achievement (Bull & Scherif, 2001), which are aspects of school readiness. The current study examined the validity of hot and cool tasks as measures of school readiness within a preschool sample (n = 86) enrolled in one of two programs: one blended Head Start and one full Head Start program. Adapted hot and cool self-regulation tasks, global observer ratings of hot and cool self-regulation tasks (Preschool Self-Regulation Assessment Assessor Report (PSRA-AR) and the Observation of Child Temperament Scale), Woodcock Johnson subtests (Letter Word, Applied Problems, and Picture Vocabulary), teacher ratings of social competence (Social Competence and Behavioral Evaluation) and emotional competence (Emotion Regulation Checklist) were collected in the fall of the school year. Results indicated that performance on cool tasks of measures cool self-
regulation were highly correlated with academic performance and that the Snack Delay task and the PSRA-AR component scores (Attention/Impulse Control and Positive Emotion) of hot self-regulation were correlated with socio-emotional competence.

Additionally, there were no age differences for hot self-regulation. Regression analyses suggested that hot self-regulation predicted socio-emotional competence and cool tasks predicted academic achievement. However, conclusions regarding hot self-regulation age differences and predictive validity are limited by the sole use of one hot task within this study and the results do not warrant a conclusion regarding whether hot self-regulation and cool self-regulation are separate self-regulation constructs, given the use of only one hot task.
Introduction

In recent years researchers have been interested in the self-regulation processes that affect preschool-age children’s academic readiness (Duncan, Schmitt, Burke, & McClelland, 2018; Lipsey et al., 2017; Solomon et al., 2018). Self-regulation is defined as the modulation of internal and external processes mediated by central and peripheral physiology (Nigg, 2017). The self-regulation construct is comprised of two components that focus on temperament (i.e. hot self-regulation or effortful control: the ability to deploy regulation for emotions and impulses) and cognitive strategies (i.e. cool self-regulation or executive function: the ability to regulate based on goal-directed and rule-governed behavior) (Liew, 2012; Nigg, 2017). Specifically, the preschool years are considered a period of drastic improvement in self-regulatory abilities from the ages of three- to five-years-old (Bassett, Denham, Wyatt, & Warren-Khot, 2012; Liew, 2012; Schmitt, Pratt & McClelland, 2014; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011). Additionally, recent research supports the notion that hot self-regulation is predictive of socio-emotional competence aspects of school readiness (Eisenberg et al., 2003; Fabes et al., 1999, Liew, Eisenberg, & Reiser, 2004), whereas cool self-regulation is predictive of academic achievement of school readiness (Blair, 2002; Blair, Granger, & Razza, 2005; Blair & Razza, 2007).

The literature review first explains the dilemma of school readiness within the state of Kentucky. This review then builds onto the body of literature concerning self-regulation as a predictor of school readiness by explaining the cool and hot components of self-regulation, and the biological and societal factors that play a role in the development of these components. Additionally, an explanation is provided of cool and
hot self-regulation associations and differentiations in their predictions of school readiness measures. Finally, this review examines the combined use of concurrent cool and hot self-regulation measures to predict school readiness.

**School Readiness in Kentucky**

As of May 2018, the Early Childhood Profile reported that only 51.3% of Kentucky preschoolers were ready for kindergarten (Kentucky Center for Education and Workforce Statistics, 2018). Kindergarten readiness was measured by performance on the BRIGANCE K Screen III that measures the domains of academic/cognitive, language, physical development, social-emotional skills, and self-help. Of the 51.3% of children prepared for kindergarten, there were differences in readiness that were related to socioeconomic status (SES) which are illustrated here by comparing children from lower and middle/upper-class backgrounds who reside in the areas where the current study’s population is from. Bowling Green Independent and Warren County School Districts within the western region of Kentucky are the two school districts where the current study’s participants will begin kindergarten. For example, students from middle/upper-class backgrounds who attended Jody Richards Elementary School, Potter-Gray Elementary School, and W.R. McNeill Elementary School were 68.8%, 71.9%, and 91.8% kindergarten ready, respectively, compared to students from poverty-stricken backgrounds who attended Dishman-McGinnis Elementary School, Warren Elementary School, and Parker-Bennett-Curry Elementary School who were 44.4%, 43.6%, and 26.4% kindergarten ready, respectively, in 2017 (Kentucky Department of Education, 2017).
These alarming statistics not only point to the fact that almost half of all children entering kindergarten in the state of Kentucky are not prepared to execute the academic and socioemotional skills needed for the classroom, but that academic readiness may be mostly related to socioeconomic status (Dilworth-Bart, 2012). As these statistics relate to socioeconomic status, about 18% of Kentucky residents and 25% of all American children live in poverty, (United States Census Bureau, 2017) limiting many Kentucky children’s access to proper resources like libraries, exhibits, and playgrounds that foster cognitive and socioemotional development and properly engage children in this critical developmental time period.

Given the association of poverty with reduced opportunities to promote the development of self-regulation abilities, how does this association relate to school readiness and academic achievement? Kindergarten readiness is defined by specific expectations that primary schools set for children and parents to prepare for school entry (e.g. approaches to learning; health and physical well-being; language and communication development; social and emotional development; and cognitive development and general knowledge). Views on school readiness imply it is multidimensional, including cognitive and socioemotional skills. School readiness is comprised of the ways in which children engage with and make sense of increasingly complex types of information that involve children’s social and emotional skills, as well as aspects of cognitive ability, attention, language, and executive functions acquired through peer and teacher relationships (Blair & Raver, 2015). Collectively, sources that define school readiness not only point to the importance of early academic abilities as the best predictors of later academic abilities, but also aspects of cognitive abilities, executive
functioning, and attentional regulation that are especially important for learning in school (Blair & Raver, 2015; Duncan et al., 2007; Keogh, 1992; Martin, Drew, Gaddis, & Moseley, 1988; Palisin & Scarr, 1986).

In the state of Kentucky, the Department of Education Task Force defined school readiness as consisting of five broad domains: approaches to learning, health and physical well-being, language and communication development, social and emotional development, and cognitive and general knowledge (Kentucky Department of Education, 2018). Along with these expectations, there are a set of aspirations that the Task Force hopes children will have developed by the time of school entry. These aspirations are defined in the realm of health and physical well-being as having a balanced diet, receiving adequate amounts of rest, and engaging in tasks that involve fine motor skills (Kentucky Department of Education, 2018). From the emotional and social developmental realm, some aspirations involve the ability to follow rules and routines, focus and listen, and express own needs and wants while learning to share/play with others (Kentucky Department of Education, 2018). Additionally, aspirations from the cognitive and general knowledge realm are aimed toward abilities that involve using five to six words to make sentences, learning to count, and identifying the name of shapes and colors (Kentucky Department of Education, 2018). However, how are these specific school readiness capabilities related to features of self-regulation?

**Self-Regulation**

Self-regulation comprises “hot” regulatory processes (i.e., effortful control) that are grounded in temperament, as well as “cool” regulatory processes (i.e., executive function) that are attentional and cognitive abilities. Collectively, these abilities depend
on the integration of physiological, attentional, behavioral, cognitive, and interpersonal/social processes (Calkins & Howse, 2004; Thompson, 2009). Children who have adapted self-regulation skills successfully show the ability to manage their emotions, control their physical impulses, delay gratification, regulate their attention with inhibition and disinhibition, make behavioral adjustments in different contexts, use cognitive abilities to problem solve, and work well with others in an array of social contexts (Nigg, 2017). Self-regulation continues to develop over the course of one’s life; however, these abilities show drastic improvement between three and five years of age (Tominey & McClelland, 2011). Hence, although overall mastery of these individual self-regulation abilities may not be attainable, enhanced abilities are essential for adaptive functioning in an academic setting and can be depicted in Figure 1.

![Figure 1. Comparisons of subcomponents of Cool Executive Functioning and Hot Effortful Control.](image-url)
**Effortful Control: “Hot” Self-Regulation.** Researchers who study self-regulation from a temperament or bottom-up point of view, driven by external arousal and spontaneous rewards, focus primarily on the effortful control aspect of self-regulation. Effortful control skills in preschool populations are observed in specific social-emotional abilities that help enhance emotional intelligence, social intelligence, and personal intelligence (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). Early in life, these social-emotional intelligence factors are formed by heredity and environmental factors, but continue to develop progressively across the lifespan (Liew, 2012).

Researchers generally define effortful control as the ability to inhibit a dominant response in order to perform a subdominant response (Garstein, Slobodskaya, Putnam, & Kinsht, 2009; Murray & Kochanska, 2002). In an academic setting, effortful control provides children with the abilities to focus attention when there are distractions in the classroom, to not interrupt others and sit still, and to force oneself to do an unpleasant task when the dominant response for a child is the urge to engage in a more pleasant task (Liew, 2012).

Effortful control consists of three subcomponents: inhibitory control, attention shifting and emotion regulation (Liew, 2012; Nigg, 2017).

**Response Inhibition.** *Inhibitory control* is defined as the ability to inhibit a dominant response for a subdominant response that is represented through attentional and response inhibitory control (Joyce et al., 2016). *Response inhibitory control* is the ability to postpone the initiation of a dominant response (Nigg, 2017). This type of inhibitory control is important for children to excel in learning, to wait their turn, and to tolerate the postponement of rewarding events (i.e. delay of gratification; Marshmallow Test: children wait for an allotted amount of time with a treat and are told they can either eat
the treat or wait until the experimenter returns for additional treats; Mischel, Shoda, & Rodriguez, 1989). Alternatively, attentional inhibitory control is the ability to suppress a dominant response to perform a contradictory action. Attentional inhibitory control is important for overriding the dominant response of correctly identifying certain stimuli instead of identifying them in the opposite manner. For example, in a measure of attentional inhibitory control like the Head Toes Knees Shoulders task (HTKS; Ponitz et al., 2008) children are asked to do the opposite of what the experimenter says, like touching their head when the experimenter tells them to touch their toes, forcing them to inhibit the dominant response of enacting the experimenter’s command. The main difference between response and attentional inhibitory control is the action that emanates for children after inhibiting a dominant response (i.e. children focusing on teacher instruction instead of disruptive classmates) (Joyce et al., 2016).

**Attention Shifting.** Attention shifting is another subcomponent of effortful control that is similar to response inhibitory control. Attention shifting involves the ability to regulate impulsivity and purposefully deploy attention during emotional arousal (Bassett et al., 2012). Research on this topic points to the ability to reallocate attention within one’s internal and external environments to support goals and tasks. This subcomponent of effortful control is difficult because it requires that children reduce levels of fear or negative affect by disengaging attention from negative thoughts or threatening stimuli and focusing attention on more positive and adaptive stimuli (White, McDermott, Degnan, Henderson, & Fox, 2011). In some academic settings, children may come across situations where they are faced with a challenging situation, like reading a difficult book, but they have to produce positive goal-directed thoughts that encourage themselves to
engage in the strenuous task. Consequently, this type of effortful control is considered in previous literature to be more of a lukewarm self-regulation ability because it requires children to cognitively strategize to inhibit emotions associated with their internal or external situations (Nigg, 2017).

**Emotion Regulation.** Another subcomponent of effortful control is emotion regulation. This form of hot self-regulation is a key component that helps children understand the nature of their own internal and external states to help monitor, evaluate and modify emotional reactions to accomplish a specific goal (Carlson, 2005; Cole, Dennis, Smith-Simon, & Cohen, 2009; Stefan & Avram, 2017; Thompson & Meyer, 2007). Research points to the fact that this form of hot self-regulation allows children to modulate expressive responses depending on the situation with which children are faced. Conscious control of different emotional processes helps children develop awareness of dealing with situations where they can respond properly regarding the social context (Cole et al., 2009).

Consequently, children who have good emotion regulation abilities can form internal states or effective internal strategies that help them deal successfully with external or social situations that may be challenging (Liew, 2012). Children may engage in specific internal or cognitive strategies like self-soothing, distracting, and help-seeking behaviors that help to reduce distress in challenging social situations (Hill, Degnan, Calkins, & Keane, 2006). Additionally, children who lack the ability to regulate their emotions may exhibit externalizing behavior problems (i.e. temper tantrums, screaming, and whining) that are linked to the inability to develop proper strategies for dealing with stressful situations (Hill et al., 2006). Adequate ability in this realm of hot self-regulation
is important for the ever-changing challenges that children may face in an academic setting due to the new and different social and instructional demands with which children are faced. This dimension of self-regulation is considered to emerge between three to six months of age and continues to mature throughout childhood (Nigg, 2017).

**Brain Development and Hot Self-Regulation.** A key component to the rapid development of hot self-regulation abilities in preschool years is the manifestation of connections in specific areas of the brain. The orbitofrontal cortex of the brain has been found to be associated with hot effortful control abilities because of its proximity with the limbic system, which is a complex system in the brain primarily responsible for human instincts, controlling basic emotions like anger, fear, and pleasure, and controlling drives like dominance, hunger, and sex (Carlson, 2005; Willoughby et al., 2011). Hence, damage to this area of the brain has been found to result in expressions of inappropriate social and emotional behavior (Carlson, 2005). Consequently, this specific area of the brain is especially important for the emotion regulation subcomponent of hot effortful control.

Along with the orbitofrontal cortex of the brain, there are three attentional systems that are developed substantially by the end of the preschool years: the reticular activating system, the posterior attentional system, and the anterior attentional system (Calkins, 2007). From toddlerhood to preschool years, these attentional systems are responsible for developing regulatory mechanisms that maintain attentional persistence in different emotional and behavioral states (Calkins, 2007).

The reticular activating system is located in the brain stem and is responsible for maintaining general attention and alertness that helps with distraction prevention.
The posterior attentional system is an important mechanism for engagement and disengagement of attention; this system is located in three areas of the cortex: the superior colliculus, the pulvinar nucleus of the thalamus, and the parietal lobe (Calkins, 2007). Both the first and second attentional systems contribute to basic inhibitory control abilities in preschoolers. The third and last attentional system, the anterior attentional system, is located in the midprefrontal cortex and is important for maintaining reactive motivational functions in children when they are required to respond to specific commands but inhibit others (Rothbart, Derryberry, & Posner, 1994).

Typical instances of the importance of this attentional system for preschool children can be depicted in tasks that require the ability to switch between incompatible rules like the complex Simon Says task where children are required to inhibit a dominant response and perform a subdominant response (Calkins, 2007; Jones, Rothbart, & Posner, 2003). Due to the complexity of the anterior attentional system for specific inhibitory abilities, this portion of the brain is developed last between toddler and preschool years (Jones et al., 2003).

**Executive Function: “Cool” Self-Regulation.** Researchers who study self-regulation in preschoolers from a more cognitive perspective tend to examine how specific top-down processing abilities like working memory, response inhibition, and cognitive flexibility are used to modify behavior (Diamond, Barnett, Thomas, & Munro, 2007; Garon, Bryson, & Smith, 2008; Zelazo, Craik, & Booth, 2004). These abilities are responsible for processing, planning, and restoring information to modify behavior or execute a specific task and evolve during the preschool years and beyond due to the rapid development of the prefrontal cortex (PFC) (Roberts & Pennington, 1996).
**Working Memory.** Working memory consists of the ability to maintain and manipulate information over short periods of time and is considered a prerequisite for the other specific executive functioning abilities like planning and reasoning (Grunewaldt, Løhaugen, Austeng, Brubakk, & Skranes, 2013). For example, in the Tower of London task, children must use working memory strategically to problem solve the placement of three colored balls on an apparatus that has three pegs of different lengths, after using a picture as a goal state reference for ball placement (Baughman & Cooper, 2007). Working memory ability improves rapidly from the ages of three- to five-years-old, as represented by the inability of three- and four-year-olds versus the ability of five-year-olds to perform working memory tasks in the Tower of London task (Luciana & Nelson, 1998). In the preschool setting, working memory enables children to remember and carry out instructions given by teachers in order to carry out an assigned task effectively; thus, working memory has been associated strongly with early literacy and mathematics skills (Bull, Espy, & Wiebe, 2008).

**Attentional Inhibition and Cognitive Flexibility.** Another major component of executive functioning is attentional inhibition. General inhibitory control abilities overlap with the temperamental perspective, but from the executive control perspective, attentional inhibition is represented as the ability to suppress triggered behavior or sustain a behavior based on an externally- or internally-driven goal (Qu, Finestone, Qin, & Reena, 2013). Response inhibition also encompasses the ability to discriminate targets from distractors and is represented specifically in the Dimensional Card Change Sort Task (Qu et al., 2013; Zelazo, Müller, Frye, & Marcovitch, 2003). In this task, children are introduced to two boxes that have two different target cards affixed on the front.
Children are then presented a set of cards and required first to place the card in the appropriate box based on one modality (color) and then later to switch to another modality (shape). Inhibiting the dominant response of placing the card in the previously practiced box when switching between modalities stems from the ability to use cognitive flexibility (set shift or task shift), by which the modality is chosen based on the task demand. Cognitive flexibility is considered a more hierarchical complex executive function that requires not only inhibition of a dominant response, but also now rewiring the representation of a correct response due to the rule or task shift (Zelazo, Reznick, & Spinazzola, 1998). Hence, an incorrect response in the Dimensional Change Card Sort Task is likely the result of cognitive inflexibility to switch the rules based on the modality.

**Brain Development and Cool Self-Regulation.** Neurologically, response inhibition is involved heavily in the activation of the orbitomedial prefrontal cortex (Nigg, 2017). Additionally, response inhibition and cognitive flexibility stem from increases in dopamine in the substantia nigra and ventral tegmental of the cortex that are responsible for positive mood and lead to the specific actions of reward-seeking, goal setting, rule selection, flexibility and rule use (Ashby, Isen, & Turken, 1999). Response inhibition and cognitive flexibility abilities are regarded as low-level executive functioning skills that emerge in toddlerhood and preschool and are usually mastered in adolescence (Nigg, 2017). The ability to inhibit a dominant response is more prevalent in 4-year-old preschoolers than in younger preschoolers who have not developed these same response inhibition and cognitive flexibility skills (Jacques & Zelazo, 2001).
Influences on the Development of Self-Regulation Skills. Individual differences in self-regulation are mediated by a range of individual internal variables like cognitive development, arousal and physiological regulation, and external sources like parenting and poverty (Arnsten, 2009, Bradley & Corwyn, 2002, Brooks-Gunn, Duncan, & Aber, 1997). Poverty raises the risks of prenatal and perinatal complications that ultimately affect attentional, neurological and affective development. The multiple stressors that are associated with poverty affect the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system (ANS), two systems associated with attentional, behavioral and emotional behaviors that are components of physiological regulation that may heighten arousal and affect effortful control processes (Blair & Raver, 2012a; Raver, 2004). Individual differences in self-regulation ability are supported in the literature to be correlated highly with SES, and children from low-income backgrounds are at risk for developing delays in self-regulation abilities (Blair & Raver, 2015). Parents who provide nurturance that enhances cognitive and socioemotional development reduce these risks for low-income children, making self-regulation abilities malleable to the consistencies that parents and environments reinforce (Zilberstein, 2016).

Socioeconomic Status. Children who come from higher socioeconomic status backgrounds generally experience orderly and predictable environments that provide consistent parenting techniques, age-appropriate physical and social resources, and stimulating experiences that assist in cognitive development (Dilworth-Bart, 2012). In these environments, children can expect and rely on the consistency of their parents and the predictability of their everyday schedules. Responsive and predictable environments foster prototypical self-regulation that enhances learning opportunities (Blair & Raver,
Children from higher socioeconomic status backgrounds are more likely to be exposed to parents who have more economic stability, who are married and have a higher education than those who come from low-income backgrounds (Blau, 1999; Mayer, 1997). More prevalent social interactions consist of warm and responsive parenting that seeks to attend to children’s emotional needs, as well as sensitivity to thoughts, emotions, and behaviors to meet situational demands (Colman, Hardy, Albert, Raffaelli, & Crockett, 2006). Access to better, parks and educational outlets that cognitively stimulate children are also factors that children from higher socioeconomic status backgrounds have the luxury of enjoying, enhancing experiences for proper child cognitive and social development (Brooks-Gunn & Duncan, 1997).

Conversely, the quality of the home environment for low-income children has been regarded widely as the predecessor for low-quality learning opportunities because of the higher levels and prevalence of disorganization and chaos (Dilworth-Bart, 2012). For example, children from low-income backgrounds receive significantly fewer parent verbalizations and shorter utterances of speech when compared to their higher income counterparts (Hart & Risley, 1995; Hoff, 2003). Additionally, past literature studying American samples found that 35% of low-income parents read to their children daily and 22% take their children to the library once a month, compared to the 58% and 48% of parents above the poverty line, respectively (Federal Interagency Forum on Child and Family Statistics, 2000). Parent interactions in disadvantaged homes have also been shown to be less attentive to and supportive of children’s emotional needs, and less instrumentally supportive in enhancing cognitive stimulation needs (Evans & Kim, 2013).
Children in these disadvantaged environments experience chaos through greater instances of household and neighborhood violence (e.g. incidents of crime within one’s neighborhood and less responsive peer interactions), as well as greater family disruption (e.g. higher divorce and separation rates) (Vernon-Feagans et al., 2011). Children who come from low-income populations often deal with stressors associated with higher household density and more changes in the household due to maternal partner departures and entrances (Vernon-Feagans et al., 2011). Along with these domestic instabilities, they are more likely to have parents who must endure more nonstandard work hours, and less reliable transportation and childcare (Raver, 2012). These factors shape the self-regulation system in ways that are more adaptive for an aversive context, rather than a predictable school context (Blair & Raver, 2015; Evans, 2004; Sampson, Raudenbush, & Earls, 1997; Sinclair, Pettit, Harrist, Dodge, & Bates, 1994).

In addition, the lack of daily schedules and routines that disadvantaged children typically experience hinders the development of self-regulation due to the lack of consistency and predictability that is necessary for the execution of inhibitory and attentional self-regulatory skills (Brown, Ackerman, & Moore, 2013). Specifically, an array of literature has supported that low-income children are less competent in self-control, have diminished capacity for working memory, exhibit weaker inhibitory control, and have problems with delaying gratification (Blair, 2010; Blair & Raver, 2012b; Evans & Kim, 2013).

Moreover, research suggests that the self-regulation difficulties associated with poverty contribute to enhanced internalizing and externalizing symptoms and social difficulties (Evans & Kim, 2013). These symptoms arise from coping strategies that
children use, like disengagement, withdrawal, and avoidance to deal with various stressors (Evans & Kim, 2013). However, these symptoms can be avoided when children engage in coping strategies that involve problem solving and cognitive reappraisal when dealing with stressors; children actively depict stressors as less threatening and become more optimistic about overcoming stressors (Evan & Kim, 2013).

Literature supports that stressors can have serious effects on the neuroendocrine pathways that are responsible for regulating hormonal activity in the body (Raver, 2012). The stressors from poverty-stricken environments on parents not only lead to parents being less sensitive and effective at engaging their children to encourage language development but also ultimately combine with household chaos for overstimulation that directly influences cognitive and language development trajectories (Raver, 2012). However, when caregiving behaviors are supportive and nurturing, the production of moderate levels of cortisol that increase activity in the PFC may enhance executive functions like working memory, cognitive flexibility and attentional control necessary for cognitive and language processes (Blair, 2010; Blair & Raver, 2012a). For children developing in stressful and chaotic environments, developing inhibitory and attentional regulatory systems in the PFC show decreased activity during stressful events due to increases in cortisol in the HPA (Arnsten, 2009; Blair & Raver, 2012a; Matheny, Wachs, Ludwig, & Phillips, 1995), which interferes with the development of executive functions.

It should be noted that executive functioning and effortful control abilities are considered malleable and very reactive to experience, making them susceptible to stressors that create changes in children neurobiologically but also responsive to responsive, language-rich, predictable environments, making these abilities a good target for intervention.
Overall, an unpredictable and chaotic home environment is associated with unhealthy cognitive and socioemotional development for children (Ackerman, Kogos, Youngstrom, Schoff, & Izard, 1999). Due to the prevalence of these environmental factors, children who come from low-income populations are not provided with the same experiences or opportunities that their counterparts (children from high-income samples) may experience, putting them at risk for delays in self-regulation and learning abilities. Furthermore, it is evident that SES plays a major role in the stressors that impact cognitive development during the period of rapid development (the preschool years) in the PFC, but developmental outcomes can be mediated by parental nurturance and children’s cognitive strategies used when facing these stressors (Evans, 2004; Vernon-Feagans, Garrett-Peters, Willoughby, & Mills-Koonce, 2011).

**Self-Regulation Measures and Adaptive Behavior**

Numerous studies have investigated the relations among specific self-regulatory abilities and academic achievement in the preschool and early elementary school years (Blair & Razza, 2007; McClelland et al., 2007; Mischel et al., 1989). These studies not only have investigated the strong associations between academic skills and cool self-regulation skills like engagement in goal-directed tasks, but also hot self-regulation tasks that involve persistence and the delay of gratification. These findings demonstrate that different elements of self-regulation in early childhood contribute substantially to the school readiness and overall academic achievement.

Researchers have investigated components of self-regulation using an array of measurements in preschool populations (i.e. neuroimaging techniques, behavioral tasks, and questionnaires) to gain understanding of the internal and external mechanisms that
shape individual self-regulation abilities (Carlson, 2005; Krain et al., 2006; Rothbart, Ellis, Rueda, & Posner, 2003; Thompson & Giedd, 2000). Previous studies have measured self-regulation using neuroimaging techniques, by differentiating cool self-regulation in the dorsolateral prefrontal cortex and the hot self-regulation abilities specific to the orbitofrontal cortex (Krain et al., 2006). Behavioral measurements of both cool and hot self-regulation use instruments that are adapted from the Preschool Self-Regulation Assessment (PSRA; Smith-Donald, Raver, Hayes, & Richardson, 2007) and the Laboratory Temperament Assessment Battery (Lab-Tab; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1993) that measure specific components of effortful control like delaying, slowing down gross and fine motor activity, suppressing/initiating activity to signals, and effortful attention. Common tasks that are used from these behavioral battery assessments include the delay of gratification, Snack Delay task (Kochanska, Murray, & Harlan, 2000), that is used as a measure of inhibitory control and the Disappointing Gift task (Saarni, 1984) that is used as a measure of emotion regulation when children are provided with an undesirable gift. The benefit of using behavioral measurements is that the experimenter can measure behavior objectively in a research setting where there is increased internal validity. However, these behavioral assessments are more expensive and labor intensive, taking about 30 minutes to an hour to complete.

From the cool self-regulation realm, previous research has shown that executive function abilities that involve working memory, inhibitory control and set shifting are key predictors of academic competence. For example, Espy et al. (2004) found that a battery of tasks measuring these three key executive function abilities was predictive of math skills in preschoolers. Additionally, Bull and Scherif (2001) found that executive function
measures that involved working memory and set-shifting skills, like the Counting Span Task and the Wisconsin Card Sorting Task were associated strongly with math achievement at the end of first grade. In the Counting Span Task children are required to recall the number of green spots (target items) versus red spots (distractor items) on a set of cards, and in the Wisconsin Card Sorting Task where children are required to sort cards by either the color, shape or number on the card. On the other hand, emotion regulation, a component of hot self-regulation, was found to be predictive of early elementary math and reading skills, standardized math and literacy scores in kindergarten, and higher classroom engagement that enhanced early learning and achievement (Ursache, Blair, & Raver, 2012).

Survey measurements commonly have included reports from teachers and parents concerning effortful control as in the Child Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001) and the Preschool Behavior Questionnaire (PBQ; Behar & Stringfield, 1974) that collectively measure elements of internalizing and externalizing behaviors, as well as specific subcomponents of temperament like extraversion, negative affect, and effortful control. The benefit of using questionnaire measurements is that parents and teachers can observe children in many different situations and contexts, unlike behavioral measurements that only measure behavior in one setting (Cummings, Davies, & Campbell, 2000).

However, parents’ and teachers’ reports may have biases of interpretation based on their individual experiences with children (Cummings et al., 2000). For example, a parent bases his/her response on his/her one-on-one shared experiences with the child in the home context. Teachers’ reports are based on observations and interactions with the
child and other students in the classroom and playground contexts. Teachers have experience with large numbers of children and can compare a given child to many of his or her peers. Both parents and teachers may misinterpret item(s) on the questionnaire or be unable to discriminate labeled behaviors (i.e. inhibition, emotion regulation, and attention shifting). Although survey measurements can be beneficial for their ability to illustrate child behaviors in different settings, the individual experiences that teachers’ and parents’ report may be biased because of the variance in the types of interactions experienced in the different settings in which they encounter children. Hence, the current study aims to avoid any of these biases by not only providing questionnaires, but also behavioral assessments from trained researchers to provide a dual-lens of child behavior in multiple contexts.

Based on previous longitudinal studies that have used different measures of individual components of self-regulation, there seem to be inconsistencies about what exactly these components predict (i.e. higher academic achievement, better peer or teacher relationships, or less future behavioral misconduct). A primary example of these inconsistencies stems from the fact that behavioral instruments explicitly measure components of self-regulation objectively, whereas questionnaires seem to measure individual components subjectively and less directly. On one hand, direct behavioral measurements of hot self-regulation, like the delay of gratification task that measures inhibitory control, have been strong predictors of fewer conduct/behavioral problems (Allan & Lonigan, 2011). Also, deficient performance on other measures of disinhibition like set-shifting tasks that assess conflict inhibitory control and the stroop-like tasks have
been associated with conduct problems in preschool children (Berlin, & Bohlin, 2002; Gusdorf, Karreman, van Aken, Deković, & van Tuijl, 2011).

Recent major studies that have used interventions to address school readiness, like the Chicago School Readiness Project (CSRP), showed that delay and attention measurements adapted from the PSRA significantly predicted higher attention and greater impulse control in intervention children than in children who were not a part of the intervention (Raver et al., 2011). Additionally, in the years beyond preschool, specific behavioral inhibitory control tasks such as the Walk-a-line and Star tasks that require children to inhibit their dominant urge to disregard provided instruction have been found to predict third grade mathematics achievement (Liew, McTigue, Barrois, & Hughes, 2008).

However, when survey measures are used, self-regulation seems to be assessed from a more holistic perspective instead of as a complex paradigm that has multiple individual components. For example, reports of overall low abilities of effortful control have been associated with specific social skills like the inability to regulate externalizing behaviors adequately (Rothbart et al., 2003). In a longitudinal study conducted in mainland China, social competence mediated the association between the CBQ, used as a measurement of parents’ and teachers’ ratings of inhibitory and attentional focusing control, and GPAs in fifth graders going to the sixth grade (Zhou, Main, & Wang, 2010). More recently, Moed et al. (2017) found that low attention focusing and inhibitory control, as subcomponents of the CBQ, moderated the prediction of parent-child relationships on teen GPAs as a measure of academic success.
Hence, although survey measurements of self-regulation provide a glimpse of this overall construct, they fail to assess how the individual mechanisms (i.e. working memory, inhibitory control, set shifting, inhibition, attention shifting, and emotional regulation) evolve in this rapidly developing period in the preschool years. Using a behavioral battery assessment, the research conducted by Carlson (2005) provided direct evidence of the evolution of specific hot effortful control and cool executive function abilities. Specifically, the use of behavioral tasks allows researchers to measure behavior objectively on which tasks preschoolers score better across time points and which tasks show ceiling effects or sustained ability to perform specific behavioral tasks. Sole use of questionnaires may disregard the objective approach to measuring these specific abilities and may not be the best approach to the investigation of individual differences and age group effects that were seen in Carlson (2005). It also is important to note that the use of just behavioral tasks also may disregard the importance of the interpersonal perceptions that teachers and parents provide when reporting their children’s behavior using a questionnaire (Cummings et al., 2000).

**Statement of the Problem**

Consequently, future research on self-regulation skills in preschool populations should encompass the use of both behavioral measures and questionnaires to serve as valid representations of children’s behavior. Using both types of measurements longitudinally should allow a depiction of the emergence and progressive growth of hot and cool self-regulation. It is important to understand how these subcomponents can be measured objectively in a research setting using a battery of tasks, along with questionnaires that subjectively measure children’s behavior in their natural settings from
individuals who may be able to provide a better depiction of behavior on a day-to-day basis.

The preschool years are a critical period when self-regulation skills that influence academic performance are developing rapidly (Eisenberg, Valiente, & Eggum, 2010). During this rapid development, specific self-regulatory abilities like working memory, attentional focusing and inhibitory control skills have been associated with early academic reading, mathematics and cognitive skills (Ponitz, McClelland, Matthews, & Morrison, 2009). These findings also are supported by studies that have examined improvement of specific self-regulatory abilities longitudinally through interventions like the Chicago School Readiness Project (CSRP; Jones, Bub, & Raver, 2013), Research Based Developmentally Informed (REDI; Bierman, Nix, Domitrovich, Welsh, & Gest, 2015) project, and the Tools of Mind (Solomon et al., 2018). These intervention programs for children from low-income backgrounds not only improved overall self-regulatory skills, but also found improvements in academic skills like vocabulary, letter naming, mathematics, literacy development, and reasoning skills that are necessary for the kindergarten classroom (Blair & Raver, 2015).

Future research should address the evolution of these specific self-regulatory abilities using a study that encompasses both behavior and questionnaire measurements. Using a battery of tasks that involves different subcomponents of hot and cool self-regulation should provide an objective and accurate depiction of the rapid development that occurs in the preschool years. Along with these measurements, academic measures should be administered to assess how these specific measures relate to school readiness. Specifically, future research should address how preschool self-regulation abilities may
mediate the effect that the stressors of poverty may have on children who are entering school. Hence, the overall importance of the investigation in this area may provide insight into what specific self-regulatory abilities may be well developed at this age for this population, and other abilities that may need to be targeted through program intervention, utilizing specific government programs like Project Head Start.

The Current Study

The current study assessed a battery of hot and cool self-regulation measures as predictors of academic readiness and socioemotional competence within a low to middle/high income, blended Head Start and regular preschool sample to analyze the predictive validity of self-regulatory abilities for school readiness. Data were collected from preschoolers and their teachers during the fall (time 1) and spring (time 2) semesters of the 2018-2019 academic school year; however, the current project will focus only on measures assessed in the fall semester. Measures of hot and cool self-regulatory abilities were assessed using a battery of tasks adapted from the Preschool Self-Regulation Assessment (PSRA; Smith-Donald et al., 2007) and the Laboratory Temperament Assessment Battery (Lab-Tab; Goldsmith et al., 1993). Academic achievement was assessed using the Woodcock Johnson (WJ) III Test of Cognitive Abilities (Schrank, McGrew, & Woodcock, 2001) subtests: Letter-word, Applied Problems, and Picture Vocabulary. Socioemotional competence was assessed with teacher ratings of children’s social competence, internalizing and externalizing behaviors using the Social Competence and Behavior Evaluation (SCBE-30; LaFreniere & Dumas, 1996), along with emotion regulation and levels of lability using the Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997).
Findings from hot and cool self-regulation literature point to the fact that hot processes are highly predictive of socioemotional processes (Eisenberg et al., 2003; Fabes et al., 1999, Liew et al., 2004), whereas cool processes are associated with academic achievement (Blair, 2002; Blair et al., 2005; Blair & Razza, 2007). There were five hypotheses that guided this study. 1) It was expected that there would be an age effect of hot self-regulation, such that older preschoolers would perform better than young preschoolers on hot tasks at time 1 because of the findings of an age effect for hot tasks in previous literature (Di Norcia, Pecora, Bombi, Baumgartner, & Laghi, 2015). Additionally, it was expected that 2) if hot self-regulation tasks are a convergent measure of socioemotional processes, such that preschoolers’ time 1 performance on these tasks would be correlated strongly or moderately with time 1 socioemotional competence. Conversely, it was expected that cool self-regulation tasks is a concurrent measure of executive functions associated with academic achievement, such that 3) preschoolers’ time 1 performance on cool tasks would be correlated strongly or moderately with time 1 academic achievement measures. If strong or moderate correlations were found between time 1 hot self-regulation tasks and socio-emotional competence ratings, it was hypothesized that 4) time 1 hot tasks would predict time 1 socio-emotional competence school readiness measures above and beyond cool tasks. Similarly, if strong or moderate correlations were found between cool tasks and academic achievement measures, it was hypothesized 5) then time 1 cool tasks would predict time 1 academic achievement school readiness measures above and beyond hot tasks.
Method

Participants

Data from 86 preschoolers (51 boys; 35 girls) between the ages of three and five ($M = 4.3$, $SD = .72$), who were enrolled at two blended Head Start programs were collected, along with reports from their teachers. Head Start classification was determined by federal guidelines, placing all children below the poverty line guidelines in Head Start; the remaining children were considered to be in “day-care.” In blended programs, children who are Head Start and “day-care” attend preschool together. The students from the Western Kentucky University Child Care Center ($n = 65$) were enrolled in a blended program, and the Warren County Head Start at Community Action of Southern Kentucky ($n = 21$) were enrolled in a Head Start only program. Parents were informed via parent meetings and/or project staff at the centers during times when children were dropped off and picked up by parents, where parental consent forms were dispersed for parents to complete and turn in to teachers if they wished for their child to participate in the IRB approved study (see Appendix A). During parent meetings, parents were informed of the purpose of the study, the use of video recordings and incentives for child participation, and information of the toys and snacks for the completion of each assessment.

Procedure

All measures from children were collected at two time-points: mid-fall (time 1) and mid-spring (time 2) of the 2018-2019 school year. The current study utilizes data from just time 1. Trained research assistants administered a battery of tasks assessing hot
and cool self-regulation abilities in one session and finished with a separate session, if needed, to prevent participant fatigue. Verbal assent was first obtained from each child before they were removed from the classroom to participate in each session, providing each child an age appropriate explanation of the assessment as a collection of games. Then there was an introduction of the second experimenter when the first experimenter entered a separate empty testing classroom. Prior to the behavioral assessment, an explanation for the use of the camera during the assessment was given, and a confirmation for the child’s choice of termination of the assessment at any time served as the second form of child assent.

Children were administered a battery of hot and cool self-regulation measures consisting of eight tasks in the form of one of two orders in a quiet room at their Head Start center; the assessment was filmed for later observational coding. Two experimenters assessed each child. One experimenter escorted the child from the classroom, operated the recording camera (brand: Sony; model number: DCR-SR100) and microphone (brand: Sony; model number: ECM-HW1), and kept track of time with a stopwatch for tasks that required it. The other experimenter administered the tasks and recorded times with a stopwatch. Children were randomly assigned to two conditions that had different orders of hot self-regulation tasks. To prevent fatigue, all measures were assessed in multiple sessions, if necessary, making each session 25-45 minutes (30 minutes on average). If more than one session was needed for each order, session 1 ended with Snack Delay. In a separate administration session, one trained research assistant completed the Woodcock-Johnson III assessment with each child as a measure of academic achievement.
Upon completion of the battery of tasks, the child returned to the classroom and experimenters completed independently a 28-item Preschool Self-Regulation Assessment Assessor Report examiner rating scale (PSRA-AR; Smith-Donald et al., 2007) and 9-item measure of temperament known as the Observed Child Temperament Scale (OCTS; Stifter, Putnam, & Jahromi, 2008). Teachers provided consent to complete questionnaire measures for each child participating, identified with each child’s name and participant number. Each classroom was comprised of a lead teacher and an assistant teacher, however, all teacher reports were collected from the lead teachers. As an incentive all teachers were provided with a gift card worth $5 for each questionnaire measure completed. Upon receiving the completed assessments from teachers at the end of time 1 all names were marked out for confidentiality purposes.

Measures

For each child, one order was used in the fall and the second order in the spring, (because of the alternating administration of hot tasks, the Snack Delay task was the only hot task administered to all children in both time 1 and time 2; all other hot tasks were excluded from analyses for the purposes of this study):

- Order 1: Pencil Tap, Dimensional Change Card Sort, Impossibly Perfect Circles, Snack Delay, Day/Night, Head Toes Knees Shoulders, No Stickers Left, and Gift Delay

- Order 2: Pencil Tap, Dimensional Change Card Sort, Attractive Toy in a Transparent Box, Snack Delay, Part 1 of Disappointing Gift, Day/Night, Head Toes Knees Shoulders, and Part 2 of Disappointing Gift
“Hot” Self-Regulation Tasks

1. *Impossibly Perfect Circles* (Goldsmith et al., 1993). This task required the experimenter to ask the child to draw a perfect green circle. After each circle was completed, the experimenter critiqued the circle (e.g., too small/big, lopsided, narrow, etc.) and told the child to draw another one. This continued for 3.5 minutes until the experimenter said that the child had finally drawn the perfect circle and asked him/her to make it into a smiley face. Children’s responses to critiques were recorded by both experimenters for the duration of the task to assess emotion regulation strategies during the sadness/frustration evoking task.

2. *No Stickers Left* (Goldsmith et al., 1993). This task required the experimenter to ask the child to pick a sticker from a set of options. The experimenter left the room to look for the sticker that was selected and returned to tell the child that there were no stickers left. The experimenter left the room again and returned with the selected sticker. The child’s response to not receiving the sticker was recorded by both experimenters to assess emotion regulation strategies during the sadness-evoking task.

3. *Gift Delay* (Smith-Donald et al., 2007). This task required children not to peek while the experimenter noisily wrapped a “surprise,” while both experimenters recorded the latency (in seconds) to first peek. The child was then directed to wait without touching the wrapped “surprise,” while both experimenters recorded the latency (in seconds) to the first touch.
4. **Snack Delay** (Smith-Donald et al., 2007). This task required the experimenter to instruct the child to wait for a signal before “finding” a snack under a clear cup and placing it into a second clear cup to save for later. The level of waiting was coded on a four-point scale (1: eats snack; 2: touches snack; 3: touches cup/timer, 4: doesn’t touch anything) and whether the child kept their hands flat or not (1: yes; 0: no). This task was modified by adding longer waiting periods if the child passed (i.e. did not eat the snack) the four required trials at 20, 40, 10, and 60 seconds. Additional trials (20, 90, 10, 120, 15, 150 seconds) were provided until the child ate the snack. An average of the snack delay code was computed by adding the codes from the four-point scale (1-4) and the hands flat code (0-1) and then dividing by the number of trials completed. Higher scores during task depict better hot self-regulatory inhibitory control abilities during a rewarding/enticing event and lower scores depict worse inhibitory control abilities. Latencies were not used for the analyses because of the alternating times between each successive trial.

5. **Attractive Toy in a Transparent Box** (Goldsmith et al., 1993). This task required the experimenter to ask the child which toy he/she liked the best out of two choices. The experimenter then locked the toy in a transparent box. The experimenter told the child that he/she could use a set of keys to unlock the box and play with a toy while the experiment left the room to get something else. However, the experimenter provided the child with an incorrect set of keys before leaving. After a delay of up to four minutes, the
experimenter returned with the correct set of keys. The child’s behavior while the first experimenter was absent was recorded by the second experimenter.

6. *Disappointing Gift* (Cole, 1986; Stifter, Dollar, & Cipriano, 2011). This task was divided into three parts. Children were instructed to rank six toys (small stuffed animal, toy car, hacky sack ball, a small dinosaur, etc.) from most to least desirable. Children then performed other tasks in the assessment as a method of earning the prize at the end. In the first part of coding behavior, after all the other tasks were completed, the child was rewarded with the least desirable toy, while the experimenters observed the child’s reaction for 30 seconds. In the second part, after a short delay, the experimenter left the room for thirty seconds while the second experimenter observed the child’s behavior. In the third part, the first experimenter returned to the room and presented the child with the highest ranked toy, and experimenters coded behavior for 30 seconds. This task was designed to measure emotion regulation strategies during a frustration/sadness-evoking event when the experimenter was both present and absent.

*“Cool” Self-Regulation Tasks*

1. *Pencil Tap* (Smith-Donald et al., 2007). This task required children to tap once when the experimenter tapped twice, and to tap twice when the experimenter tapped once during sixteen total trials. The child received a point for every correct trial, and task performance was measured by the total percent of correct responses. This task was designed to assess working memory aspects of cool self-regulation by remembering the rule for each modality,
while also assessing aspects of inhibitory control. The percent of correct trials out of 16 possible trials was computed, with higher percentages indicating better inhibitory control and working memory.

2. *Dimensional Change Card Sort* (Zelazo, 2006). This task required children to play a game with the experimenter where they were asked to sort cards according to a modality (color or shape). If the child passed the first two modalities, an advanced task asked them to use a third modality rule (border vs. non-border). This task was designed to assess working memory aspects of cool self-regulation by remembering the rule for each modality, while also assessing aspects of working memory, inhibitory control and cognitive flexibility during task shifting. The percent of number of correct trials out of the 6 trials in the color game, 6 trials in the shape game, and 12 trials in the advanced game were computed for each game separately, with higher percentages indicating better working memory, inhibitory control, and cognitive flexibility.

3. *Head Toes Knees Shoulders* (Ponitz et al., 2009). This task required children to play a game in which they had to do the opposite of what the experimenter said. When the experimenter told the child to touch his/her head, the correct response was for the child to touch his/her toes and vice versa. If the child passed this part of the task, an advanced task added knees/shoulders, where the experimenter told the child to touch his/her shoulders and the correct response was for the child to touch his/her knees, and vice versa. This task was designed to assess working memory aspects of cool self-regulation by
remembering the rule for each modality, while also assessing aspects of inhibitory and cognitive flexibility during task shifting. The percent of correct trials in the head/toes game and percent of correct trials in the shoulders/knees were computed for each game separately, with higher percentages indicating better working memory, inhibitory control and cognitive flexibility.

4. *Day/Night* (Diamond, Kirkham, & Amso, 2002). This task required children to play a game where they are shown either a black card with stars and a moon or a white card with a yellow sun by the experimenter. The child was instructed to say “day” when he/she saw a black card with stars and moon and to say “night” when he/she saw a white card with the yellow sun. This task was designed to assess working memory aspects of cool self-regulation by remembering the rule for each modality, while also assessing aspects of inhibitory and cognitive flexibility during task shifting. The percent of correct trials out of 16 possible trials was computed, with higher percentages indicating better inhibitory control and working memory.

**Global Self-Regulation Assessment Reports.** The PSRA-AR was used to serve as a global measure of the child’s attention, emotions, and impulsivity and behavior throughout the session. A total of 25 of the items were rated on a 4-point Likert scale format (e.g. 0 = “Child spends most of time off-task, inattentive,” to 3 = “Child looks closely at pictures to distinguish them” for “Pays attentions for instructions and demonstrations”). A total of 3 items were rated dichotomously on a “Yes” or “No” format on aggression behaviors (e.g. “Yes” or “No” for “Aggressive towards objects”) that were combined to form one item to measure overall global aggressive behavior.
Several items on the PSRA-AR were excluded due to overly skewed distributions (E4 – E7, F1 – F3, and the Aggression items). A principal component analysis on the remaining 21 items yielded 3 components with eigenvalues >1 reflecting attention, impulse control, and positive emotion similar to previous findings (Geiger, Ernst, & Lemerise, 2019; Smith-Donald et al., 2007). However, only two items loaded above .500 for the third component, so given the overlap among these original 3 components, an additional principal component analysis was run restricting the outcome to two components for 20 items with loadings above .500 (Attention/Impulse Control, $\alpha = .95$; Positive Emotion, $\alpha = .91$) that explained 61.8% of the variance (Table 1). An Oblimin with Kaiser Normalization rotation method interpretation was selected to provide a more accurate interpretation of the component loadings for each item. In addition, interrater reliability was high at the construct level for both components (Attention/Impulse Control, ICC = .96; Positive Emotion, ICC = .89). It is important to note that the results from the use of the PSRA-AR components should be interpreted with caution because of the current study’s sample size (N = 86) is a bit small in the context of the requirements for a true principal component analysis (N of at least 100).

The OCTS was used to serve as a global measure of activity level, reaction to novel persons, compliance, frustration, positive affect, shyness/fearfulness, task persistence, comprehension, and language production.
Table 1.
*Rotated Component Matrix for PSRA-AR (n=86)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Component</th>
<th>Attention/Impulse Control</th>
<th>Positive Emotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td></td>
<td>0.857</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td>0.898</td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td></td>
<td>0.857</td>
<td></td>
</tr>
<tr>
<td>Focus</td>
<td></td>
<td>0.843</td>
<td></td>
</tr>
<tr>
<td>Distractibility</td>
<td></td>
<td>0.837</td>
<td></td>
</tr>
<tr>
<td>Destructiveness</td>
<td></td>
<td>0.614</td>
<td></td>
</tr>
<tr>
<td>Planning Ability</td>
<td></td>
<td>0.682</td>
<td></td>
</tr>
<tr>
<td>Impulse Control</td>
<td></td>
<td>0.760</td>
<td></td>
</tr>
<tr>
<td>Patience/Interruption</td>
<td></td>
<td>0.665</td>
<td></td>
</tr>
<tr>
<td>Waiting</td>
<td></td>
<td>0.635</td>
<td></td>
</tr>
<tr>
<td>Seated</td>
<td></td>
<td>0.697</td>
<td></td>
</tr>
<tr>
<td>Alert</td>
<td></td>
<td>0.537</td>
<td></td>
</tr>
<tr>
<td>Cooperates</td>
<td></td>
<td>0.870</td>
<td></td>
</tr>
<tr>
<td>Defiant</td>
<td></td>
<td>0.832</td>
<td></td>
</tr>
<tr>
<td>Passively Noncompliant</td>
<td></td>
<td></td>
<td>0.839</td>
</tr>
<tr>
<td>Engagement</td>
<td></td>
<td></td>
<td>0.697</td>
</tr>
<tr>
<td>Accomplishment</td>
<td></td>
<td></td>
<td>0.817</td>
</tr>
<tr>
<td>Confidence</td>
<td></td>
<td></td>
<td>0.657</td>
</tr>
<tr>
<td>Intense Positivity</td>
<td></td>
<td></td>
<td>0.858</td>
</tr>
<tr>
<td>Frequent Positivity</td>
<td></td>
<td></td>
<td>0.813</td>
</tr>
</tbody>
</table>

*Note.* Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
School Readiness Measures.

Social Competence. Socio-emotional school readiness was assessed by teachers using the Social Competence and Behavior Evaluation, Preschool edition (SCBE-30; LaFreniere & Dumas, 1996), adapted from the original 80-item scale (LaFreniere, Dumas, Capuano, Dubeau, 1992). This is a validated measure that consists of 30 items rated on a 6-point Likert scale format (e.g. 1 = “Never” to 6 = “Always” for “Negotiates solutions to conflicts with other children”), which evaluated social competence, externalizing behavior problems, and internalizing behavior problems. In a previous study factor analyses of this measure revealed three main factors: eight items measuring social competence (joyful, secured, integrated, autonomous, tolerant, calm, prosocial, cooperative) with factor loadings ranging from .58 to .81, four items measuring externalizing behaviors (angry, aggressive, egotistical, oppositional) with factor loadings ranging from .83 to .89, and four items measuring internalizing behaviors (depressive, anxious, isolated, dependent) with factor loadings ranging from .75 to .84 on this construct (LaFreniere et al., 1992). Higher scores for each subscale indicated greater social competence, higher frequency of negatively expressed behaviors, and higher frequency of withdrawn behaviors respectively. Previously reported high internal consistency was yielded for these three factors considered as subscales (.80 to .92) as indexed by Cronbach’s coefficient alpha (LaFreniere & Dumas, 1996). Within the present sample Cronbach’s alphas ranged from .79 to .91 across all three subscales. The average score for each subscale (Social Competence, Externalizing Behaviors, and Internalizing Behaviors) was used in bivariate correlation and regression analyses.
**Emotion Regulation.** Teachers also filled out the Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997) as a measure of socio-emotional school readiness. This is a 24-item measure with items positively and negatively weighted on a 4-point Likert scale format (e.g. 1 = “Never” to 4 = “Almost Always” for “Exhibits wide mood swings”) that evaluated children’s emotion regulation, intensity, valence, and situationally appropriate emotional expressions. Factor analyses from a previous study of this measure revealed two main factors: eight items that measure emotion regulation (appropriate effective displays, empathy, and emotional self-awareness) with factor loadings ranging from .59 to .72 and fifteen items measuring emotion lability/negativity (inflexibility, dysregulated negative affect, and unpredictability and suddenness of mood change) with factor loadings ranging from .79 to .90 (Shields & Cicchetti, 1997). Higher scores for each subscale indicated greater expression and awareness of emotions of self/others and more persistent mood swings, respectively. Previously reported high internal consistency was yielded for both factors considered as subscales (.83 and .96 respectively) as indexed by Cronbach’s coefficient alpha (Shields & Cicchetti, 1997). Within the present sample Cronbach’s alpha for emotion regulation and lability were .89 and .71, respectively. The average scores for both subscales (Emotion Regulation and Lability) were used in bivariate correlation and regression analyses.

**Academic Achievement.** To measure academic school readiness three subtests from the Woodcock Johnson III (WJ III) Test of Cognitive Abilities (Woodcock et al., 2001) were used: i) Letter Word Identification; ii) Applied Problems, and iii) Picture Vocabulary. The Letter-Word Identification and Applied Problems subtests are a part of the Standard Test Book, whereas the Picture Vocabulary subtest is a part of the Extended
Test book. These subtests have been utilized in studies assessing emergent literacy and numeric skills in preschool-age children and predictors of preschool performance on cool and hot measures from the PSRA and socioemotional ratings from teachers on the SCBE and ERC (Geiger, et al., 2019; McClelland et al., 2014; Pupura, Hume, Sims & Lonigan, 2011). Split-half coefficients have been reported from each subtest ranging between .87 and .94 (Schrank et al., 2001). All scores from each subtest were raw scores due to the inability to access the software necessary for score transformation.

1. The Letter-Word Identification subtest required the child to pronounce letters and words correctly with progressively increased difficulty (e.g. “What is the name of this word?”; correct response = 1, incorrect response = 0). The score of this subtest was the number of correct responses as an assessment of basic reading skills.

2. The Applied Problems subtest required the child to complete a series of mathematical counting, numeric and word problems with progressively increased difficulty (e.g. “How many cows are in this picture?”; correct response = 1, incorrect response = 0). The score of this subtest was the number of correct responses as an assessment of basic mathematical solving skills.

3. The Picture Vocabulary subtest required children to label a series of items in a picture with progressively increased difficulty in identification ability (e.g. “What is this?”; correct response = 1, incorrect response = 0). The score of this subtest was the number of correct responses as an assessment of oral language and oral expression.
Results

Descriptive statistics (means, standard deviations, skewness, kurtosis) were computed for self-regulation tasks to examine possible ceiling or floor effects, along with overly skewed distributions (> +/− 2.0). Raw scores from the three Woodcock Johnson subtests were used as measures of academic school readiness. Additionally, composite ratings of from the social competence, externalizing and internalizing behaviors subscales of the SCBE and emotional regulation and lability subscales of the ERC were used as measures of social-emotional school readiness. Additionally, correlations between all behavioral battery task scores, PSRA-AR component scores, Woodcock-Johnson subtest scores, SCBE, and ERC measures were computed.

Descriptive Analyses

Time 1 descriptive analyses for self-regulation tasks are presented in Table 1. Due to the pass/fail contingency for the continuation of the DCCS and HTKS games, completion rates were as follows: DCCS Color game pass rate = 95.5% (n = 83), DCCS Shape game pass rate = 39.5% (n = 34), DCCS Advanced game pass rate = 1.2% (n = 1), HTKS head/toes game pass rate = 32.7% (n = 28), and HTKS shoulders/knees game pass rate = 12.9% (n = 11). The DCCS Advanced game was excluded from due to only one child successfully advancing to the Advanced game. Additionally, due to overly skewed distributions (> +/−2.0), the following task variables were removed from further analyses: DCCS Color game (-6.4) and the HTKS Shoulders/Knee game (2.1). The Snack Delay task was the only task that was administered to all the children within the sample. Perfect performance on the Snack Delay task was defined as the child keeping his/her hands flat (and therefore not touching the test materials or snack) until the timer sounded; 17.2% of
Snack Delay trials met this criterion. Given the low pass rate, performance on this task was measured with the Snack Delay average code. Finally because Snack Delay was the only hot task administered to all children, all other hot tasks were excluded from descriptive statistics and further analyses.

Table 2.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Reliability^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pencil Tap (% Correct)</td>
<td>86</td>
<td>46.2</td>
<td>0.3</td>
<td>0.0</td>
<td>100.0</td>
<td>0.3</td>
<td>-1.2</td>
<td>.99</td>
</tr>
<tr>
<td>DCCS Color (% Correct)</td>
<td>86</td>
<td>97.7</td>
<td>0.1</td>
<td>0.0</td>
<td>100.0</td>
<td>-6.4</td>
<td>40.5</td>
<td>.76</td>
</tr>
<tr>
<td>DCCS Shape (% Correct)</td>
<td>86</td>
<td>43.9</td>
<td>0.5</td>
<td>0.0</td>
<td>100.0</td>
<td>0.2</td>
<td>-1.9</td>
<td>.98</td>
</tr>
<tr>
<td>DCCS Advanced (% Correct)</td>
<td>86</td>
<td>19.2</td>
<td>0.3</td>
<td>0.0</td>
<td>100.0</td>
<td>0.6</td>
<td>-1.4</td>
<td>.93</td>
</tr>
<tr>
<td>HTKS Game 1 (% Correct)</td>
<td>86</td>
<td>17.5</td>
<td>0.2</td>
<td>0.0</td>
<td>100.0</td>
<td>0.7</td>
<td>-1.0</td>
<td>.99</td>
</tr>
<tr>
<td>HTKS Game 2 (% Correct)</td>
<td>86</td>
<td>11.6</td>
<td>0.2</td>
<td>0.0</td>
<td>100.0</td>
<td>2.1</td>
<td>3.4</td>
<td>.99</td>
</tr>
<tr>
<td>Day/Night (% Correct)</td>
<td>86</td>
<td>61.0</td>
<td>0.4</td>
<td>0.0</td>
<td>100.0</td>
<td>-0.6</td>
<td>-1.1</td>
<td>.99</td>
</tr>
<tr>
<td>Snack Delay Average Code</td>
<td>86</td>
<td>3.8</td>
<td>0.8</td>
<td>0.8</td>
<td>5.0</td>
<td>-1.7</td>
<td>2.8</td>
<td>.99</td>
</tr>
<tr>
<td>Attention/Impulse Control</td>
<td>86</td>
<td>0</td>
<td>1</td>
<td>-3.4</td>
<td>0.9</td>
<td>-1.5</td>
<td>1.7</td>
<td>.96</td>
</tr>
<tr>
<td>Positive Emotion</td>
<td>86</td>
<td>0</td>
<td>1</td>
<td>-2.2</td>
<td>1.8</td>
<td>-0.1</td>
<td>-0.8</td>
<td>.89</td>
</tr>
<tr>
<td>Letter Word</td>
<td>85</td>
<td>7.8</td>
<td>4.7</td>
<td>0.0</td>
<td>20.0</td>
<td>0.4</td>
<td>-0.7</td>
<td>-</td>
</tr>
<tr>
<td>Applied Prob</td>
<td>85</td>
<td>9.4</td>
<td>4.9</td>
<td>0.0</td>
<td>19.0</td>
<td>-0.2</td>
<td>-0.8</td>
<td>-</td>
</tr>
<tr>
<td>Picture Vocab</td>
<td>85</td>
<td>12.9</td>
<td>3.9</td>
<td>1.0</td>
<td>22.0</td>
<td>-0.5</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Social Comp</td>
<td>95</td>
<td>4.0</td>
<td>1.0</td>
<td>2.0</td>
<td>5.9</td>
<td>0.1</td>
<td>-0.8</td>
<td>.79^a</td>
</tr>
<tr>
<td>Ext. Behaviors</td>
<td>95</td>
<td>1.8</td>
<td>0.9</td>
<td>1.0</td>
<td>5.0</td>
<td>1.5</td>
<td>1.9</td>
<td>.91^a</td>
</tr>
<tr>
<td>Int. Behaviors</td>
<td>95</td>
<td>1.5</td>
<td>0.5</td>
<td>1.0</td>
<td>3.7</td>
<td>1.7</td>
<td>4.2</td>
<td>.74^a</td>
</tr>
<tr>
<td>Emotion Regulation</td>
<td>95</td>
<td>3.3</td>
<td>0.9</td>
<td>2.3</td>
<td>4.0</td>
<td>-0.2</td>
<td>-0.8</td>
<td>.71^a</td>
</tr>
<tr>
<td>Lability</td>
<td>95</td>
<td>1.7</td>
<td>0.5</td>
<td>1.0</td>
<td>3.2</td>
<td>1.0</td>
<td>0.4</td>
<td>.89^a</td>
</tr>
<tr>
<td>N (listwise)</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Tasks in bold were excluded in further analyses due to excessive skew and kurtosis.*

^a Internal consistency calculated using Coefficient alpha
Hot Self-Regulation Group Differences

Because previous findings support that the PSRA-AR measure mainly indexes aspects of emotion regulation and is a predictor of social competence as measured by the SCBE (Geiger et al., 2019; Smith-Donald et al., 2007), the unstandardized average PSRA-AR component scores (Attention/Impulse Control and Positive Emotion) were used along with the Snack Delay average score in analyses that addressed hot self-regulation. To address the first hypothesis that there would be an age effect for hot self-regulation, the average Snack Delay code and the PSRA-AR component scores were used to examine group, gender and age differences in hot self-regulation. Gender was controlled due to previous findings of gender effects of girls outperforming boys in self-regulation measures (Matthews, Ponitz, & Morrison, 2009). Age was calculated as a continuous variable by calculating the number of days, months, and years old and dividing this calculated number by 365.25. A 3 (Hot Self-Regulation: Snack Delay average code, Attention/Impulse Control, Positive Emotion) by 2 (Gender) by 2 (Group: WKU CCC vs. Warren County Community Action) repeated measures MANCOVA with age as a covariate was conducted that yielded no significant effects for gender, group, and age.

Hot Self-Regulation and Socio-Emotional Ratings

To address the second hypothesis that time 1 hot tasks would be correlated with time 1 SCBE and ERC variables, bivariate correlations for these variables as well as with age and the PSRA-AR components scores presented in Table 3. The average Snack Delay code was not correlated with any of the socioemotional ratings, however, Attention/Impulse Control from the PSRA-AR was correlated with Social Competence,
Externalizing Behaviors, and Lability, and Positive Emotion from the PSRA-AR was correlated with Externalizing Behaviors. Additionally, the average Snack Delay code, Attention/Impulse Control, and Positive Emotion were not correlated with age, as expected from the repeated measures MANOVA analysis.
Table 3.

*Correlations of Hot Tasks and Socio-emotional Ratings.*

<table>
<thead>
<tr>
<th></th>
<th>Attention/Impulse Control</th>
<th>Positive Emotion</th>
<th>Social Comp</th>
<th>Int Behavior</th>
<th>Ext Behavior</th>
<th>Lability</th>
<th>Emotion Reg.</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Snack Code</td>
<td>.53**</td>
<td>-.21</td>
<td>.18</td>
<td>-.01</td>
<td>-.09</td>
<td>-.13</td>
<td>.10</td>
<td>-.11</td>
</tr>
<tr>
<td>Attention/Impulse Control</td>
<td>-</td>
<td>-.14</td>
<td>.29**</td>
<td>-.13</td>
<td>-.24</td>
<td>-.36**</td>
<td>.20</td>
<td>.03</td>
</tr>
<tr>
<td>Positive Emotion</td>
<td>-</td>
<td>-.07</td>
<td>-.08</td>
<td>.24*</td>
<td>.15</td>
<td>.08</td>
<td>.08</td>
<td>.12</td>
</tr>
<tr>
<td>Social Comp.</td>
<td>-</td>
<td>-.29**</td>
<td>-.45**</td>
<td>-.68**</td>
<td>.80**</td>
<td>.10</td>
<td>.10</td>
<td>-</td>
</tr>
<tr>
<td>Int. Behavior</td>
<td>-</td>
<td>.18</td>
<td>.25*</td>
<td>-.53**</td>
<td>-.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ext. Behavior</td>
<td>-</td>
<td>-.83**</td>
<td>-.35**</td>
<td>.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lability</td>
<td>-</td>
<td>-.55**</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotion Reg.</td>
<td>-</td>
<td>-.55**</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-</td>
<td>-.55**</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p* < .05; **p** < .01*
Cool Self-Regulation and Academic Achievement

Due to the high correlations among the cool task scores (Pencil Tap, DCCS Shape, HTKS Game 1, and Day/Night) ($rs > .33$), a principal component analysis was conducted excluding the DCCS Advanced game due to only one child successfully advancing to the Advanced game. The principal component analysis with standardized eigenvalues generated one component with eigenvalues $> 1.0$: Cognitive Flexibility/Attention Shifting (Table 4). The one component structure accounted for 55.4% of the variance. Internal consistency of the final construct was moderately high (Cognitive Flexibility/Attentional Inhibition, $\alpha = .77$). This Cool task principal component was used in correlation and regression analyses to assess the relationship and predictive validity for academic achievement measures.

Table 4.

Component Matrix for Cool Task (n=86)

<table>
<thead>
<tr>
<th>Task</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cog Flexibility/Atten. Inhibition</td>
</tr>
<tr>
<td>Pencil Tap</td>
<td>0.881</td>
</tr>
<tr>
<td>DCCS Shape</td>
<td>0.710</td>
</tr>
<tr>
<td>HTKS Game 1</td>
<td>0.789</td>
</tr>
<tr>
<td>Day/Night</td>
<td>0.559</td>
</tr>
</tbody>
</table>

Note. Extraction Method: Principal Component Analysis. Rotation Method:

To address the third hypothesis that cool tasks would be moderately or strongly correlated with academic achievement measures, concurrent correlations for the time 1 cool task component, age, and academic achievement are presented in Table 5. The cool task component was significantly correlated with all the Woodcock-Johnson subtests and age.
Table 5.

*Correlations for the Cool Task Component and Academic Achievement.*

<table>
<thead>
<tr>
<th></th>
<th>Letter Word</th>
<th>Applied Problems</th>
<th>Picture Vocab</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cog Flexibility/Attn. Inhibition</td>
<td>.33**</td>
<td>.54**</td>
<td>.50**</td>
<td>.37**</td>
</tr>
<tr>
<td>Letter Word</td>
<td>-</td>
<td>.51**</td>
<td>.51**</td>
<td>.41**</td>
</tr>
<tr>
<td>Applied Problems</td>
<td>-</td>
<td>.64**</td>
<td>.43**</td>
<td></td>
</tr>
<tr>
<td>Picture Vocab</td>
<td>-</td>
<td>-</td>
<td>.25*</td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p < .05; p < .01***

**Academic and Socio-emotional Predictions**

To examine the fourth and fifth hypotheses that hot task performance would predict socio-emotional ratings and that cool task performance would predict academic achievement performance, the predictive validity of the selected hot and cool tasks for school readiness measures were examined through hierarchical regression analyses (Cohen & Cohen, 1983). Separate analyses were conducted for the time 1 Woodcock-Johnson subtests (Letter Word, Applied Problems, and Picture Vocabulary), time 1 SCBE subscales (Social Competence, Externalizing Behaviors, and Internalizing Behaviors) and time 1 ERC subscales (Emotion Regulation and Lability). Gender and group (WKU Child Care Center vs. Warren County Community Action) were not controlled for due to insignificant effects in the MANCOVA analyses. The predictor variables were age, hot and cool task variables, PSRA-AR variables and age by task and component interactions at time 1. Because none of these interactions were significant, they are not discussed.
further below. All the predictor variables were centered using standard z scores in the same manner of previous studies (Anaya, 2016).

**Socio-emotional competence.** Hierarchical multiple regression analyses examining socio-emotional competence predictions were conducted for each SCBE subscale (Tables 6 and 7). In these analyses, (Step 1) age was entered into the equation because of this hypothesis that there would be an age effect for hot self-regulation, (Step 2) followed by the cool task component score (Cognitive Flexibility/Attention Inhibition), followed by the hot self-regulation (Snack Delay average code, Attention/Impulse Control, and Positive Emotion), in order to test the hypothesis that hot regulation would predict socio-emotional aspects of school readiness above and beyond cool regulation. Additionally, interaction terms between each age and the cool component score (Step 4) followed by age and Snack Delay, Attention/Impulse Control, and Positive Emotion (Step 5) were entered. Last, the total predictive variance (R²) was reported to assess the total predictive validity with each variable within the final hierarchical regression model.

Results of these regression analyses indicated that the addition of the Attention/Impulse Control component of the PSRA-AR predicted Externalizing Behaviors and Lability above Age and the cool task component and therefore confirms the hypothesis about hot self-regulation and socioemotional ratings. Additionally, when the cool task score was entered in the regression model in step 2, it significantly added to the predictive validity for social competence and emotion regulation above the variance associated with age. Only regression coefficients for each new variable added in each successive step are reported in Tables 6 and 7.
Table 6.

*Final Hierarchical Regression Analyses for SCBE Ratings.*

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor</th>
<th>Social Competence</th>
<th>Int. Behaviors</th>
<th>Ext. Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F(Change)</td>
<td>ΔR²</td>
<td>β</td>
</tr>
<tr>
<td>1</td>
<td>Age</td>
<td>0.110</td>
<td>0.001</td>
<td>0.138</td>
</tr>
<tr>
<td>2</td>
<td>Cool</td>
<td>7.050**</td>
<td>0.085**</td>
<td>1.429*</td>
</tr>
<tr>
<td>3</td>
<td>Hot</td>
<td>2.320</td>
<td>0.080</td>
<td>0.248</td>
</tr>
<tr>
<td></td>
<td>Average Snack</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Atten/Impulse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Positive Emot.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p < .05; **p < .01*
Table 7.

**Final Hierarchical Regression Analyses for ERC Ratings.**

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor</th>
<th>Emotion Regulation</th>
<th>Lability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F(Change)</td>
<td>ΔR²</td>
</tr>
<tr>
<td>1</td>
<td>Age</td>
<td>0.070</td>
<td>0.001</td>
</tr>
<tr>
<td>2</td>
<td>Cool</td>
<td>7.094*</td>
<td>0.096*</td>
</tr>
<tr>
<td>3</td>
<td>Hot</td>
<td>0.841</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>Average Snack</td>
<td></td>
<td>-0.011</td>
</tr>
<tr>
<td></td>
<td>Atten/Impulse</td>
<td></td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>Positive Emot.</td>
<td></td>
<td>0.312</td>
</tr>
<tr>
<td></td>
<td>Total R²</td>
<td></td>
<td>0.154</td>
</tr>
</tbody>
</table>

*Note.* *p* < .05; *p* < .01**
**Academic Achievement.** Hierarchical multiple regression analyses examining academic achievement were conducted separately for each Woodcock-Johnson subtest (Table 8). Steps for analyses were similar to those of socio-emotional analyses. In these analyses, (Step 1) age was entered into the equation, (Step 2) hot self-regulation (Snack Delay average code, Attention/Impulse Control, and Positive Emotion) was entered, followed by the cool task component score (Cognitive Flexibility/Attentional Inhibition; Step 3) in order to test the hypothesis that cool regulation would predict academic achievement aspects of school readiness above and beyond hot regulation. Additionally, interaction terms between age and the hot self-regulation (Step 4) followed by age and the cool component score (Step 5) were entered. Lastly, the total predictive variance ($R^2$) was calculated to assess the total predictive validity with each variable within the hierarchical regression model.

Results for academic achievement analyses indicated that for the Letter Word subtest, cool task performance did not explain any variance above and beyond the significant predictor of age and insignificant addition of hot self-regulation. However, the hypothesis for cool regulation and academic achievement was confirmed with the Applied Problems and Picture Vocabulary subtests, where the cool task score predicted above and beyond age and the hot self-regulation. Additionally, age significantly predicted the variance associated with Letter Word and Applied Problems scores. Also, hot self-regulation predicted Applied Problems and Picture Vocabulary above age when added to the hierarchical regression model. Only regression coefficients for each new variable added in each successive step are reported in Table 8.
Table 8.

*Final Hierarchical Regression Analyses for W.J. Subtests of Academic Achievement.*

| Step | Predictor       | Letter Word | | | | Word | | | | Applied Problems | | | | Picture Vocabulary | | | |
|------|----------------|-------------|---|---|---|-------------|---|---|---|-------------|---|---|-------------|---|---|-------------|---|---|
| 1    | Age            | 17.809***   | 0.201** | -4.055* | 12.628**   | 0.151** | 1.182* | 2.858 | 0.039 | -1.941 | 12.628** | 0.151** | 1.182* | 2.858 | 0.039 | -1.941 |
| 2    | Hot            | 1.854       | 0.060   | 6.152** | 0.181** | 1.187* | 5.459* | 0.187* |         |         |         |         |         |         |         |         |
|      | Average Snack  | -7.970      |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
|      | Atten/Impulse  | 3.821       |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
|      | Positive Emot. | -0.645      |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| 3    | Cool           | 0.346       | 0.004   | -0.651 | 5.716* | 0.052* | 3.588* | 12.164**| 0.119**| -2.714* | 0.326   | 0.421   | 3.75    | 0.375   | 0.35    | 0.375 |

*Note.* *p < .05; p < .01**
Discussion

It is important to understand the mechanisms associated with self-regulation given its association with school readiness (Blair & Raver, 2015; Duncan et al., 2007; Keogh, 1992; Kentucky Department of Education, 2018; Martin et al., 1998; Palisin & Scarr, 1986). Self-regulation also is considered important due to its rapid development within the preschool years (Ponitz et al., 2009). Research concerning self-regulation defines the two main subdomains of self-regulation as executive functioning (cool self-regulation) and effortful control (hot self-regulation) (Liew, 2012; Nigg, 2017). Recent studies have addressed these subdomains as separate components (i.e. Liew, 2012), whereas others have addressed these subdomains as combined processes (i.e. Nigg, 2017). The purpose of the current study was to test the validity of hot and cool self-regulation tasks as concurrent predictors of school readiness measures. It was hypothesized for the data collected from time 1, 1) older preschoolers would perform better than young preschoolers on hot tasks, 2) hot task performance would be at least moderately associated with socioemotional competence ratings, 3) cool self-regulation would be strongly or moderately correlated with academic achievement measures, 4) hot tasks would predict socio-emotional competence school readiness measures above and beyond cool tasks, and 5) cool tasks would predict academic achievement school readiness measures above and beyond hot tasks.

Regarding the first hypothesis that older preschoolers would perform better than young preschoolers on hot tasks, older preschoolers did not perform better than younger preschoolers for hot self-regulation (Snack Delay average code, Attention/Impulse Control, and Positive Emotion). There was no main effect of age for the hot task
variables analyzed in the repeated measures MANCOVA and follow-up ANCOVA analyses, which is inconsistent with previous findings (Carlson, 2005; Willoughby et al., 2011). First, children performed quite poorly on the Snack Delay task with only 17.2% of trial passed. Thus, the lack of age differences may be due to floor effects. It is important to note that there are other processes within the hot self-regulation domain (e.g. attention shifting and emotion regulation) that were not measured within this Snack Delay variable. Measure of these processes would require detailed coding of the videotapes of the task.

Regarding the second hypothesis that hot task performance would be at least moderately associated with socioemotional competence ratings; results revealed that the snack delay average code was not correlated with socio-emotional ratings. The lack of association between this task and the subscales may be related to the lack of sensitivity to individual differences in the snack delay live coding scheme. For example, when children did not keep their hands flat a code of 4 (does not touch cup) or code 3 (.touches cup) was received on 64.7% of the trials. However, these codes could be given for anything from touching the plate that the cup and snack were on, a brief touch of the cup, or picking the cup up and playing with it. Coding the snack delay task using the video recordings from the task would allow a more detailed assessment of behavior that would have more variance than the current average code. Perhaps then correlations with the SCBE and ERC subscales would be found.

However, the Attention/Impulse Control PSRA-AR component score was significantly correlated with Social Competence and Lability. Positive Emotion was correlated with Externalizing Behaviors. Although the addition of these variables was
exploratory, these results confirm that Snack Delay was not coded in a way that taps into the same hot self-regulation constructs that the PSRA-AR component scores did. Also, the PSRA-AR’s association with the socio-emotional ratings is consistent with previous literature (Geiger et al., 2019, Smith-Donald et al., 2007). Results pertaining to the correlations between the PSRA component scores and the Snack Delay task indicate that inhibitory control was captured by both the global behavior report and observational task. These results are consistent with previous literature where the Attention/Impulse Control component of the PSRA-AR was correlated with PSRA task components and point to the variance overlap that the Attention/Impulse Control component has with behavioral tasks, and the association that structured observational reports have with teacher reports of socio-emotional behaviors (Smith-Donald et al., 2007).

In support of the third hypothesis that cool self-regulation would be correlated strongly or moderately with academic achievement measures, preschoolers’ cool task performance was correlated strongly with the Woodcock-Johnson subtests. Although the DCCS color, DCCS advanced, and HTKS knee/shoulders games were not entered into the cool task component score, the strong correlations between the academic achievement scores (i.e. Woodcock-Johnson subtests) and the component score support the general hypothesis that cool self-regulation is correlated with academic school readiness, which is consistent with previous literature (Espy et al., 2004; Ursache et al., 2012). Specifically, these results point to the fact that the cool tasks (Pencil Tap, DCCS, HTKS, and Day/Night) were highly associated with mathematical, reading, writing, and object labeling skills (all skills assessed from the Woodcock-Johnson subtests) that are beneficial for achievement at the kindergarten level. Specifically, the working memory,
attentional inhibition, and cognitive shifting skills required for these cool tasks are supported within this study to be associated with the skills assessed from the Woodcock-Johnson subtest. These results are consistent with previous literature emphasizing the importance of working memory and inhibitory control for mathematical skills (Bull & Scherif, 2001; Espy et al., 2004). However, it is important to note that the Woodcock-Johnson scores used in this study were raw data and not standardized data. Interpretation of the theoretical and practical implications should be interpreted with caution.

Regarding the fourth hypothesis, that hot tasks would be more predictive of socioemotional competence, hot self-regulation did predict socio-emotional ratings (Externalizing Behaviors and Lability) above and beyond age and cool tasks (Hongwanishkul et al., 2005). The fact that the hot self-regulation variables did not predict the remaining socio-emotional ratings (Social Competence, Internalizing Behaviors, and Emotion Regulation) may be indicative of the lack of variance associated with the Snack Delay average code, as a measure of response inhibitory control. Additionally, cool self-regulation performance was predictive of the Social Competence and Emotion Regulation when added to the regression model. These results are consistent with Anaya (2016) where hot tasks from the PSRA were predictive of Social Competence and cool tasks from the PSRA were predictive of Social Competence, Externalizing Behaviors, and Lability. Additionally, because the current study used a hot task and the PSRA-AR scores for hot self-regulation, these results emphasize that the PSRA-AR may tap into hot self-regulation processes in a different way the hot and cool tasks do.

Regarding the fifth hypothesis, cool tasks did predict academic school readiness measures above and beyond hot task performance, which is consistent with previous
literature looking at the predictive validity of cool tasks predicting academic outcomes (Anaya, 2016; Roberts & Pennington, 1996). According to the regression results for the academic school readiness measures, cool task performance significantly predicted performance on the Applied Problems and Picture Vocabulary subtests but failed to predict performance on the Letter Word subtest. These results are consistent with previous literature concerning cool self-regulation uniquely and additionally predicting academic achievement measures (Anaya, 2016; Blair & Razza, 2007; Willoughby et al., 2011). Overall, the current findings support previous literature demonstrating that cool tasks are associated with math performance (i.e. Applied Problems; Espy et al., 2004) and overall academic achievement measures of school readiness (Blair & Razza, 2007; McClelland et al., 2007).

In summary, the validity of hot and cool self-regulation predicting school readiness measures was significant. Overall, cool self-regulation tasks predicted aspects of school readiness measures better than did hot self-regulation measures. These findings support theoretical trends given the operational definitions of each self-regulation component within this study (Anaya, 2016; Blair & Razza, 2007).

**Strengths and Limitations**

**Strengths.** The first major strength of this study was the use of a multi-method approach. Not only did this study utilize reports of behavior from observers and teachers, but this study also used a behavioral battery assessment that was predictive of various school readiness outcomes. The use of the battery of hot and cool tasks allowed this study to measure different self-regulatory processes objectively and the use of the Woodcock-Johnson allowed researchers to assess academic achievement without the bias that
teachers may provide with their behavior reports. Contrasting, the teacher ratings provided aspects of classroom behavior that the experimenters were unable to capture with the battery of tasks and the Woodcock-Johnson. Additionally, the performance on the battery of tasks was not only correlated, but also predictive of school readiness outcomes, supporting their utility for future studies.

This study also attempted to flesh out self-regulation as a predictor by using different types of hot and cool self-regulation tasks. Few studies have investigated self-regulation using a combination of hot and cool measures (Anaya, 2016; Smith-Donald et al., 2007) in order to flesh out the different self-regulatory processes as predictors of different types of school readiness outcomes (i.e. socio-emotional ratings vs. academic achievement). It is important for literature pertaining to self-regulation as a predictor to point out how and under what circumstances different self-regulation processes are associated with school readiness. This study addressed that issue by using numerous hot and cool tasks, however, future studies should investigate the difference in school readiness predictions with the remaining hot tasks that were not analyzed for this study.

**Limitations.** There were many limitations concerning the interpretation of this study’s results. The main limitation of this study was small sample size which prevented the use of the other five hot tasks that were assessed. This ultimately contributed to the lack of variance associated with the hot self-regulation task making it difficult to assess the predictive validity of this task for socio-emotional ratings. One main limitation to consider concerns how behavior was coded on Snack Delay. The simple four-point coding system did not tap into the variance in behavior associated with coding emotion regulation and attention shifting strategies as other components of hot self-regulation
processes. For example, it may be that children utilize strategies to shift attention and regulate emotions from the emotionally arousing situation elicited by the Snack Delay task that are not being captured and not addressed in this study. Specifically, children may shift their attention from the experimenter toward an external object not associated with the task in the room to successfully deploy attention, or they may express negative emotion through facial or body expressions that may be coded. The coding of these types of behaviors (i.e. attention shifting and emotion regulation) is important because they also are associated with socioemotional school readiness (Duncan et al., 2007). In addition, the “touches cup” code of 3 applied to a wide range of behaviors that varied in the degree of dysregulation (e.g., a brief touch versus picking up the cup and playing with it). Future studies should use the video recordings of snack delay and other hot tasks to capture the entirety of behavior accurately.

Additionally, the inability to measure individual hot self-regulation accurately (i.e. response inhibitory control, attention shifting and emotion regulation) using the hot tasks made it difficult to make inferences about the differences/commonalities of hot and cool subcomponents of self-regulation. Hence, the results from this study do not allow conclusive inferences pertaining to the relations and the unique predictive validity that hot tasks had with school readiness measures; the cool task results were more promising (Anaya, 2016; Carlson, 2005; Smith-Donald et al., 2007).

Another limitation of this study were the unstandardized scores used from the Woodcock-Johnson subtest within the correlational and regression analyses. The software necessary from the Compuscore and Profiles Program (McGrew & Woodcock, 2001) for score transformation into age-equivalent, grade-equivalent, and standardized scores was
inaccessible for this study. These scores allow for interpretation of comparing each child’s performance age- and grade-based norms. The inability to use these types of scores limits the conclusive interpretation of the results for the relationship and predictive validity of the cool task score on the Woodcock-Johnson subtests. Future research should address this dilemma and utilize the standard scores instead of the raw scores.

Additionally, from a broader perspective the lack of a comparison group for children designated as qualifiers for Head Start, was not analyzed within this study. We were unable to compare the relationship and predictive validity for self-regulation skills from this group of children and children undesignated as Head Start qualifiers to compare low and middle/high-income group performance. Specifically, this provided the inability to truly measure self-regulation differences based on SES. Previous literature supports the notion that children from low SES backgrounds are less competent in self-control, have diminished capacity for working memory, exhibit weaker inhibitory control, and have problems with delaying gratification (Blair, 2010; Blair & Raver, 2012b; Evans & Kim, 2013). Hence, future studies should address this issue and investigate whether similar trends within this study are consistent between SES groups.

**Implications**

Although there are limitations to this study, the results have practical and theoretical implications. For example, the hot self-regulation and cool self-regulation tasks that were used for this study were correlated and predictive of variance associated with school readiness. One possible future step should involve the assessment of longitudinal prediction of these tasks from time 1 and time 2, to analyze if this trend is consistent at both time periods.
The results of this study do not provide conclusive evidence whether hot and cool self-regulation are separate constructs or are combined constructs of executive functioning and effortful control. Although this study points to the fact that the cool tasks were more reflective of higher-order processes and were associated strongly and predictive of academic achievement, we cannot determine whether these processes map on the same or different self-regulation processes that the hot tasks do. Furthermore, future studies may be able to flesh out this dilemma from a theoretical perspective by specifically assessing all subcomponents of hot self-regulation.

Conclusions

Self-regulation processes are considered important for school readiness (Duncan et al., 2018). Hot and cool self-regulation tasks were used to predict school readiness measures. Results indicated that cool tasks were highly correlated and predictive of academic measures of school readiness, whereas the Snack Delay average code and the PSRA-AR component scores were predictive of socio-emotional ratings of school readiness. Hence, a conclusive judgment regarding hot self-regulation may not be suitable without better measures of Snack Delay and the other hot tasks that are based on detailed coding of the videotapes of the tasks. In summary, results suggest that cool tasks are valid measures of self-regulation, but some modifications to the coding and scoring systems for hot tasks need to be made to capture the hidden behavioral variance associated with this subdomain of self-regulation. Hence, further practical and theoretical implications cannot be made until future research addresses this problem.
References


doi:10.1111/j.1467-8624.2010.01561.x

doi: 10.1080/87565649609540642


APPENDIX: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

DATE: July 30, 2018
TO: Elizabeth Lemerise, Ph.D.
FROM: Western Kentucky University (WKU) IRB
PROJECT TITLE: [1257647-3] Longitudinal Examination of Predictors of School Readiness
REFERENCE #: IRB 18-461
SUBMISSION TYPE: Revision
ACTION: APPROVED
APPROVAL DATE: July 30, 2018
EXPIRATION DATE: June 30, 2019
REVIEW TYPE: Full Committee Review

Thank you for your submission of Revision materials for this project. The Western Kentucky University (WKU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Full Committee Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of June 30, 2019.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Paul Mooney at (270) 745-2129 or irb@wk.edu. Please include your project title and reference number in all correspondence with this committee.