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A Head to Toes Approach to Computerized Testing of Executive Functioning in Young Children

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A HEAD TO TOES APPROACH TO COMPUTERIZED TESTING
OF EXECUTIVE FUNCTIONING IN YOUNG CHILDREN

By
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ABSTRACT

The Head-Toes-Knees-Shoulders task (HTKS; Ponitz, McClelland, Matthews, & Morrison, 2009) is a commonly used measure of executive functioning (EF) designed for use with young children. Consistent with the larger literature demonstrating significant relations between EF skills and important developmental outcomes, substantial associations between the HTKS task and reading comprehension, vocabulary, letter and word identification, phonological awareness, and mathematics skills have consistently been reported. Scores on the HTKS task are also consistently associated with behavioral outcomes and other performance- and report-based measures of EF skills. Although the HTKS task is a useful measure of EF for young children, the original version of the HTKS task has a number of limitations. Included among these limitations are consistently reported ceiling effects toward the end of kindergarten, potential motivational issues with older children, and the possibility of errors in administration and scoring using live administration of the task. Lonigan (2013) developed a computerized version of the HTKS task as a means of addressing potential problems associated with near-ceiling performance and motivational issues. The goal of this study was to examine the construct and convergent validity of the computerized version of the HTKS task with important developmental outcomes, to determine its utility as a measure of EF for use with young children. It was hypothesized that the computerized version of the HTKS task would provide an equivalent, if not better, measure of EF in young children as the original HTKS task. In the current study, 126 preschool-aged children were administered both versions of the HTKS as well as a battery of performance-based EF tasks and measures of pre-literacy and mathematics skills. Parents and teachers completed report-based measures of externalizing behaviors. Findings from this study indicated that the computerized version of the HTKS task offered a valid measure of EF, equivalent to that of the original HTKS task, for use with preschool-aged children. Furthermore, the computerized version of the HTKS task offered the added benefits of standardized administration, more accurate scoring of self-corrected responses, and the capability of response-latency in addition to accuracy scoring.

CHAPTER 1

INTRODUCTION

Children's self-regulation is an important capacity, related to other significant developmental outcomes, including academic achievement, social competence, and problem behaviors (e.g., Blair, 2002; Eisenberg et al., 2000; Vitaro, Brendgen, Larose, & Tremblay, 2005). The construct of self-regulation is broadly defined in the literature as consisting of multiple aspects of children's behavior, including planning, controlling, and directing abilities. More narrowly, self-regulation can be defined as an underlying temperamental or cognitive capacity that allows individuals to regulate cognition, behavior, and attention. From a cognitive perspective, the construct most frequently associated with self-regulation is executive function (EF). EF is a multidimensional construct, which is defined by domain general cognitive processes, associated with the regulation of emotions and goal-directed behaviors.

Factor-analyses with data from adults (e.g., Miyake et al., 2000) and older children (e.g., Lehto, Juujarvi, Kooistra & Pulkkinen, 2003) have identified three distinct components of EF: inhibitory control (IC), working memory (WM), and shifting (SH). IC refers to the ability to inhibit a proponent response in favor of a subordinate response. WM refers to the ability to maintain and manipulate information held in memory. SH refers to the ability to switch attention between mental sets or tasks. SH has also been suggested to be integral to the ability to engage and disengage with aspects within tasks (Miyake et al., 2000).

Self-regulation skills are particularly important in early childhood academic and behavioral functioning. Research findings consistently indicate that self-regulation skills, including IC, WM, and SH, are associated with academic outcomes in preschool and early elementary grades (e.g., Allan & Lonigan, 2011; Blair & Razza, 2007; McClelland et al., 2007). In young children, these self-regulation skills have been shown to be predictive of academic abilities independent of initial cognitive (e.g., McClelland, Morrison, & Holmes, 2000) and academic ability (e.g., Howse, Lange, Farran, & Boyles, 2003; McClelland et al., 2000; Ponitz et al., 2009). Children with poor self-regulation skills have also been found to be at an increased risk of academic difficulties and school dropout in late childhood and early adolescence (Duncan et al., 2007; Eisenberg et al., 2000; Vitaro et al., 2005). Taken together, these findings

demonstrate an important association between self-regulation skills and academic outcomes starting in early childhood and persisting throughout late childhood and early adolescence.

Substantial associations between self-regulation and behavioral outcomes in young children have also been consistently reported. Results of meta-analytic studies examining the relations between self-regulation and externalizing behavior disorders, demonstrate moderate associations between self-regulation and symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD; Alderson et al., 2007; Willcutt et al., 2005) and somewhat inconsistent relations with symptoms of Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD; Pennington & Ozonoff, 1996). Amongst non-clinical populations of young children, self-regulation has also been shown to be associated with individual differences in externalizing behaviors (Rezazadeh et al., 2011; Hughes & Ensor, 2011; Sulik, Blair, Mills-Koonce, Berry, & Greenberg, 2015). Given the substantial associations between self-regulation and academic and behavioral functioning in young children, the accurate assessment of self-regulatory skills is particularly important in identification of children at risk for difficulties upon school entry.

In young children self-regulation is typically assessed by either report- or performance-based measures. Report-based measures involve either self, parent, or teacher ratings of self-regulatory skills based on observations of behaviors within everyday situations. Report-based measures of self-regulation offer an easy to administer, more time efficient, and ecologically valid alternative to performance-based measures of self-regulation. However, rating scales have been criticized as assessing skills only tangentially related to self-regulation (Spiegel, Lonigan, Phillips, in press) and although they are designed to assess the same underlying construct as performance-based measures, the two types of measures often demonstrate only small to moderate associations (Toplak, West, & Stanovich, 2013),

Performance-based measures offer a direct method to assess self-regulatory skills. One such measure is the Head-to-Toes task (HTT; Ponitz et al., 2008). The HTT task is an adapted version of the Head to Feet assessment designed by McCabe, Rebello-Britto, Hernandez, and Brooks-Gunn (2004). The HTT task is a response conflict EF task (i.e., a task which requires the child to perform a subordinate response while refraining from performing a dominant response), which is played as a game in which participants are told to do the opposite of a command. For instance, participants are told that when they hear the command, “touch your toes” they should touch their head. Participants are scored on 10 trials, with a maximum score of 20. Two points

are awarded for a correct response, zero points for an incorrect response, and one point for any motion toward the incorrect response that is self-corrected. The HTT task is primarily a measure of IC, although Ponitz et al. (2008) stipulates that other EF skills, including WM and attention, are necessary for success in the task. The HTT task has demonstrated strong psychometric properties, including inter-rater reliability and validity when used to assess children ages 36-78 months (McClelland, Cameron, Connor et al., 2007; Ponitz et al., 2008).

A more recent and complex version of the HTT task, the Head-Toes-Knees-Shoulders task (HTKS; Ponitz, McClelland, Matthews, & Morrison, 2009) adds two additional response conflict commands. Specifically, participants are told to touch their knees when they hear the command “touch your shoulders” and touch their shoulders when they hear the command “touch your knees.” The head and toes commands are interspersed for the first 10 trials and all four commands are interspersed for the second 10 trials. The HTKS task has a maximum score of 40 and utilizes the same item-level scoring as the HTT task. Both the HTT and HTKS tasks offer a direct and easily administered measure of self-regulatory skills with strong psychometric properties.

Utility of the HTKS

Results of studies with preschool and kindergarten children demonstrate significant concurrent and longitudinal associations between scores on the HTT and HTKS tasks and academic and behavioral outcomes. Significant positive associations are consistently reported between scores on the HTKS task and concurrent measures of literacy ability (Graziano et al., 2015; Matthews, Ponitz, Morrison, 2009; Ponitz et al., 2009; Skibbe, Connor, Morrison, & Jewkes, 2011; Skibbe, Phillips, Day, Brophy-Herb, & Connor, 2012; Wanless et al., 2011). Across studies, small to moderate relations between the HTKS task and reading comprehension, vocabulary, letter and word identification, and phonological awareness skills have been reported. It has also been demonstrated that the HTT and HTKS tasks have longitudinal validity in predicting literacy achievement. For instance, McClelland et al. (2007) reported that preschool children’s HTT scores, in the fall of their prekindergarten year, significantly predicted their literacy and vocabulary abilities in the spring of the same year. Ponitz et al. (2009) similarly

reported that kindergarteners' fall HTKS scores significantly predicted their spring vocabulary and literacy skills.

Scores on the HTKS task are also associated with mathematic abilities both concurrently (Ponitz et al., 2009; Skibbe et al., 2011, 2012; Wanless et al., 2011; Matthews et al., 2009) and longitudinally (Ponitz et al., 2009). Ponitz et al. reported that HTKS scores from the fall of the kindergarten year significantly predicted math abilities in the spring of the same year. Furthermore, they reported that this relation remained significant even after controlling for the effects of initial mathematic ability.

Moderate relations have also been reported between scores on the HTT and HTKS tasks and parent- and teacher-reports of self-regulation and externalizing behaviors (e.g., Graziano et al., 2015; Lonigan, Spiegel, et al., 2016; Matthews, Ponitz, Morrison, 2009; Ponitz et al., 2009). Graziano et al. (2015) compared kindergarteners' HTKS scores with concurrent parent and teacher ratings of EF and reported that children with higher performance on the HTKS task were also rated by parents as having better EF skills. Ponitz et al. (2009) reported that children whose teachers rated them as having higher behavior regulation at the end of kindergarten also scored substantially higher on a concurrently administered HTKS task. Although modest, the correlations reported across these studies are consistent with those found in the literature comparing parent and teacher reports with direct assessments of behavior (e.g., Eisenberg et al. 2000; Smith-Donald, Raver, Hayes, & Richardson, 2007). Substantial associations have also been found between the HTKS task and report-based measures of externalizing behavior problems (e.g., Lonigan, Spiegel, et al., 2016). However, as with the larger literature on the relation between EF and externalizing disorders, the results seem to be discrepant based on the specific symptoms being examined. For instance, Lonigan, Spiegel et al. (2016) reported substantial relations between HTKS scores in preschool and both general externalizing behaviors and specific inattention in early elementary school. However, no significant association was reported between HTKS scores and specific symptoms of hyperactivity/impulsivity or ODD.

Consistent with previous research, indicating strong associations between different types of performance-based EF tasks (e.g., Lerner & Lonigan, 2014), scores on the HTT and HTKS tasks are consistently reported as being moderately to strongly related to scores on other performance-based IC (e.g., Allan & Lonigan, 2011) and WM (e.g., Graziano et al., 2015; Lonigan, Lerner et al., 2016) tasks. Allan and Lonigan (2011) reported moderate to strong

correlations between commonly used EF performance tasks, including; HTKS, Grass-Snow (Carlson & Moses, 2001), and Walk-A-Line-Slowly (Kochanska et al., 1996). Scores on a delay of gratification task (Hongwanishkul et al. 2005), however, were uncorrelated with the other EF tasks, including the HTKS task. These findings indicate that the HTT and HTKS tasks measure a distinct IC construct, which can be differentiated from other measures of self-regulation, including delay of gratification.

Although the HTT and HTKS tasks are useful measures of self-regulation for preschool and kindergarten children, the age range within which they can be reliably utilized may be limited. Results of studies that have used the HTT or HTKS tasks indicate that by late kindergarten, many children are able to perform these tasks without errors, resulting in ceiling effects and non-normally distributed scores. This profile of performance can limit the ability to determine the true association between children's developing capacity for self-regulation and other developmental outcomes and limit the capacity to use this measure longitudinally. Findings from Ponitz et al. (2008) indicated that the HTT task is most useful and appropriate with children ages 4-5 years due to ceiling effects. Specifically, Ponitz et al. (2008) reported that across sites between 0-20% of the sample (age 5 years), scored at the ceiling of the HTT task.

The HTKS task may be appropriate for use with a wider age range than the HTT task; however, the HTKS task may also be limited by ceiling effects. Findings from Ponitz et al. (2009) indicated that although skewness and kurtosis were not an issue with the HTKS task, scores tended to fall above the halfway mark, with approximately 12% of participants scoring the maximum score of 40. Scores tended to be clustered around the ceiling of the task, with an average score of 30 by the end of kindergarten (Ponitz et al., 2009). Furthermore, findings from studies on the effects of gender on HTKS scores indicate that ceiling effects may be especially pronounced in females. These studies have reported significantly less variability in HTKS scores for girls than for boys, with girls' scores being more highly clustered around the ceiling and the variability of boy's scores remaining more normally distributed, by the end of kindergarten (Matthews et al., 2009; Wanless et al., 2013).

An important question about children's self-regulation concerns the rate and timing of development of self-regulatory capacity. Important developments in EF skills occur throughout the first nine years of life, with marked changes occurring between the ages of 3 and 6 (e.g., Diamond & Taylor, 1996; Espy, Kaufmann, McDiarmid, & Glisky, 1999) and between ages 7

and 9 (Anderson, 2002). Optimally, measures of self-regulation would span the age range during which there is rapid growth of self-regulation capacity; however, as previously noted, the HTT and HTKS tasks begin to have ceiling effects as children near the end of their kindergarten year. Moreover, whereas preschool and kindergarten children are likely to find the HTT and HTKS tasks fun and game like, such tasks may be less developmentally appropriate for grade-school children, potentially resulting in sub-optimal performance on the task because older children may be unmotivated to perform well on a task that they find age-inappropriate. Such distributional problems and potential motivational issues limit the ability to use the HTT or HTKS tasks to study the development and developmental significance of self-regulation skills beyond kindergarten.

As a means of addressing potential problems associated with near-ceiling performance and motivational issues, Lonigan (2013) developed a computerized version of the HTKS task. Previous research on other neuropsychological performance tasks has similarly addressed these concerns by creating adapted computerized versions of tasks to more accurately detect performance errors by standardizing test administration and providing automated immediate response recording (Luciana, 2003). In the computerized version of the HTKS task, participants are presented with an outline of a human body. Just as with the original HTKS task, the computerized version requires participants to remember four commands. For the first 10 trials of the computerized HTKS task, the head and toes commands are interspersed, and for the second 10 trials, all four commands are interspersed. Like the original HTKS task, the computerized version is a response conflict task, meaning that throughout the task participants are required to do the opposite of each command. The computerized version is scored the same way as the original HTKS task, with an item level score of 0-3 awarded based on accuracy. The maximum score on the computerized version of the HTKS task is 40.

In addition to the benefits of increased precision and standardization, the computerized version of HTKS task allows for the recording of children's response times. In general, results from studies indicate that there is a pattern of decreasing errors on EF tasks with increasing age (e.g., Davidson, Amso, Anderson, & Diamond, 2006); however, even older children and adults continue to demonstrate substantial variability in reaction times for accurate responses (e.g., Diamond & Kirkham, 2005; Davidson, Amso, Anderson, & Diamond, 2006). Preliminary evidence suggests that response accuracy (i.e. number of correct responses) is a more sensitive

measure of EF than response time for young children (Cohen, Bixeman, Meiran, & Diamond, 2001). However, findings from studies comparing adults' accuracy and response times have indicated that although little to no differences are detected in response accuracy scores, significant differences in response time can be detected (Diamond & Kirkham, 2005). Consequently, the computerized version of HTKS task may provide a more sensitive index of children's developing self-regulation by yielding scores for both accuracy and response time.

Current Study

Given the strength of results to date for the original HTT and HTKS tasks with younger children, it is important to demonstrate that both the original and computer version assess the same underlying construct to the same degree within this age group. Although, as noted above, there are numerous advantages of the computerized version for older children, younger children may have difficulties with the computerized version for reasons that are independent of self-regulation. For instance, motor skills are still developing during the preschool years and preschool-age children may have had limited prior exposure to computers. As a result, young children may have difficulty manipulating a mouse correctly, and thus have difficulty using it to point in response to commands throughout the HTKS task. Such difficulties could lead to an underestimation of IC skills. Consequently, the primary goal of this study was to evaluate the degree to which the original and computerized versions of the HTKS task provide an equivalent measurement of self-regulation for young children.

It was hypothesized that the original and computerized versions of the HTKS task would provide equivalent measures of self-regulation in preschool age children. To test the construct and convergent validity of the computerized version of the HTKS task, a series of commonly used EF performance tasks were administered. The performance-based tasks are designed to assess IC, either via response-conflict (i.e., participants are asked to follow the "do the opposite" rule) or response-suppression IC (i.e., participants are asked to suppress an urge or desire to act in a certain manner) tasks. Moderate correlations between these performance-based measures and the two HTKS tasks were hypothesized, based on findings from previous research, that have indicated moderate correlations between the HTKS task and other EF performance measures (e.g. Allan & Lonigan, 2011).

A commonly used parent- and teacher-report measure of externalizing behaviors was used to further assess the construct and convergent validity of the computerized HTKS task. The Strengths and Weaknesses of ADHD-symptoms and Normative-Behaviors rating scale (SWAN), focuses on externalizing behavior problems, including symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder (ODD). Moderate correlations between the report-based measure and the two HTKS tasks were hypothesized, based on findings from previous research, that indicated moderate correlations between the original HTKS task and parent- and teacher-report measures of EF and behavior problems (e.g., Matthews, Ponitz, & Morrison, 2009; Ponitz et al., 2009; Wanless et al., 2011).

To further test the convergent validity of the computerized HTKS task, two measures of academic ability were administered. One measure assessed pre-literacy abilities (e.g., print knowledge, vocabulary, and phonological awareness) and the other assessed emerging mathematics ability. Based on the moderate positive correlations between the original HTKS task and academic abilities, consistently found in previous research (e.g., Ponitz et al., 2009; Skibbe et al., 2011, 2012; Wanless et al., 2011; Matthews et al., 2009), moderate correlations between these academic measures and the computerized HTKS task were hypothesized.

Other factors may influence children's performance on tasks designed to measure EF. Specifically, young children may be less familiar with computer tasks or may have less well-developed fine motor skills that could influence the degree to which their recorded responses reflect the underlying construct of IC. Similarly, responses may reflect more general self-regulatory or "rule-following" behaviors of children. To address the first concern, a mouse-tracking task, that assessed participants' abilities to manipulate and point with a mouse, was administered. Children who were unable to demonstrate competency with the mouse were excluded from the study. To address the second concern, a delay-of-gratification task was administered. Delay-of-gratification tasks are associated with self-regulation skills; however, the nonsignificant negative correlation between the HTKS task and delay-of-gratification tasks reported in previous research (e.g. Allan & Lonigan, 2011) indicates that delay tasks measure a different underlying construct than IC tasks. A small negative correlation between the delay-of-gratification task and the computerized HTKS task was thus hypothesized.

CHAPTER 2

METHODS

Participants

Data from 130 children ranging in age from 48 to 77 months ($M = 57.24$ months, $SD = 6.90$) were collected for the present study. Four children were excluded because they were unable to demonstrate competency using a computer mouse or refused to participate in the performance-based tasks, resulting in a sample size of 126. All children were recruited from preschools in Tallahassee, FL and the surrounding areas. The sample included 68 girls (54%), and the majority of children were white (70.6%); 19.8% were black/African American; 3.2% were Latino/Hispanic; 3.2% were Asian; and 3.2% were classified as other.

Measures

Background questionnaire. Parents completed a background questionnaire concerning children's age, gender, prior childcare or preschool experience, ethnicity, parental education level, and annual income.

Parent and Teacher Ratings

The Strengths and Weaknesses of ADHD-Symptoms and Normal-Behaviors Rating Scale (SWAN). Parents and teachers rated children on the SWAN (Swanson et al., 2001), a 30-item questionnaire with three subscales: Inattention, Hyperactivity/Impulsivity, and Oppositional Defiant Behavior. Items on the SWAN are designed to be restated versions of symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder (ODD) from the Diagnostic and Statistical Manual 4th Edition (DSM IV; American Psychiatric Association, 2000). Items on the SWAN are scored on a seven point Likert scale based upon discrepancies between the child's behavior and the rater's perception of the average population, with item scores ranging from 3 (far above average) to -3 (far below average). The SWAN has

high internal consistency (Cronbach's alpha) of .95 and test-retest reliability ranging from .71 to .76 (Lakes, Swanson, & Riggs, 2012) across subscales.

Direct Assessments of EF

Head Toes Knees Shoulders (HTKS). Children completed the HTKS task (Ponitz et al., 2009), a performance-based measure of EF. In the HTKS task, children are asked to inhibit a dominant response and respond to commands in a conflicting, non-automatic manner. Specifically, they are told to remember four rules: if the administrator says 1) "touch your head" the correct response is to touch one's toes, 2) "touch your toes" the correct response is to touch one's head, 3) "touch your knees" the correct response is to touch one's shoulders, and 4) "touch your shoulders" the correct response is to touch one's knees. Children are given two practice trials and 20 scored trials. For the first 10 trials, children are only tested on the "head" and "toes" rules. In the second 10 trials, all four rules are interspersed. No points are awarded if the child touches the incorrect body part, two points are awarded if the child touches the correct body part, and one point is awarded if the child moves in the direction of the incorrect body part, but is able to self-correct and ends by touching the correct body part, resulting in scores ranging from 0 to 40. The HTKS task has been shown to be a reliable and valid measure of EF; with inter-rater agreement of total score higher than would be expected by chance ($\kappa = .90$; Ponitz, McClelland, Matthews & Morrison, 2009).

Head Toes Knees Shoulders-Computerized Version (HTKS-c). Children completed the HTKS-c task, which requires children to follow the same four rules as the original HTKS task (Ponitz et al., 2009), but utilizes computerized administration and scoring. Children are presented with an outline of a human body and asked to move the mouse to and click on the correct body part when prompted by the computer program. The cursor always begins at the center of the outlined body and the computer is programmed to detect and record movements, mouse clicks, and response times. Consistent to the original HTKS task the computerized version has 20 trials, with a minimum score of 0 and maximum score of 40. The HTKS-c had strong internal consistency (Cronbach's alpha = .95; Omega = .91) in the present sample.

Grass-Snow. The Grass-Snow task (Carlson & Moses, 2001) is a response conflict IC performance task in which children are shown one white and one green block. Children are first

asked “which block is the color of grass and which block is the color of snow?” They are then told to point to the white block when the administrator said “grass” and to the green block when the administrator said “snow.” Children are given two practice trials and 16 scored trials. No points are awarded if the child fails to point to a block, one point is awarded if the child points to the incorrect colored block, two points are awarded if the child points to the incorrect colored block, but self-corrects and ends by pointing to the correct block, and three points are awarded if the child points to the correct block. Overall scores for this task range from 0 to 48. Previous studies have reported strong internal consistency for the Grass-Snow task ($\alpha = .85$; Allan & Lonigan, 2014).

Day-Night. The Day-Night task, based on the protocol utilized by Kochanska et al. (1996), is a response conflict performance task in which children are shown images of a sun and a moon. Children are first asked “which is seen during the day and which is seen at night.” They are then instructed to point to the image of the “sun” when the administrator says night and point to the image of the moon when the administrator says “day.” For each trial, two points are awarded if the child points to the correct image, one point is awarded for a self-correct ending on the correct image, and no points are awarded for incorrect responses. There are a total of 10 test trials, with a total possible score of 20. Reliability for the Day-Night task was .84 within the present sample.

Pencil Tap. The Pencil Tap task (Smith-Donald, Raver, Hayes, Richardson, 2007) is a response conflict IC task. Children are provided a pencil and instructed to tap it once when the examiner taps twice and to tap their pencil twice when the examiner taps once. There are a total of 10 trials with a total maximum score of 20. For each trial, one point is awarded for correct response and no points are awarded for incorrect or self-corrected responses. The Pencil Tap task demonstrated strong reliability ($\alpha = .91$) in the present study.

Walk-a-Line-Slowly. The Walk-a-Line-Slowly task (Kochanska et al., 1996) is a response suppression IC performance task. In this task a 2-1/2 inch by 12 foot piece of painter’s tape is laid in a straight line on the floor. Children are instructed to walk normally across the tape for one practice trial. Children are then instructed to walk as slowly as possible across the tape for two trials. Scoring for this task is an average of the time it takes the child to walk across the tape for the two slow trials. A larger average time for the two slow trials reflects higher IC skills. The

Walk-a-Line-Slowly task has been shown to be a reliable and valid measure IC ($\alpha = .77$; Allan & Lonigan, 2011).

Delay of Gratification. This task was modeled after the Delay of Gratification task in Allan and Lonigan (2011), which was modeled after the task in Hongwanishkul et al. (2005). Children were presented with eleven immediate versus delay choices; of which 2 are practice trials and 9 are scored trials. Children are presented with the choice of a small immediate reward or larger delayed reward (e.g. one sticker now or five stickers later). Based on the child's decision he/she is either immediately awarded one sticker or the larger reward is placed in a paper bag for later. Children are awarded one point for each reward they choose to delay. Previous research has indicated that the Delay of Gratification task has strong reliability ($\alpha = .88$; Allan & Lonigan, 2011).

Academic Measures

Test of Preschool Early Literacy (TOPEL). Children completed the TOPEL (Lonigan, Wagner, Torgesen, & Rashotte, 2007), a measure of literacy skills in preschoolers. The TOPEL has three subtests: Print Knowledge (PK), Definitional Vocabulary (DV), and Phonological Awareness (PA). The PK subtest is a 36-item test designed to assess letter and word identification and sound discrimination. The DV subtest is a 35-item test designed to assess surface and deep vocabulary knowledge. The PA subtest is a 27-item test designed to assess word elision and blending abilities. Internal consistency across the subtests ranges from .86 to .96, and concurrent validity across subtests ranges from .59 to .77 (Lonigan, Wagner, Torgesen, & Rashotte, 2007).

Florida Voluntary Pre-Kindergarten Assessment (VPK). The VPK (Florida, Department of Education, 2011) is comprised of 4 subtests: Print Knowledge, Phonological Awareness, Oral Language, and Mathematics. For the purposes of this study only the Mathematics subtest was administered. The Mathematics subtest assesses early math skills, including counting, identifying numbers, adding, and subtracting. Findings from multiple studies have indicated strong reliability and validity for the VPK. The internal consistency across studies for the Mathematics subtest, as discussed in the VPK manual, indicate high internal consistency ($\alpha = .86$ to $.87$; Lonigan, 2011).

Procedure

This study was reviewed and approved by the Florida State University Institutional Review Board. All preschool directors provided written permission to conduct the study in their preschool centers. Parents or guardians provided written informed consent/permission for children's participation, and assent was collected from all children. All direct assessment of children was conducted by trained research assistants in a quiet area of the child's preschool. Administration of the battery of IC and pre-academic skills was conducted across multiple 20- to 40-minute sessions, based on preschools' schedule and children's attentional capacity. Concurrent with direct assessment of children, parents and teachers were asked to complete the SWAN.

Not all children completed all measures due to various reasons, including administration error, child refusal, and children leaving school prior to completion of testing. Pre-academic assessments were completed on all children; however, scores for the Definitional Vocabulary subtest of the TOPEL could not be calculated for one child due to an administration error. Between 61 percent ($n = 78$) and 100 percent ($n = 129$) of children completed the performance-based measures of IC, depending on the specific assessment. All children completed both versions of the HTKS task. Not all parent and teacher report data was completed. Specifically, teacher reports were obtained for 88 percent ($n = 114$) of children, and parent reports were obtained for 64 percent ($n = 83$) of children. Children with and without completed measures of IC and delay-of-gratification did not differ on sex or race but were more likely to be older than children with completed IC data. Children with missing parent or teacher reports did not differ on sex, race, or age.

CHAPTER 3

RESULTS AND DISCUSSION

Descriptive statistics are shown in Table 1. The majority of children's scores on the HTKS task fell above the halfway score of 20 out of 40 points (i.e., 60.8%), with 36 percent of children scoring at or above 30. However, consistent with findings from Ponitz et al. (2009), skewness and kurtosis did not indicate a non-normal distribution. Scores on the computerized HTKS task were also normally distributed, with only 3.2 percent of children scoring at or above 30. Bivariate correlation between all EF tasks are shown in Table 2. The correlation between the computerized and original HTKS tasks was .64 ($p < .001$).

Convergent Validity of the HTKS-c

To test the hypothesis that the computerized HTKS task offers an equivalent, if not better measure of IC, compared to the original HTKS task, 12 multilevel analyses comparing the convergent correlations of the two versions of the HTKS task with other IC performance tasks, delay-of-gratification, parent and teacher reports of self-regulation, and measures of academic abilities were examined. Differences between the correlations were tested in Mplus (Muthén & Muthén, 2010), using the Wald chi-square test of parameter equalities. The Wald test is appropriate when examining the assumption that parameters differ from one another. The Wald test, unlike other likelihood tests, begins with the alternative model and examines the impact of moving toward the null hypothesis of parameter equality (Engle, 1984). It is a test of the alternative hypothesis, meaning that significant results indicate non-equality between parameters. Conversely, non-significant results indicate equality between parameters and indicate that constraining parameters to equality will offer equivalent or improved model fit. Full Information Maximum Likelihood (FIML) estimation was used to account for missing data in all analyses. All models were estimated using a sandwich estimator to account for the nested structure of the data (i.e., children were nested within classrooms).

The first analysis assessed the construct and convergent validity of the HTKS tasks with performance-based IC. For this analysis, correlated-correlations between the two versions of the HTKS task and an IC latent variable, composed of scores on the Grass-Snow, Day-Night, Pencil

Tap, and Walk-a-Line-Slowly tasks, were assessed. To account for the effect of age on performance, both HTKS tasks were regressed on age and the correlations between the IC latent variable and age were constrained to equality across HTKS versions. Model fit was assessed using several fit indices. Model fit was excellent based on the nonsignificant χ^2 value ($\chi^2 = 5.24$), comparative fit index (CFI = 1.00) and Tucker-Lewis index (TLI = 1.03) values greater than .95, and a root mean squared error of approximation (RMSEA = .00, $p = .85$) value below .05. Overall, results indicated significant relations between the original and computerized versions of the HTKS task and significant relations with each version of the task and the IC latent variable (see Figure 1). The Wald test indicated that the difference between these parameters was not statistically significant (Wald = 2.38, $p = .12$). The second analysis assessed the divergent validity of the HTKS tasks with the delay-of-gratification task. Correlations between both versions of the HTKS task and scores on the delay-of-gratification task were non-significant (see Table 3). The Wald tests of these parameters were also non-significant (Wald = 2.58, $p = .11$).

For the third analysis, correlations for parent- and teacher-reported scores on the SWAN with both versions of the HTKS task were examined. Parent-reported externalizing behavior was uncorrelated with both the original and computerized versions of the HTKS task (see Table 3). The computerized version of the HTKS was significantly correlated with teacher-reported inattention but not with teacher-reported hyperactivity/impulsivity or oppositional defiant behaviors (see Table 3). In contrast, the original HTKS task was significantly correlated with teacher-reported oppositional defiant behaviors and hyperactivity/impulsivity but not with teacher-reported inattention. The Wald test was non-significant for all models (see Table 3).

To assess the convergent validity of the HTKS tasks with academic outcomes correlations between the two HTKS tasks and PA, PK, DV, and mathematics were examined. The correlations between both versions of the HTKS task and PA and DV were significant and equivalent to one another based on the results of Wald tests (see Table 3). Scores on PK were not significantly correlated with either the original HTKS task or the computerized HTKS task (see Table 3). Although the correlation between the mathematics test and scores on the computerized HTKS task was higher than the correlation between scores on the mathematics test and scores on the original HTKS, results of the Wald test indicated that this difference was not statistically significant (see Table 3).

Discussion

The purpose of this study was to examine the convergent and divergent validity of the computerized version of the HTKS task with other measures of IC, delay-of-gratification, academic ability, and behavioral outcomes. A series of multilevel models was conducted to examine correlations between the original and computerized versions of the HTKS with these developmental outcomes. As expected, the two versions of the HTKS task were moderately associated. Across analyses, both versions of the HTKS task had small-to-moderate associations with IC, academic ability, and teacher ratings of externalizing behaviors. Neither the computerized nor original version of the HTKS task was associated with scores on a delay-of-gratification task or parent ratings of externalizing behaviors. Results of Wald tests of parameter equality indicated that the associations between the computerized and original versions of the HTKS task with all outcomes were equivalent. Overall the computerized HTKS task demonstrated good construct validity when compared to the original HTKS task and other commonly used measures of IC. Further, the computerized HTKS task demonstrated good utility and convergent validity as evidenced by substantial associations with pre-literacy abilities, emerging mathematics, and teacher ratings of externalizing behaviors. Taken together, these findings support the use of the computerized version of the HTKS as a measure of EF in preschool age children.

Correlations between the original and computerized versions of the HTKS task were moderate, indicating that the two versions of the HTKS task measured highly related constructs. Although this correlation was not as high as had been hypothesized, based on the similar nature of the tasks, it was larger than the associations between all other IC tasks in the present study, and it was higher than the small to moderate relations between measures of IC typically reported with young children (e.g., Lerner & Lonigan, 2014; Toplak, West, & Stanovich, 2013). Additionally, the association between the two versions of the HTKS task was consistent with the test-retest reliability of the original HTKS task, which has been reported to range from .60 to .74, depending on the age of the children being examined (McClelland et al., 2014).

Convergent Validity of HTKS

Both versions of the HTKS task were moderately associated with the IC latent variable, and there was no statistically significant difference in the size of the associations between the two versions of the HTKS task and the latent IC variable. This finding suggests that the two versions of the HTKS task do not differ substantially and that the computerized HTKS offers an equivalent measure of IC when compared to the original task. The associations between both versions of the HTKS and IC were commensurate with associations reported in previous research (e.g., Allan & Lonigan, 2011). The strength of these associations with other IC tasks suggests that although performance on the HTKS tasks may require integration of WM and SH skills, as Ponitz et al. (2008) claimed, it is primarily a measure of IC. Taken together, these findings lend support to the construct and convergent validity of the computerized HTKS as a measure of IC in young children.

To assess the divergent validity of the computerized HTKS task, associations with scores on a delay-of-gratification task were examined. Consistent with previous research, in which small, non-significant associations between measures of IC and delay-of-gratification tasks in young children have been reported (e.g., Allan & Lonigan, 2011), correlations between both versions of the HTKS tasks and scores on the delay-of-gratification task were non-significant. These findings indicate that similar to the original HTKS task, the computerized version of the HTKS task assesses a construct distinct from delay-of-gratification.

HTKS and Externalizing Symptoms

In contrast to results of some prior studies that report substantial relations between the HTKS task and report-based measures of externalizing behaviors (e.g., Graziano et al., 2015; Lonigan, Spiegel et al., 2016; Matthews, Ponitz, Morrison, 2009; Ponitz et al., 2009), parent-reported externalizing behaviors were not significantly associated with either version of the HTKS task. However, previous studies have tended to assess the association of the HTKS task with parent reports of behavioral regulation (Matthews, Ponitz, Morrison, 2009; Ponitz et al., 2009), whereas the current study examined its association with parent reports of ADHD and ODD symptoms. Although related constructs, the differences between behavior regulation and

symptoms of ADHD and ODD may account for the discrepancies between the present findings and those in the previous literature.

Consistent with previous research (Lonigan, Spiegel et al., 2016) the computerized version of the task was substantially related to teacher-reported inattention but not hyperactivity/impulsivity or oppositional behavior. Teacher ratings of inattention were associated with the computerized version of the HTKS task such that children rated as more inattentive also performed more poorly on the computerized HTKS task. However, this pattern of associations was reversed for the original HTKS task, which was substantially associated with teacher ratings of hyperactivity/impulsivity and ODD symptoms, but not symptoms of inattention. This discrepancy may indicate that the computerized version of the HTKS has an added attentional demand not assessed by the original task. The computerized version of the HTKS task is programmed to wait to administer items until the cursor is moved to the center of the screen. In contrast, the original version of the HTKS task utilizes live administration, which allows examiners to redirect the child's attention or wait to administer items until the child appears to be attending to the task. The computerized version's decreased ability to adjust for child attentional capacity, as compared to the original version, may account for the differences in relations of the two versions of the task and teacher ratings of inattention.

Differences in the method of administration and scoring may offer an explanation for the discrepancy in relations between the two versions of the HTKS and hyperactivity/impulsivity. Specifically, the original HTKS task requires children to physically move their bodies to respond to each item. The child's score is dependent upon his or her inhibition of physical movement and the examiner's interpretation of the child's movement. Children prone to hyperactivity are more likely than their non-hyperactive peers to exhibit movement throughout the task as a result of their hyperactivity rather than their IC. These movements may be mistakenly scored as an incorrect or self-corrected response due to the physical nature of the HTKS task. The computerized version of the HTKS is less likely to be impacted by hyperactivity, as the task's scoring is less dependent on physical movement than is the original version.

The original HTKS task has notable motivational issues, especially with older children who may view the task as age-inappropriate and, as a result, may not put forth their best effort while engaging in the task. The association between the original HTKS task and oppositional behavior may be due to similar motivational issues in children with defiant tendencies. The

computerized version of the task was designed to address these motivational issues, and the non-significant association between the computerized version of the HTKS task and oppositional behavior may indicate that it has succeeded in doing so with preschool age children. However, future studies should examine the impact of motivation on performance on both versions of the HTKS task with the use of a direct measure of motivation and a wider age range.

HTKS and Academic Ability

Consistent with previous research demonstrating the association between self-regulatory skills and emerging academic abilities in young children (e.g., Allan & Lonigan, 2011; Ponitz et al., 2009; Wanless et al., 2011), results from this study indicated that performance on the HTKS task was positively associated with pre-literacy and mathematics abilities. Across analyses, the original version of the HTKS tended to be more strongly related to pre-literacy skills than was the computerized version of the task; however, the differences between these relations were not statistically significant. In contrast, mathematics ability was more strongly associated with scores on the computerized version of the HTKS task than with the original version. However, this difference was also not statistically significant.

Overall, the similar nature of the associations between the HTKS tasks and academic abilities highlight the convergent validity of the computerized HTKS task when administered to preschool children. Additionally, the associations of the HTKS tasks with these emerging literacy and mathematics abilities were consistent with the small to moderate effects reported in a recent meta-analysis examining the association between laboratory measures of EF skills and academic abilities (Jacobs & Parkinson, 2015). To understand the association between self-regulatory skills and emerging academic abilities a discussion of the possible underlying mechanisms is important. An executive attentional system has been theorized as a mechanism underlying self-regulatory skills, such as IC (e.g., Posner & Rothbart, 2007). As this system develops throughout early childhood, it is posited that it increasingly enables children to exert voluntarily control over their behaviors (Garon et al., 2008). Within an academic context, as this system develops children are increasingly capable of directing their attention towards classroom activities, and suppressing the urge to engage in other activities (Allan et al., 2014).

Theoretically, engaging in classroom activities provides children with increasing opportunities to absorb and learn the taught material.

Unique relations between self-regulatory skills and academic abilities have been posited. Specifically, it has been suggested that IC is more strongly associated with mathematics than literacy skills (e.g., Blair & Razza, 2007; Brock, Rimm-Kafman, Nathanson, & Grimm, 2009), presumably due to the common influence of the prefrontal cortex on both self-regulatory skills and mathematics (e.g., Willoughby, Kupersmidt, & Voegler-Lee, 2012). Findings from a recent meta-analysis indicate that WM, SH, and IC are equally related to mathematics, but that WM and SH are more highly correlated with literacy than is IC (Jacob & Parkinson, 2015). These findings may indicate that EF skills in general are associated with mathematics, whereas specifically WM and SH are associated with literacy ability. Findings from the present study indicate that the HTKS task is consistently related to both emerging literacy and mathematics abilities. To better understand the implications of these associations future work is necessary to determine the extent to which the two versions of the HTKS task are construct pure measures of IC and the relative contribution of additional executive skills (e.g., WM and SH) to success on these tasks.

Limitations and Future Directions

Despite the strengths of this study, including a relatively large sample and inclusion of additional measures that allowed for the examination of theoretically expected relations between the HTKS tasks and other constructs, the study had a number of limitations. First, the sample population was limited to preschool-age children. This age range was selected because previous research on the HTT and HTKS tasks has had strong results in measuring self-regulation with young children, and the primary goal of the present study was to evaluate the degree to which the original and computerized versions of the HTKS task provided an equivalent measurement of self-regulation within the population with which it was originally designed to be used. However, restricting the age range to preschool-aged children limits the ability to generalize the results and make claims regarding the utility of the computerized HTKS task with elementary-aged children. It will be important for future studies to examine the extent to which the computerized HTKS task can be used with a wider age range.

Second, although the computerized HTKS task offers the ability to record response latency in addition to response accuracy scores, response-latency scoring was not included in the current analyses. The decision to use response-accuracy scores was made because the original version of the HTKS task does not allow for response-latency scoring under typical administration procedures. Furthermore, evidence suggests that response accuracy is a more sensitive measure of EF than response time for young children (e.g., Cohen et al., 2001). However, findings from studies comparing adults' accuracy and response times have indicated that, although little to no differences are detected in response accuracy scores, significant differences in response time can be detected (e.g., Diamond & Kirkham, 2005). Consequently, future studies would benefit from examining whether the scoring system of the computerized HTKS task allows it to provide a more sensitive index of children's developing self-regulation skills across a wider age range, by exploring the validity of response latency scores on the computerized version of HTKS task, both concurrently in young children and longitudinally across a wider age range.

Third, the present study only examined convergent validity of the HTKS tasks with measures of IC. Future studies that include multiple performance- and report-based measures of EF as correlates should be conducted to further assess the convergent validity of the HTKS task. Expanding beyond the correlates we selected to include measures of other self-regulatory skills, such as WM and SH, might allow for further examination of the task purity and construct validity of the computerized HTKS task.

Conclusions

A number of previous studies have examined the psychometric properties and utility of the original HTKS task as a measure of EF in young children (e.g., Graziano et al., 2015; Lonigan, Spiegel et al., 2016; Ponitz et al., 2009). However, the original version of the HTKS task has a number of limitations. Included among these limitations are consistently reported ceiling effects toward the end of kindergarten, potential motivational issues with older children, and the possibility of errors in administration and scoring using live administration of the task. The computerized version of the HTKS task (Lonigan, 2013) was designed to address these issues by standardizing administration and scoring as well as potentially increasing child

engagement through the computerized application. Findings from this study indicate that the computerized version of the HTKS task offers a valid measure of EF, equivalent to that of the original HTKS task, for use with preschool children. Furthermore, the computerized version of the HTKS task offers the added benefits of standardized administration, more accurate scoring of self-corrected responses, and the capability of response-latency scoring in addition to accuracy scoring.

Table 1.

Descriptive Statistics for Study Variables

	<i>N</i>	Mean	SD	Skewness	Standard Error	Kurtosis	Standard Error
Age	125	57.24	6.92	1.08	.22	1.30	.43
HTKS	125	21.21	14.88	-.38	.22	-1.47	.43
HTKS-c	125	14.24	11.17	-.03	.22	-1.59	.43
GS	123	25.67	4.79	-1.61	.22	2.11	.43
Day	79	15.56	4.85	-1.21	.27	.60	.54
Pencil	76	15.68	6.04	-1.38	.28	.58	.55
Walk	125	15.34	8.13	1.87	.22	5.33	.43
DV	124	105.99	11.22	-1.13	.22	2.24	.43
PK	125	111.79	13.52	-2.26	.22	10.93	.43
PA	125	106.61	14.13	-.62	.22	-.22	.43
Math	125	95.33	16.05	-.70	.22	-.41	.43
T-inattention	111	1.57	2.45	1.61	.23	1.46	.46
T-hyp/imp	111	2.19	2.87	1.06	.23	-.28	.46
T-ODD	111	1.94	2.56	1.16	.23	.17	.46
P- inattention	83	.73	1.39	2.23	.26	4.83	.52
P- hyp/imp	83	1.40	2.09	2.04	.26	4.14	.52
P- ODD	83	1.23	1.93	1.89	.26	3.24	.52

Note. HTKS = Head Toes Knees Shoulders Task; HTKS-c = Head Toes Knees Shoulders Task – computerized; GS = Grass Snow; Day = Day-Night; Pencil = Pencil Tap; Walk = Walk a Line Slowly; DV = Definitional Vocabulary; PK = Prink Knowledge; PA = Phonological Awareness; T-hyp/imp = teacher rated hyperactivity and impulsivity; T-ODD = teacher rated Oppositional Defiant Disorder; P-hyp/imp = parent rated hyperactivity and impulsivity; P-ODD = parent rated Oppositional Defiant Disorder.

Table 2.

Bivariate Correlations for IC Variables and Age

	Age	HTKS	HTKS Comp	GS	Day	Pencil	Walk
Age	---						
HTKS	.53***	---					
HTKS-c	.52***	.64***	---				
GS	.28**	.40***	.35***	---			
Day	.35**	.38**	.22	.43***	---		
Pencil	.27*	.44***	.44***	.55***	.47***	---	
Walk	.22*	.20*	.27**	.22*	.14	.25*	---

Note. HTKS = Head Toes Knees Shoulders Task; HTKS-c = Head Toes Knees Shoulders Task – computerized; GS = Grass Snow; Day = Day-Night; Pencil = Pencil Tap; Walk = Walk a Line Slowly.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 3.

Results from Multilevel Correlated-Correlation Models and Wald Tests of Parameter Equality

Measure	HTKS task		Wald Test
	Original	Computerized	
Print Knowledge	.19	.11	1.93
Phonological Awareness	.42***	.43***	2.13
Definitional Vocabulary	.35***	.34***	1.40
Mathematics	.13	.20*	.06
Inhibitory Control	.42***	.40***	2.38
Delay of Gratification	.02	-.10	2.58
Teacher Ratings			
Inattention	-.20	-.25*	.04
Hyp/Imp	-.22*	-.18	.99
Defiant	-.24**	-.15	2.05
Parent Ratings			
Inattention	.12	.11	.26
Hyp/Imp	.02	-.07	.83
Defiant	.07	.04	.38

Note. HTKS = Head Toes Knees Shoulders task; Hyp/Imp = Hyperactivity and Impulsivity.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Figure 1. *Relations Between Versions of the Head Toes Knees Shoulders Tasks and Performance-Based Inhibitory Control*

Note. HTKS = Head Toes Knees Shoulders task.

$***p < .001$.

APPENDIX A

USE OF HUMAN SUBJECTS IN RESEARCH – APPROVAL MEMORANDUM

The Florida State University
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
[\(850\) 644-8673](tel:(850)644-8673) · FAX [\(850\) 644-4392](tel:(850)644-4392)

APPROVAL MEMORANDUM

Date: 10/23/2014

To: Jamie Spiegel

Address: 1107 West Call Street Tallahassee FL 32306
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
A Head to Toes Approach to Computerized Testing of Executive Functioning in Young Children

The application that you submitted to this office in regard to the use of human subjects in the research proposal referenced above has been reviewed by the Human Subjects Committee at its meeting on 10/08/2014. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 10/7/2015 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is FWA00000168/IRB number IRB00000446.

Cc: Christopher Lonigan, Advisor
HSC No. 2014.13704
The Florida State University
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
[\(850\) 644-8673](tel:(850)644-8673) · FAX [\(850\) 644-4392](tel:(850)644-4392)

RE-APPROVAL MEMORANDUM

Date: 10/15/2015

To: Jamie Spiegel

Address: 1107 West Call Street Tallahassee FI 32306
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research
A Head to Toes Approach to Computerized Testing of Executive Functioning in Young Children

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 10/12/2016, you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc: Christopher Lonigan, Advisor
HSC No. 2015.16340

APPENDIX B

PARENT CONSENT FORM

Informed Consent/Participation Form

Title: A Head to Toes Approach to Computerized Testing of Executive Functioning in Young Children (Parent Consent)

Investigator: Jamie A. Spiegel, M.A.

Telephone: Phone: [REDACTED]

The purpose of the research project in which we are asking your child to participate is to learn more about how children's ability to regulate their behavior is related to their developing academic skills. This project will provide important information that will help researchers and educators to understand better key signs of preschool children's growing competencies related to later school success. This will allow educators to create better methods of preventing academic problems in young children.

If you decide to participate in this project, your part in the project may include:

1. Completing questionnaires that ask about your child's participation in educational activities, ability to regulate his/her behavior, developmental history, and characteristics of your family, such as number of children, reading habits, and amount of education completed. These questionnaires will also ask about your child's preference for different day-to-day activities, and general characteristics about your child, like his or her activity level, moods, ability to interact with others, and general behavior.

Should you decide to participate and allow your child to participate, her or his part will include:

1. Being assessed from time-to-time with measures of self-regulation, language skills, and early academic skills, such as reading, vocabulary, and mathematics. Trained undergraduate research assistants will conduct these assessments at your child's preschool. Many of these assessments are commonly used educational measures of vocabulary and reading-related skills. Other assessments include measures of how well children can follow directions, solve problems, or involve looking at pictures on a computer screen and responding to pictures that appear. Children typically enjoy these assessments. Many of the tasks are similar to common childhood games, like Simon Says. We will not continue a test or task if your child indicates that he or she does not want to participate. Children may receive a small, age-appropriate prize (e.g., a sticker or a toy) for their participation, even if they do not complete all activities.

For this project, assessments will be conducted at the beginning of the preschool year. Assessments for this project will be conducted in 20 to 30 minutes sessions, based on your child's interest and other activities ongoing in the preschool. We expect that all assessments for the project will take no more than a total of 90 minutes. We will arrange sessions with your child's teacher to limit disruption of ongoing activities.

2. We will ask your child's teacher to complete rating forms on behavior in the school settings.

Your participation may result in the following benefits:

1. If you request, we will tell you about your child's assessment results. These results will let you know how your child's academic are developing.
2. The information we gather from this project will be used to understand better how to help children get the most from their school experiences. This information may be used to help children who are having problems with their language, reading, and math-related skills.

There are no more risks to participating in this study than would normally be encountered in everyday life.

Your participation is completely voluntary. You do not have to participate if you do not want to. Your decision whether to participate or not will have no effects on any other treatment or services for which you are eligible from Florida State University or your child's preschool. You may change your mind and withdraw from this project at any time without penalty. There are no risks associated with withdrawal from this project.

All information collected for this project will be kept confidential to the extent allowed by law. Confidentiality will be ensured in the following ways: In public reports of the results of this project, we will only report results that have been averaged over large numbers of children. No child or family will ever be identified publicly. Assessments of your child's skills are solely for research purposes. These assessments and other information gathered on your family and child will be kept in a locked file storage area in project offices at the Department of Psychology at Florida State University, identified only by a code, and will not be available to your child's school or to any other person or institution unless you ask us in writing to provide this information to someone. Identifying information will be retained for a period of up to 2 years following completion of this project. It is expected that the project will end by 10/01/2016. Data from this project, with all identifying information removed, will be retained indefinitely.

If at any time you have questions about this project, please contact Jamie Spiegel at the Department of Psychology, Florida State University, by phone [REDACTED] or by email [REDACTED]. A description of the group results of this project will be sent to you upon request. If you have questions about your rights as a participant in this project, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Office of the Vice President for Research, at (850) 644-8633 (or by email at humansubjects@fsu.edu).

If you agree to participate in this research project and allow your child to participate, please sign and print your name and the name of your child below (next page). Your signature indicates that you have read the information provided above, or have had it read to you, and that you have decided to participate. A copy of this consent form has been offered to you.

Signature and printed name of parent or legal guardian

Date

Printed name of child

Child's Date of Birth

Please include the following information so that we can contact you regarding project results.

Street Address

City

State

Zip

Home Phone: _____

Work Phone: _____

Email address: _____

APPENDIX C

TEACHER CONSENT FORM

Informed Consent/Participation Form

Title: A Head to Toes Approach to Computerized Testing of Executive Functioning in Young Children (Teacher Consent)

Investigator: Jamie A. Spiegel, M.A.

Telephone: Phone: [REDACTED]

The purpose of the research project in which we are asking you to participate is to learn more about how children's executive function skills and abilities to regulate their behavior develop and are related to their developing academic skills. This project will provide important information that will help researchers and educators to understand better key signs of young children's growing competencies related to later school success. This will allow educators to create better methods of preventing academic problems in young children.

If you decide to participate in this project, your part in the project will include:

1. You will be asked to complete questionnaires/rating forms on children's behavior, activity level, and skills in the preschool setting. The time required for this task will vary depending on the number of participating children in your classroom. Each form takes approximately 5 to 15 minutes to complete.

Your participation may result in the following benefits:

1. The information we gather from this project will be used to understand better how to help children get the most from their school experiences. This information may be used to help children who are having problems with their language and reading-related skills.

We know of no risks associated with your or your participation in this project.

Your participation is completely voluntary. You do not have to participate if you do not want to. Your decision whether to participate or not will have no effects on any other treatment or services for which you are eligible from Florida State University. You may change your mind and withdraw from this project at any time without penalty. There are no risks associated with withdrawal from this project.

All information collected for this project will be kept confidential to the extent allowed by law. Confidentiality will be ensured in the following ways: In public reports of the results of this project, we will only report results that have been averaged over large numbers of children, teachers, and classrooms. No individual child, family, or teacher will ever be identified publicly. All assessments are conducted solely for research purposes. These assessments and other information gathered on you or your classroom will be kept in a locked file storage area in project offices at the Department of Psychology at Florida State University, identified only by a code, and will not be available to any other person or institution unless a child's parent asks us in writing to do so. Identifying information will be retained for a period of up to 2 years following

completion of this project. It is expected that the project will end by 10/01/2016. Data from this project, with all identifying information removed, will be retained indefinitely.

If at any time you have questions about this project, please contact Jamie Spiegel at the Department of Psychology, Florida State University, by phone [REDACTED] or by email [REDACTED]. A description of the group results of this project will be sent to you upon request. If you have questions about your rights as a participant in this project, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Office of the Vice President for Research, at (850) 644-8633 (or by email at humansubjects@fsu.edu).

If you agree to participate in this research project, please sign and print your name below (next page). Your signature indicates that you have read the information provided above, or have had it read to you, and that you have decided to participate. A copy of this consent form has been offered to you.

Signature and printed name

Today's Date

Please include the following information so that we can contact you regarding project results.

Street Address

City

State

Zip

Cell Phone:

Work Phone:

Email address:

REFERENCES

- Alderson, R. M., Rapport, M. D., & Kofler, M. J. (2007). Attention-Deficit/Hyperactivity Disorder and behavioral inhibition: A meta-analytic review of the stop-signal paradigm. *Journal of Abnormal Child Psychology*, 35, 745-758.
- Allan, N. P., & Lonigan, C. J. (2011). Examining the dimensionality of effortful control in preschool children and its relation to academic and socioemotional indicators. *Developmental Psychology*, 47, 905-915.
- Allan, N. P., & Lonigan, C. J. (2014). Exploring dimensionality of effortful control using hot and cool tasks in a sample of preschool children. *Journal of Experimental Child Psychology*, 122, 33-47.
- American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders: DSM-IV-TR. Washington, DC: American Psychiatric Association.
- Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology*, 8, 71-82.
- Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist*, 57, 111-127.
- Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, 78, 647-663.
- Brock, L. L., Rimm-Kaufman, S. E., Nathanson, L., & Grimm, K. J. (2009). The contributions of 'hot' and 'cool' executive function to children's academic achievement, learning-related behaviors, and engagement in kindergarten. *Early Childhood Research Quarterly*, 337-349.
- Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, 72, 1032-1053.
- Cohen, S., Bixenman, M., Meiran, N., & Diamond, A. (2001). Task switching in children. In *South Carolina Bicentennial Symposium on Attention*.
- Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44.
- Diamond, A., & Kirkham, N. (2005). Not quite as grown-up as we like to think: Parallels between cognition in childhood and adulthood. *Psychological Science*, 16, 291-297.

- Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to "do as I say, not as I do". *Developmental Psychobiology*, 29, 315-334.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental Psychology*, 43, 1428-1446.
- Eisenberg, N., Guthrie, I. K., Fabes, R. A., Shepard, S., Losoya, S., Murphy, B. C., et al. (2000). Prediction of elementary school children's externalizing problem behaviors from attention and behavioral regulation and negative emotionality. *Child Development*, 71, 1367-1382.
- Engle, R. F. (1984). Wald, likelihood ratio, and Lagrange multiplier tests in econometrics. *Handbook of econometrics*, 2, 775-826.
- Espy, K. A., Kaufmann, P. M., McDiarmid, M. D., & Glisky, M. L. (1999). Executive functioning in preschool children: Performance on A-not-B and other delayed response format tasks. *Brain and Cognition*, 41, 178-199.
- Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive Function in Preschoolers: A Review Using an Integrative Framework. *Psychological Bulletin*, 134, 31-60.
- Graziano, P. A., Slavec, J., Ros, R., Garb, L., Hart, K., & Garcia, A. (2015). Self-regulation assessment among preschoolers with externalizing behavior problems. *Psychological Assessment*, 27, 1337.
- Hongwanishkul, D., Happaney, K. R., Lee, W. S. C., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology*, 28, 617-644.
- Howse, R. B., Lange, G., Farran, D. C., & Boyles, C. D. (2003). Motivation and self-regulation as predictors of achievement in economically disadvantaged young children. *Journal of Experimental Education*, 71, 151-174.
- Hughes, C., & Ensor, R. (2011). Individual differences in growth in executive function across the transition to school predict externalizing and internalizing behaviors and self-perceived academic success at 6 years of age. *Journal of Experimental Child Psychology*, 108, 663-676.
- Kochanska, G., Murray, K., Jacques, T. Y., Koenig, A. L., & Vandegeest, K. A. (1996). Inhibitory control in young children and its role in emerging internalization. *Child Development*, 67, 490-507.
- Lakes, K. D., Swanson, J. M., & Riggs, M. (2012). The Reliability and Validity of the English and Spanish Strengths and Weaknesses of ADHD and Normal Behavior Rating Scales in a Preschool Sample Continuum Measures of Hyperactivity and Inattention. *Journal of attention disorders*, 16, 510-516.

- Lehto, J. E., Juujärvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology*, 21, 59-80.
- Lerner, M. D., Lonigan, C. J. (2014). Executive function among preschool children: Unitary versus distinct abilities. *Journal of Psychopathology and Behavior Assessment*, 36, 626-639.
- Lonigan, C.J. (2011). *Florida VPK assessment measures: Technical manual*. Tallahassee, FL: Department of Education.
- Lonigan, C. J. (2013). *Head Toes Knees Shoulders- computerized version*. Tallahassee, FL: authors.
- Lonigan, C. J., Lerner, M. D., Goodrich, J. M., Farrington, A. L., & Allan, D. M. (2016). Executive function of Spanish-speaking language-minority preschoolers: Structure and relations with early literacy skills and behavioral outcomes. *Journal of Experimental Child Psychology*, 46-65.
- Lonigan, C. J., Spiegel, J. A., Goodrich, J. M., Morris, B. M., Osborne, C. M., Lerner, M. D., & Phillips, B. M. (2016). Does preschool self-regulation predict later behavior problems in general or specific problem behaviors? Manuscript submitted for publication.
- Lonigan, C. J., Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (2007). TOPEL: Test of preschool early literacy. *Austin, TX: Pro-Ed*.
- Luciana, M. (2003). Practitioner review: Computerized assessment of neuropsychological function in children: Clinical and research applications of the Cambridge neuropsychological testing automated battery (CANTAB). *Journal of Child Psychology and Psychiatry*, 44, 649-663.
- Matthews, J. S., Ponitz, C. C., & Morrison, F. J. (2009). Early gender differences in self-regulation and academic achievement. *Journal of Educational Psychology*, 101, 689-704.
- McCabe, L. A., Rebello-Britto, P., Hernandez, M., & Brooks-Gunn, J. (2004). *Games children play: Observing young children's self-regulation across laboratory, home, and school settings*. New York, NY, US: Oxford University Press, New York, NY.
- McClelland, M. M., Cameron, C. E., Connor, C. M., Farris, C. L., Jewkes, A. M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology*, 43, 947-959.
- McClelland, M. M., Cameron, C. E., Duncan, R., Bowles, R. P., Acock, A. C., Miao, A., & Pratt, M. E. (2014). Predictors of early growth in academic achievement: The head-toes-knees-shoulders task. *Frontiers in Psychology*, 5, 1-14.

- McClelland, M. M., Morrison, F. J., & Holmes, D. L. (2000). Children at risk for early academic problems: The role of learning-related social skills. *Early Childhood Research Quarterly, 15*, 307-329.
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.
- Muthén, L.K. & Muthén, B.O. (1998-2010). Mplus User's Guide. Sixth Edition. Los Angeles, CA: Muthén & Muthén.
- Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37*, 51-87.
- Ponitz, C. E. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly, 23*, 141-158.
- Ponitz, C. C., McClelland, M. M., Matthews, J. S., & Morrison, F. J. (2009). A structured observation of behavioral self-regulation and its contribution to kindergarten outcomes. *Developmental Psychology, 45*, 605-619.
- Posner, M. I., & Rothbart, M. K. (2007). Research on Attention Networks as a Model for the Integration of Psychological Science. *Annual Review of Psychology, 1*-23.
- Rezazadeh, S. M., Wilding, J., & Cornish, K. (2011). The relationship between measures of cognitive attention and behavioral ratings of attention in typically developing children. *Child Neuropsychology, 17*, 197-208.
- Skibbe, L. E., Connor, C. M., Morrison, F. J., & Jewkes, A. M. (2011). Schooling effects on preschoolers' self-regulation, early literacy, and language growth. *Early Childhood Research Quarterly, 26*, 42-49.
- Skibbe, L. E., Phillips, B. M., Day, S. L., Brophy-Herb, H. E., & Connor, C. M. (2012). Children's early literacy growth in relation to classmates' self-regulation. *Journal of Educational Psychology, 104*, 541-553.
- Smith-Donald, R., Raver, C. C., Hayes, T., & Richardson, B. (2007). Preliminary construct and concurrent validity of the preschool self-regulation assessment (PSRA) for field-based research. *Early Childhood Research Quarterly, 22*, 173-187.
- Spiegel, J.A., Lonigan, C.J., Phillips, B.M. (in press). Factor structure and utility of the Behavior Rating Inventory of Executive Function – Preschool Version. *Psychological Assessment*.

- Sulik, M. J., Blair, C., Mills-Koonce, R., Berry, D., Greenberg, M. (2015). The Family Life Project Investigators. Early parenting and the development of externalizing behavior problems: Longitudinal mediation through children's executive function. *Child Development, 86*, 1588-1603.
- Swanson J., Schuck S., Mann M., Carlson C., Hartman K., Sergeant J., ... & McCleary R. (2001). *The SWAN rating Scale*.
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and rating of executive function assess the same construct. *Journal of Child Psychology and Psychiatry, 54*, 131-143.
- Vitaro, F., Brendgen, M., Larose, S., & Trembaly, R. E. (2005). Kindergarten disruptive behaviors, protective factors, and educational achievement by early adulthood. *Journal of Educational Psychology, 97*, 617-629.
- Wanless, S. B., McClelland, M. M., Acock, A. C., Ponitz, C. C., Son, S., Lan, X., et al. (2011). Measuring behavioral regulation in four societies. *Psychological Assessment, 23*, 364-378.
- Wanless, S. B., McClelland, M. M., Lan, X., Son, S., Cameron, C. E., Morrison, F. J., et al. (2013). Gender differences in behavioral regulation in four societies: The United States, Taiwan, South Korea, and China. *Early Childhood Research Quarterly, 28*, 621-633.
- Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of Attention-Deficit/Hyperactivity Disorder: A meta-analytic review. *Biological Psychiatry, 57*, 1336-1346.
- Willoughby, M. T., Kupersmidt, J., & Voegler-Lee, M. (2011). Is Preschool Executive Function Causally Related to Academic Achievement? *Child Neuropsychology, 15*, 79-91.

BIOGRAPHICAL SKETCH

Jamie A. Spiegel attended Adelphi University in Garden City, New York, where she graduated with a Bachelor of the Arts degree in Psychology and Education in May 2012. After graduating from Adelphi University, she entered the Psychology graduate program at Stony Brook University. Jamie received her Masters of the Arts degree in Psychology from Stony Brook University in May 2013, after which she entered the Clinical Psychology doctoral program at Florida State University in August of 2013.