A CONFIRMATORY FACTOR ANALYTIC COMPARISON OF THE TEST OF EVERYDAY ATTENTION FOR CHILDREN

A DISSERTATION

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BY

KRISTEN CLINE BELLONI, B.A., M.A.

DENTON, TEXAS

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TEXAS WOMAN'S UNIVERSITY
DENTON, TEXAS

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Kristen Cline Belloni entitled "A Confirmatory Factor Analytic Comparison of the Test of Everyday Attention for Children." I have examined this Dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in School Psychology.

Daniel C. Miller, Ph.D.
Major Professor

We have read this dissertation and recommend its acceptance:

Department Chair

Accepted:

Dean of the Graduate School

DEDICATION

It is with much love and gratitude that I first and foremost dedicate this dissertation to my husband, Jason, for his continued love and support throughout many of my academic years. You have been my rock throughout this roller coaster ride, without complaint. My gratitude to you cannot be fully expressed. This dissertation is also dedicated to my inspiration, our children, Skylar Jane and Spencer Scott, who remind me everyday how precious is this journey called life. May you both continue on the path of seeking the knowledge necessary to reach your full potential. The "sparks" you acquire now will one day make fireworks! Cooper has earned an honorary dog-torate for the numerous hours he sat at my feet as I typed away...

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ABSTRACT

KRISTEN CLINE BELLONI, M.A.

A CONFIRMATORY FACTOR ANALYTIC COMPARISON OF THE TEST OF EVERYDAY ATTENTION FOR CHILDREN

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Attention problems are prevalent worldwide and the prevalence of Attention Deficit Hyperactivity Disorder (ADHD) continues to rise. In the school and community settings, many tests are used to assess for attention difficulties. The Test of Everyday Attention for Children (TEA-Ch) is one such test. However, the test was standardized on an Australian population, putting its generalizability to the U.S. population in question. This study included a confirmatory factor analysis (CFA) of the TEA-Ch on a U. S. sample of 158 children without identified attention problems and comparisons of demographic data.

Analysis of the data revealed significant differences in TEA-Ch performance between age groups. However, there were no significant differences based on ethnicity, sex, or parents' education level. While several factor subtests did not correlate as expected, results of the latent factor structure of the test were consistent with those of previous studies and produced a three-factor structure model consisting of selective attention, sustained attention, and attentional control/shifting attention (χ^2 (24) = 10.70, p > .05). Additional fit indices also supported the model. These results follow the theoretical models on which the TEA-Ch was based, including those of Posner and

Peterson (1990) and Mirsky, Anthony, Duncan, Ahearn, and Kellam (1991). Similar results were found in a Chinese study supporting cross validity of the TEA-Ch in cultures very different from one another. The TEA-Ch serves as a useful tool in the assessment of attention and its unique format offers many advantages over other more commonly used assessments of attention. The results of this study can serve as preliminary standardization data for the use of the TEA-Ch in the U.S.

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CHAPTER I

INTRODUCTION

Attention is essential to the learning process. While attentional processing problems were once thought to be a behavioral disorder, to fully understand attention it is important to recognize the cognitive and behavioral operations involved as well as the underlying neuroanatomical activity. Recent research on attention has shed light on the neurological processes responsible for attention and the implications of impaired attentional functioning on individuals and the society at large.

It has been estimated that 10-15% of the population experiences clinically significant attention problems (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991). The *Diagnostic and Statistical Manual-Fourth Edition-Text Revision* (DSM-IV-TR) (American Psychiatric Association [APA], 2000) reports that as many as 3-7% of school-aged children have some form of Attention Deficit/Hyperactivity Disorder (ADHD) in the United States. Furthermore, recent research has indicated that the rates of ADHD diagnosis increased an average of 3% per year from 1997 to 2006 and 5.5% per year from 2003 to 2007 (U.S. Department of Health and Human Services, 2008). Children with attention difficulties also experience problems with working memory, response inhibition, and performing dual tasks (Savage, Cornish, Manly, & Hollis, 2006). Miller (2007) states that attention serves as a "baseline for all of the higher-order processes (e.g., visual-spatial processing, language skills, memory and learning)" (p. 132). Furthermore, Hale and Fiorello (2004) note that comorbidity rates are high for those with attention difficulties, with problems including learning disabilities, behavior disorders, and difficulties with executive functioning such as planning and decision-making.

With attention affecting so many other cognitive and behavioral processes, attention-processing dysfunction can have a high cost to an individual's ability to learn and respond appropriately in society. As such, society pays a price to remediate the resulting behavioral, academic, and psychological problems. Barkley (1997) reported (as cited in Barkley, 1990; Barkley, Fischer, Edelbrock, & Smallish, 1990) that clinically significant attention problems are associated with:

> Greater risks for low academic achievement, poor school performance, retention in grade, school suspensions and expulsions, poor peer and family relations, anxiety and depression, aggression, conduct problems and delinquency, early substance experimentation and abuse, driving accidents and speeding violations, as well as difficulties in adult social relationships, marriage, and employment. (p. 65).

Psychologists use the *Diagnostic and Statistical Manual-Fourth Edition-Text Revision* (DSM-IV-TR) (American Psychiatric Association [APA], 2000) to determine if the problems are clinically significant enough to warrant a diagnosis of Attention Deficit/Hyperactivity Disorder (ADHD). Diagnosis is accomplished by utilizing various assessment tools, including behavioral observations and norm-referenced assessments, and allows multidisciplinary professionals to work together in providing appropriate interventions for clients. More specifically, school psychologists utilize these data to determine appropriate academic placement and programming specific to individual student needs.

School psychologists recognize how attention difficulties impact a student's ability to learn and recall information presented in the academic setting. Therefore, assessment and identification of attention problems is essential to the creation and implementation of effective interventions in the school setting. This is especially important in the school setting because, as Stephanatos and Baron (2007) note (as cited in Barry, Lyman, & Klinger, 2002; Mayes, Calhoun, & Crowell, 2000), approximately 50-70% of individuals diagnosed with ADHD evidence clinically significant learning problems.

The implications of child success in school are evident as students with attention problems are increasingly being identified. Educationally, children may lack the focus and sustained attention within the classroom to encode and store learned information. Even a student who is able to read fluently may not comprehend the read material unless he or she is able to actively attend to what is being read. ADHD leads to many problems in functioning of the individual as well as the individual's family and society (National Institute of Health, 2000). Children with ADHD have the potential for social and emotional difficulties, including low self-esteem, peer conflicts, social skills deficits, and emotional dysregulation; academic problems, including literacy and achievement difficulties, lower grades; and difficulties with problem solving, memory, processing speed, and fluency (Gentschel, Gonzaga, & McLaughlin, 2000; Maedgen & Carlson, 2000; Merrell & Tymms, 2001). In addition, children diagnosed with ADHD have shown to have deficits in sustained attention as well as in executive functioning (Stins et al., 2005).

Because of the many problems associated with attention problems, O'Connell, Bellgrove, Dockree, & Robertson (2006) stress the need for effective interventions for ADHD and related attention difficulties. While medication is often successful in the treatment of attention problems, it typically does not alleviate all symptoms of a student's inattentiveness. Using thorough assessments allows evaluation professionals to more accurately measure the specific attentional deficits of students so they may provide appropriate treatments and accommodations. With different types of attention being identified, there are few tests that have been found to provide measures of all of these areas of attention.

The Test of Everyday Attention for Children (TEA-Ch) was created in 2001 by Manly, Robertson, Anderson, and Nimmo-Smith and is an adaptation of an adult version of the test created by Robertson, Ward, Ridgeway, and Nimmo-Smith in 1994. The TEA-Ch includes nine subtests which are based on theoretical models of attention, such as those posed by Posner and Peterson (1990), and Mirsky et al., (1991). These models demonstrate the neural basis of attentional processes and break down attention into subcomponents.

There are several benefits of using the TEA-Ch as opposed to other attention assessment tools. For example, most attention assessments on the market are rating scales, such as with the Behavior Assessment System for Children, Second Edition (BASC-2: Reynolds & Kamphaus, 2004) and the Brown ADD Scales for Children, Adolescents, and Adults (Brown, 2001), that are intended to be used as screeners for attention problems and do not specify the different types of attention problems. Because students and various people within a student's life, such as parents and teachers, complete these rating scales, interrater reliability is a potential problem. The TEA-Ch is one of the few tests that engages the student and tests his/her ability to selectively attend, sustain attention, and shift attention by simulating real world activities; thus, giving a better overall picture of the true strengths and weaknesses of the attentional capacity and abilities. The school psychologist/neuropsychologist and assessment professionals can utilize the results of the TEA-Ch to implement effective individualized programming for students based on the identified strengths and weaknesses.

A child's attention problems must be at a clinically significant level that interferes with the child's learning in order to qualify for special education services in the schools. The TEA-Ch can serve as an effective tool in this identification process. Furthermore, utilizing the TEA-Ch in the assessment of ADHD, Manly et al. (2001) found that the diagnosis is associated with poor sustained attention and behavioral control. Another study by Sutcliffe, Bishop, and Houghton (2006) found that the TEA-Ch participants performed better when on ADHD stimulant medication than they did when off of the medication. Therefore, the test/retest option of the TEA-Ch can serve as a potential tool in assessing changes in the attentional abilities of students both before and after medications are introduced in the treatment process.

Assessing attention is not specific to those with a known or suspected diagnosis of ADHD. While many students with attention difficulties are diagnosed with ADHD, there are other primary diagnoses that exhibit attention problems as a significant symptom. For example, children with autism, schizophrenia, or other neurological conditions often present with attention difficulties at a clinically significant level (Luck & Gold, 2008). Furthermore, students who have experienced traumatic brain injury (TBI) may acquire injuries in parts of the brain responsible for attention, resulting in a diminished attentional capacity or deficits in one or many types of attention. Anderson, Fenwick, Manly, and Robertson (1998) found significant deficits in sustained and divided attention in students who experienced moderate to severe TBI.

Purpose and Significance of the Proposed Study

The purpose of the current study is to determine if the current TEA-Ch sample produces a structural model consistent with the Australian sample. This will help reveal the generalizability of the TEA-Ch normative data. Relevant literature is reviewed to aide in the development of hypotheses prior to the methodological review of the data. Structural equation modeling (SEM), and more specifically, confirmatory factor analysis (CFA) of the data will be performed to compare the two data sets. It is hypothesized that the results of the current sample analysis will be consistent with the original Australian sample by producing a good fit to the same three-factor model.

This dissertation will contribute to the knowledge base of the field of school psychology, school neuropsychology, and other attention assessment professionals. When utilizing norm-referenced assessments, it is best practice to assess people who are within the population from which the standardization sample came. Because the TEA-Ch was initially standardized on an Australian sample, this preliminary study is necessary if psychologists in the United States want to utilize and interpret the test results. The study reveals the generalizability of the initial normative Australian data and aims to enhance the assessment of attention in the United States.

Definition of Terms

The following definitions are provided for the purpose of ensuring clarity and understanding of the current study:

Attention Deficit/Hyperactivity Disorder: a disorder typically diagnosed in childhood that utilizes the DSM-IV-TR diagnostic criteria, including three types of resulting diagnosis: Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type, Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive, or Combined Type. The symptoms must be present "prior to the age of 7" and must "be present in two or more settings." Further evidence must also indicate "clinically significant impairment in social, academic, or occupational functioning" (*DSM-IV-TR:* APA, 2000, p. 92).

Autism: a spectrum of pervasive developmental disorders that includes impairment in socialization and communication. Often Autism also includes atypical behaviors, such as motor mannerisms, lack of eye contact, and delay of language or repetitive use of language.

Executive Functions: "higher level cognitive abilities that enable an individual to successfully engage in independent, goal-directed behavior. These capacities are most commonly linked to the prefrontal cortex and they guide complex behavior over time through planning, decision-making, and self-monitoring of judgments and impulses." (University of California, San Francisco, Memory and Aging Center, 2009.)

Neuropsychology: the scientific study of brain-behavior relationships, focusing on the functions of the brain and how neurological conditions impact learning, memory, development, behavior, and cognitive functioning.

Traumatic Brain Injury: "a form of acquired brain injury" that "occurs when sudden trauma causes changes to the brain." "Symptoms can be mild, moderate, or severe depending on the extent of damage to the brain" (National Institute on Neurological Disorders and Stroke, 2010).

CHAPTER II

REVIEW OF THE LITERATURE

A review of literature applicable to this study required investigation of literature specific to the historical view of attention, attention as a cognitive task with a focus on Posner and Peterson's (1990) three-system model of attention and a similar model demonstrated by Mirsky et al., (1991), and the neuropsychological assessment of attention, specifically using the Test of Everyday Attention for Children (TEA-Ch). Attention difficulties including those resulting from disorders such as Attention-Deficit/Hyperactivity Disorder (ADHD) as well as acquired attention problems in childhood are also examined.

Attention

The history of attention can be traced back to 1902, when George Frederick Still, an English physician, recognized characteristics of some children with "defects in moral control," "inhibitory volition," and were especially difficult to discipline (Stafanatos & Baron, 2007, p.6). These symptoms are consistent with the ADHD of today. Still recognized a genetic predisposition to the disorder and considered acquired nervous system insult as another possible contributing factor. The 1917-1918 spread of encephalitis across the United States resulted in many surviving children who exhibited similar symptoms, including hyperactivity and impulsivity. A comparison of these children with those who had no prior brain infections, but still exhibited these symptoms, led to the diagnostic concept of "minimal brain dysfunction" (MBD) and a multicausal approach to the condition became accepted (Stefanatos & Baron, 2007).

While the Attention Deficit Disorder (ADD) term was used in the third edition of the DSM, the diagnostic term evolved over time and the subsequent DSM-IV-TR (APA, 2000) came to recognize ADHD as a neurological disorder marked by inattention, impulsivity, and hyperactivity which occurs in approximately 3-5% of school-aged children. However, one study put worldwide ADHD prevalence rates at between 1.7% and 6.7% (Shaw et al., 2002).

The DSM-IV-TR specifies four types of clinically significant attention problems: ADHD-predominantly inattentive type, ADHD-predominantly hyperactive type, ADHD-combined type, and ADHD-not otherwise specified (APA, 2000). The subtypes are dependent on the symptoms of inattention and behavioral impulsivity/hyperactivity deficits. ADHD is increasingly being identified in children. Stefanatos and Baron (2007) reported that children with ADHD symptoms result in 30-50% of mental health agency referrals.

Theories of Attention

Broadbent (1957) postulated a simple model of attention and immediate memory. His model demonstrated how human capacity for information is limited. Broadbent utilized a Y-shaped tube, where each arm of the Y represented various sensory channels, such as an ear or eye. Broadbent used the stimulus-response model to theorize how simultaneous processing of information is difficult (i.e. competing auditory stimuli). Later, Broadbent (1958) presented a filter theory that sought to explain how a limited amount of stimuli can be stored into memory during selective attention processes. Therefore, he surmised, the information is selectively filtered and therefore not brought into consciousness. Treisman (1969) along with Deutsch and Deutsch (1963) added the ideas of early versus late selection in the filtering process. Treisman's model demonstrated how incoming stimuli are held for a short period before it is determined relevant or rejected (early selection theory). Deutsch and Deutsch's late selection theory speculated that all stimuli is subject to the same discriminatory mechanisms before it is then categorized or given meaning and determined for awareness or not. These ideas of early and late selection in the attention process demonstrated how responses are generated based on the sensory inputs of the environment.

Theories of attention have evolved and adapted with new information provided by scientific advancements, such as brain scans. While it is difficult to definitively identify brain abnormalities associated with all attention problems, magnetic resonance imaging (MRI), functional MRI (fMRI), and computerized axial tomography (CAT) scans aid in the examination of brain structures and locating areas responsible for some functional deficits. There are various brain structures that are implicated in attentional functioning. Posner and Peterson (1990) recognized at least three brain systems or networks are responsible for different types of attention: orientation, selection, and sustained attention. Their findings proposed that the orientation of attention to stimuli was made possible by the work of the posterior brain regions, including the posterior parietal lobe, the lateral pulvinar nucleus of the postereolateral thalamus, and the superior colliculus; the selection and recognition of stimuli is implicated by the anterior cingulate and motor areas; and sustained attention is implicated by the right anterior prefrontal systems. Riccio, Hynd, Cohen, and Gonzalez (1993) discussed the importance of pathways between brain structures, such as the basal ganglia, thalamus, and frontal lobes, in the attention process and the neurochemicals, catecholemines such as dopamine and norepinephrine, which are implicated in attention problems and associated difficulties. Additionally, Hale et al. (in Miller, 2010) state, "Those with true ADHD are likely to have dopaminergic insufficiency in the striatum, which leads to poor executive control of attention, inhibition, and motor activity" (p. 256). Therefore, ADHD may be a result of executive dysfunction rather than one of inattention.

The Mirsky Model and the Neuroanatomical Basis of Attention

With the recognition that specific areas within the brain appear to be responsible for different types of attention, Mirsky et al. (1991) provide a framework of attention, based on their study. Mirsky and his colleagues utilized factor analysis of test scores from two different samples, one adult sample of 203 neuropsychiatric and control adults and another sample of 435 elementary school children. Results of the analysis revealed a four-factor model of attention, each of which is measured utilizing different test measures. Kelly's (2000) study utilized factor analysis to compare 100 children from England to Mirsky's model. Results supported this model and replication produced a three-factor model, where the encode and focus/execute factors combined. Mirsky's model of attention delineates the different anatomical brain structures responsible for the various types of behavior as set forth in the theory (Mirsky, Pascualvaca, Duncan, & French, 1999). First, it is important to recognize the evolutionary theory that summates the brainstem and associated lower brain functions as the primitive foundation from which higher order thought processes have developed, including the ability to attend and inhibit responses. This attention model is useful in providing the field of school neuropsychology with specific types of attention to assess: execute/focused attention, sustained attention, shifting attention, and encoding. The following explains these different types of attention and the current associated literature findings.

Selective attention is often referred to as focused attention. This type of attention can be defined as the ability to focus one's attention while neglecting additional stimuli (Mirsky et al., 1999). This subtype of attention is emerging in the preschool years and believed to be intact in most children by school age. Children with deficits in selective attention have difficulty inhibiting responses to extraneous stimuli. Children under 4.5 years old were less likely to exhibit skills of vigilant attention on brief tasks than older children in one study (Akshoomoff, 2002).

As children age, they typically develop an increased capacity for information and increased skills for inhibiting irrelevant stimuli (Brodeur & Pond, 2001). Brodeur and Pond (2001) also found that children with ADHD were more easily distracted than a control group and younger children were most distracted by visual stimuli rather than auditory. Mirsky and colleagues referred to the term 'focus/execute' to describe this type of attention because it was difficult for them to delineate the difference between focusing to the task and the executed response. Mirsky's theory recognizes the inferior parietal cortex, the superior temporal cortex, and the corpus striatum (including structures such as the putamen, caudate, and globus palidus) as being responsible for selective attention, or focus/execute (Mirsky et al., 1999).

Sustained attention involves the ability to continuously attend over time. Betts, Mckay, Maruff, and Anderson (2006) found that sustained attention develops from 5-6 years to 11-12 years and children attend best with small chunks of information at a time. Children with ADHD typically become less attentive and lose interest after the novelty of a new task wears off (Stins et al., 2005). This type of attention has typically been measured through the use of continuous performance tests (CPTs), where the examinee must respond to certain stimuli and inhibit responses to extraneous stimuli over time. This knowledge can be beneficial in the classroom setting where teachers can present material in ways that will maintain students' attention for longer periods or by presenting smaller pieces of material at a time.

Mirsky and colleagues determined the subcortical rostral midbrain structures (which includes the mesopontine, reticular formation, and tectum) and the midline and reticular thalamic nuclei as being implicated in the ability to maintain vigilance to a task (Mirsky et al., 1999). Mirsky et al. (1990) also postulate that all sustained attention involves the corticoreticular system. There is some indication that damage to the right hemisphere of the brain is associated with sustained attention problems, leading to problems with comprehension (Saldert & Ahlsén, 2007). The inferior parietal cortex, hippocampus, superior temporal cortex, and corpus striatum have also found to be implicated in sustained attention through lesion studies (Mirsky et al., 1999).

The task of shifting attention refers to one's ability to change focus from one activity to another and requires attentional control. Mirsky et al. (1991) reported the dorsolateral prefrontal cortex and the anterior cingulate gyrus are responsible for shifting attention, revealing the 'higher order' level of functioning required for this type of attention. When a child has difficulty with shifting attention, they are often prone to perseverative behavior, or an unusual continuous focus on an activity or stimulus. Preston, Heaton, McCann, Watson, and Selke (2009) found this type of attention involves executive function and influences academic success more than other types of attention.

Mirsky and colleagues (1991) also included encoding and stabilization in the earlier conceptual model of attention, which relied on the use of the hippocampus, amygdala, midline thalamic, and brain stem. However, these aspects of attention are no longer incorporated into the overall model. Miller (2007) also referred to attentional capacity as "related to other cognitive processes such as short-term memory and behavioral factors such as distractibility and motivation" (p. 136). This refers to the amount of information one is capable of attending to while being able to withstand a tendency to be distracted by external stimuli.

Implications with Special Populations

Attention is understood to be essential for acquiring and retaining learned information. Miller (2007) stated, "It is important to remember that attention is not a unitary process and that it serves as a baseline function for all other higher-order processes" (p. 138). Therefore, the implications of attention problems are vast within the school setting. While the focus of this paper is not on attention within clinical populations, it is important to recognize how attention problems are evident within many neurodevelopmental conditions.

There are various disorders that are associated with the disturbance of attention, such as: ADHD, Autism, Tourette's Syndrome, and Asperger's Syndrome (Manly et al., 1999). The most common attention disorder is ADHD. Mirsky et al. (1999) found that children diagnosed with ADHD generally have multiple aspects of attention that show deficits.

Unfortunately some children with attention problems are often too easily misdiagnosed with ADHD, while other conditions are overlooked in the assessment process. There are many other disorders that may present with attention problems. Children who demonstrate various disabilities or disorders may exhibit different neuropsychological profiles that reflect different abilities in attentional functioning (Noterdaeme, Amarosa, Mildenberger, Sitter, & Minnow, 2001). For example, children with a depressed mood or anxiety may exhibit attention problems that look much like ADHD. Also, children with toxic metabolic conditions like Fetal Alcohol Syndrome experience attention deficits that disrupt functioning. Mattson, Calarco, and Lang (2006) found that "children with heavy prenatal alcohol exposure have pervasive deficits in visual focused attention, and deficits in maintaining auditory attention over time" (p. 361) and, shifting attention was slower in these children. Additionally, Combs and Gouvier (2004) found that attention plays a role in the affect perception for people with chronic schizophrenia and all factors of Mirsky's (1991) model of attention were significantly related to affect perception scores.

Children with other rare congenital and neurological conditions often present with attention difficulties. For example, children with Myelomeningocele, a severe form of spina bifida, showed deficits across all four areas of Mirsky's elements of attention: encode, focus/execute, sustain, and shift in one study (Loss, Yeates, & Enrile, 1998). Two of the more common conditions seen in schools today, autism and traumatic brain injury (TBI), are often associated with attention dysfunction.

Autism

Literature on the attention abilities of children with Autism Spectrum Disorders (ASD) is mixed. However, it is generally believed that children with ASD have some aspects of impaired attention when compared to their same-aged peers. Noterdame et al. (2001) found that attention deficits are different in children with autism from a group of children with language impairments. Children with autism did not show deficits in sustained or selective attention as did the language-impaired group; however, both groups demonstrated problems with shifting attention. Plaisted, Swettenham, and Rees (1999) found that children with autism performed similarly to typically developing children on a selective attention task. Additional research indicates that children with autism were able to shift attention appropriately when compared to typically developing peers (Pascualvaca, Fantie, Papgeorgiou, & Mirsky, 1998). However, Pascualvaca et al. (1998) found that children with autism had more difficulty disengaging their attention and made more perseverative and nonperseverative errors on one measure. Goldstein, Johnson, and Minshew (2001) reported that children with autism demonstrate difficulties with "encoding information and sustaining attention over time" (p. 438).

Traumatic Brain Injury

TBI is one of the most frequent causes of disruption of early childhood development and the problems and outcomes associated with TBI are largely determined by the severity of the injury and pre-injury adaptive functioning (Wassenberg, Max, Lindgren, & Schatz, 2004.) Children with mild TBI demonstrated significantly impaired sustained attention when compared to typically developing peers in one study (Chan, 2005). Furthermore, Fenwick and Anderson (1999) found that children with moderate to severe TBI exhibited significant deficits in sustained attention, focus, and response inhibition. While one study found that age at injury was not a factor in predicting outcomes (Wilmott, Anderson, & Anderson, 2000), increased recovery time was found to be associated with improved attention and impulsivity (Wassenberg et al., 2004). Wassenberg et al. (2004) also found that omission errors on one measure following TBI predicted later secondary ADHD. Zahn and Mirsky (1999) found those with closed head injury had impaired reaction time, suggesting "a difficulty in shifting attention to unexpected stimuli" (p. 352). Additionally, McAvinue, O'Keeffe, McMackin, and Robertson (2005) concluded that TBI results in error awareness and sustained attention problems.

Assessment of Attention

While there are assessments used to test a child's attention functioning, they tend to be tests or subtests that look at a narrow aspect of attention. Often these subtests are not indicative of a child's functioning in real-life situations, such as in the classroom setting (see Table 1 for a listing of attention tests, adopted from Miller (2007). However, grounded in attention theories, including Mirsky's model of attention, The Test of Everyday Attention for Children (TEA-Ch; Manly et al., 1999) is a useful test that provides an objective standardized measure of the various types of attention.

Table 1

Tests of Attention

Test	*Subtest*
Selective Attention	
Woodcock Johnson III Tests of Cognitive Abilities (WJIII-COG: Woodcock, McGrew, & Mather, 2001).	*Auditory Attention*
Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV: Wechsler, 2003).	*Coding* *Symbol Search*
NEPSY/NEPSY-II (Korkman & Kemp, 1998; 2007).	*Auditory Attention & Response Set-Parts A & B* *Visual Attention (NEPSY only)*
d2-Test of Attention (Brickenkamp & Zilmer, 1998).	
Das Naglieri Cognitive Assessment System (CAS: Naglieri, & Das, 1997).	*Expressive Attention* *Number Detection* *Receptive Attention*
Delis Kaplin Executive Functioning System (D-KEFS: Delis, Kaplin, & Kramer, 2001).	*Color-Word Inference*
Ruff 2 & 7 Selective Attention Test (Ruff & Allen, 1996).	
Test of Everyday Attention for Children (TEA-Ch: Manly et al., 1999).	*Map Mission* *Sky Search*

(Continued)

Table 1 cont'd.

Sustained Attention	
WJ III-COG (WJIII- COG: Woodcock, McGrew, & Mather, 2001).	*Pair Cancellation*
WISC-IV (WISC-IV: Wechsler, 2003).	*Cancellation*
CAS (CAS: Naglieri, & Das, 1997).	*Number Detection* *Receptive Attention*
Auditory Continuous Performance Test (ACPT: Keith, 1994).	
Conners' Continuous Performance Test II Version 5 (CPT-II-V5: Conners & Multihealth Systems Staff, 2004a).	
Conners' Continuous Performance for Windows®: Kiddie Version (CPT-II-V5: Conners & Multihealth Systems Staff, 2004b).	
Gordon Diagnostic System (Gordon, 1983).	
Integrated Visual and Auditory Continous Performance Test (Sandford & Turner, 1993-2006)	
Test of Variables of Attention (TOVA: Greenberg, 1996).	
NEPSY-II (Korkman & Kemp, 2007).	*Auditory Attention & Response Set*
TEA-Ch (TEA-Ch: Manly et al., 1999).	*Score!* *Score DT* *Walk, Don't Walk* *Code Transmission*
Shifting Attention	
CAS (CAS: Naglieri, & Das, 1997).	

(Continued)

Table 1 cont'd.

D-KEFS (Delis, Kaplin, & Kramer, 2001).	*Expressive Attention* *Trail Making* *Verbal Fluency* *Color-Word Inference* *Design Fluency*
NEPSY II (Korkman & Kemp, 2007).	*Auditory Attention & Response Set-Part B*
Wisconsin Card Sorting Test (WCST: Heaton, 1999).	
TEA-Ch (TEA-Ch: Manly et al., 1999).	*Creature Counting* *Opposite Worlds*
Divided Attention	
WJ III-COG (WJIII- COG: Woodcock, McGrew, & Mather, 2001).	*Auditory Working Memory*
WISC-IV Integrated (Wechsler, 2004).	*Letter Number Sequencing Process Approach*
TEA-Ch (TEA-Ch: Manly et al., 1999).	*Sky Search DT*
Attentional Capacity	
Children's Memory Scale (CMS: Cohen, 1997).	*Numbers Forward*
Kaufman Assessment Battery for Children-Second Edition (KABC-2: Kaufman & Kaufman, 2004).	*Number Recall* *Hand Movements* *Word Order*
NEPSY (Korkman & Kemp, 2007).	*Sentence Repetition*

(Continued)

Table 1 cont'd.

Test of Memory and Learning (TOMAL: Reynolds & Bigler, 2004)	*Digits Forward* *Letters Forward* *Manual Imitation*
WISC-IV (Wechsler, 2003).	*Digit Span*
WISC-IV Integrated (Wechsler, 2004).	*Letter Span* *Letter-Number Sequencing* *Visual Digit Span* *Spatial Span*
Wide Range Assessment of Memory and Learning, Second Ed. (WRAML; Sheslow & Adams, 2003).	*Finger Windows* *Number/Letter*
Rating Scales	
Attention Deficit Disorders Evaluation Scales-Third Edition (McCarney, 2004a)	
Attention Deficit Disorders Evaluation Scale-Secondary Age (McCarney, 2004b)	
ADHD Symptoms Rating Scale (Holland, Gimpel, & Merrell, & Merrell, 1998).	
Attention-Deficit/Hyperactivity Disorder Test (Goldberg, 1996).	
Brown Attention-Deficit Disorder Scales (Brown, 2001).	
Conners' Scales ADHD/DSM-IV™ Scales (Conners, 1997).	

Note. Adapted from *Essentials of School Neuropsychological Assessment* by Daniel C. Miller, 2007, p. 139-141, 147. Copyright 2007 by John Wiley & Sons, Inc.

The Test of Everyday Attention for Children

While the TEA-Ch was originally standardized on 293 Australian children, it is often used in the United States. Exclusionary criteria from the TEA-Ch normative sample included: prior head injury or neurological illness, sensory loss or developmental delays, referral for attention or learning problems, and prior assessment of special education (Manly et al., 1999). Raw scores for the 9 subtests are converted to scaled scores with a mean of 10 and a standard deviation of 3. Scores are reported separately for girls and boys.

The TEA-Ch consists of nine subtests, each measuring one type of attention: selective, attentional control/switching, and sustained attention. Utilizing a structural equation model of the TEA-Ch revealed a goodness of fit, where the latent variables (selective/focused attention, sustained attention, and attentional control) each linked to only one factor (subtests of the TEA-Ch) in the three-factor model (Manly et al., 1999). The measures of selective attention include the Sky Search and Map Mission scores. Attentional control/switching is assessed using the Creature Counting and Opposite Worlds subtests. Sustained attention is measured by the following subtests: Score!, Code Transmission, Walk Don't Walk, Score DT, and Sky Search DT. Manly et al. analyzed test differences between the control sample and a sample of children with diagnosed ADHD. Their findings indicated that sustained attention is implicated in ADHD more than selective attention or attentional control (Wilding, 2005).

Validity of the TEA-Ch was determined through analysis which yielded a three-factor apriori model of attention. Reliability of the TEA-Ch instrument was established and a table with test/retest correlation coefficients for the twelve subtests along with further information regarding the technical properties of the TEA-Ch will be introduced in the following chapter.

There are several benefits of the TEA-Ch as noted by Baron (2001). These include: the appealing format of the test, which is much like a computer game; the required restating of the instructions by the examinee, which ensures accurate understanding of what is expected; little variance in scores is attributed to intelligence (Manly et al, 1999); the test assesses various components of attention; and, the inclusion of two forms for test/retest ability. Additionally, the TEA-Ch utilizes "various sensory modalities during test administration, including visual, auditory, and motor modalities" (Heaton et al., 2001). Therefore, the TEA-Ch offers a format that is unique and measures attention in such a way that allows for a more thorough assessment of various aspects of attention.

Chan, Wang, Ye, Leung, and Mok (2008) studied 158 children in Hong Kong to examine the construct validity of a Chinese version of the TEA-Ch. The sample yielded a three-factor solution consistent with the original model, with factors including: selective attention, executive control/switch, and sustained attention. However, Lemiere et al. (2010) also performed a confirmatory factor analysis using two Dutch samples with an adapted Dutch version of the TEA-Ch. The two samples included a control group of 76 children and a group of 64 children with previously diagnosed ADHD. Their findings revealed a "mediocre" fit for the control sample and a poor fit for the ADHD sample. However, the small sample sizes may explain the discrepancy in results.

Medication and the TEA-Ch

Medication is typically the first line of defense for ADHD. However, children respond differently to medications and the use of stimulants may make some overly lethargic, making learning difficult. Behavioral and metacognitive strategies should also be implemented to aid in the acquisition of self-monitoring and behavioral control (Hale & Fiorello, 2004). While medications have brought a tremendous amount of relief of symptoms of ADHD for many, researchers often do not get an accurate account of a student's attentional deficits as a result. When assessing attention functioning, researchers often encounter difficulty gaining accurate data due to the large number of children receiving medication for behaviors associated with inattentiveness and hyperactivity. At times, testing will be done both on and off medication in attempts to get a clear picture of a student's functioning while assessing the effectiveness of medication.

The TEA-Ch has shown to be a sensitive measure to changes in stimulant medication when children have been tested on and off of their medications (Sutcliffe et al., 2006). With an increasingly medicated student population, this is further incentive for school neuropsychology professionals to use the TEA-Ch as a measure of attention. Another study, by Gardner, Sheppard, and Efron (2008), found that children with ADHD had improved sustained attention while using stimulant medications, whereas effects on divided and selective attention were not as apparent. Maziade et al. (2009) found that children who were administered Atomoxetine hydrochloride (ATX), a nonstimulant, noradrenergic inhibitor, showed significant improvement on the TEA-Ch and parent and teacher versions of the Behavior Rating Inventory of Executive Functions (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000).

Comparison of Australia and United States ADHD Data

Literature comparing the diagnosis, prevalence, and treatment for ADHD in Australia and the United States was reviewed. Results of the reviewed studies indicate many similarities of the two populations. Australian prevalence rates for ADHD have been at or near the 3%-5% quoted in the *DSM-IV-TR* for U.S. children (Schlachter, 2008). However, it is important to note that prevalence rates vary greatly in both populations, in part, due to inconsistent tracking methods and subjective nature of making the diagnosis. In fact, the American Academy of Pediatrics states prevalence rates at 4% to 12% (American Academy of Pediatrics, 2001).

The method of best practice in diagnosis of ADHD is similar in both the U.S. and Australia. Australia, like the U.S., utilizes the *DSM-IV-TR* to define and diagnose the disorder (Schlachter, 2008), increasing the generalizability of diagnosis across the populations. Furthermore, both populations focus on utilizing a multidimensional assessment of the disorder, such as using observational data, interviews with students and relevant adults, rating scales, thorough historical medical, school, and developmental data, and formal testing to assess symptoms of attention problems (Ciechomski, Blashki, & Tonge, 2004; National Association of School Psychologists, 2005).

Treatment and interventions utilized by the Australian and U.S. populations also tend to have many similarities. For example, medication is the most popular form of intervention for ADHD in both countries (Purdie, Hattie, & Carroll, 2002; Schlachter, 2008). The use of stimulant medication continues to increase in both countries, with an "eightfold increase between 1994 and 2000" in Australia (Schlachter, 2008).

The American Academy of Pediatrics (2001) provided additional guidelines to provide consistency in treatment for ADHD in the U.S. (Schlachter, 2008). These guidelines focus on behavioral supports for children with ADHD, including: positive reinforcement, time-out, response cost, and token economy procedures. Furthermore, the National Association of School Psychologists (NASP; 2005) issues a fact sheet on the diagnosis and treatment of ADHD, including Positive Behavioral Supports in the home and school settings. The National Health and Medical Research Council of Australia (NHMRC) provided a report with similar behavioral recommendations such as: focusing on socialization of the child and maximizing attention by establishing fixed routines (NHMRC, 1997).

Conclusion

Attention is at the heart of learning and executive functioning. Multiple structures within the brain are responsible for attention functioning as indicated by the various attention theories, including Posner and Peterson (1990) and Mirsky et al. (1991). School neuropsychology professionals are able to assess the strengths and weaknesses of student attention functioning by utilizing norm-referenced assessments including the TEA-Ch. In doing so, they can be more effective in structuring education and accommodations to meet the needs of children with attentional deficits. Children with attention difficulties are not limited to those diagnosed with ADHD, but include a host of developmental and neurocognitive disabilities.

While few tests have been designed to assess the many types of attention, the TEA-Ch has shown to be a valuable assessment instrument for attention. There is much research to date that supports its use to assess the various types of attention as established in literature of attention theory, including the Mirsky et al. (1991) model of attention. With few assessments providing such a broad look at attention, the TEA-Ch can give a more thorough picture of a student's attentional functioning by providing a closer look at different types of attention. Because the TEA-Ch was standardized on an Australian sample, there is a need for a standardized U.S. sample to allow for a more accurate and generalizable measure of the attention differences within the American student population.

Hypotheses

The following hypotheses are investigated in this study to address the following research questions: (a) Does the current sample match the three-factor structure of the Australian and Chinese samples? (b) What are the differences between demographic groups for the current sample?

1. There will be no significant differences between males and females in the current sample.
2. There will be no significant differences across age groups in the current sample.
3. There will be no significant differences when comparing ethnic groups in the current sample.
4. There will be no significant differences when comparing parental education levels in the current sample.

5. Consistent with the Australian and Chinese samples, the current TEA-Ch sample will demonstrate a three-factor structure consisting of sustained attention, selective/focused attention, and attentional control/shifting attention.
    a. The Sky Search and Map Mission subtests will load onto the selective attention factor.
    b. The Creature Counting and Opposite Worlds subtests will load onto the attentional control/shifting attention factor.
    c. The Score!, Code Transmission, Walk, Don't Walk, Score DT, and Sky Search DT subtests will load onto the sustained attention factor.

CHAPTER III

METHODOLOGY

The purpose of this study was to compare a population tested with the Test of Everyday Attention for Children (TEA-Ch) collected in the United States with the original sample data collected in Australia. Additional comparison is made with a Chinese sample. These comparisons provided a way to further the validity and generalizability of the original normative sample and strengthen the results of the test for the U.S. population. The following chapter describes the participants and methodology that were utilized.

Participants

There was a discrepancy in the numbers suggested for a sufficient sample size for confirmatory factor analysis, which is considered a high sample technique (Tabachnick & Fidell, 2007). Hoelter's (1983) index indicated a critical N of 200 to be sufficient for a model fit for the χ^2 statistic. Other researchers have suggested a range of 5 to 20 persons per item (Bryant & Yarnold, 1995; Hair, Anderson, Tatham, & Black, 1995). The results of this current study included 158 participants between the ages of 6 years, 0 months and 15 years, 11 months within the United States. Consistent with the Australian sample, all potential participants were initially screened to determine if they met the necessary criteria. Exclusionary criteria included if the child had ever been assessed for special education services or if their teacher had expressed concerns regarding their ability to pay attention or learn. Additionally, the children were not eligible participants if they had been diagnosed as developmentally disabled or diagnosed with a sensory impairment; received a head injury resulting in loss of consciousness; or had any serious neurological illness, such as epilepsy, meningitis, or cerebral palsy.

Participants for the U.S. sample were stratified into six age bands matching the sample obtained in Australia: 6-6.11, 7-8.11, 9-10.11, 11-12.11, 13-14.11, and 15-15.11. Three ethnicities were utilized matching the Australian sample: African American, Hispanic, and Caucasian. Parents' education level was also included in the stratification of data, including: less than high school level, high school graduates, and post graduate education levels. Census data were used to determine the necessary percentages for categorization of age groups, ethnicity, gender, and parent's education level. As Table 2 indicates, the sample included 80 females (51%) and 78 males (49%). Of these, 110 identified themselves as Caucasian (70%), 29 identified as African American (18%), and 19 identified as Hispanic (12%). The majority of students in the sample had parents whose education level is greater than high school (n = 94; 60%), with 40 identifying as high school educated (25%), and 24 with less than a high school education (15%). The age bands were distributed with 24 in the 6-year-old group (15%), 40 in the 7 to 8 age group (25%), 37 in the 9 to 10 year age group (23%), 30 in the 11 and 12 year group (19%), 19 in the 13 and 14 year age group (12%), and 8 in the 15-year-old group (5%).

Table 2

Descriptive Statistics for the Current Sample

	Frequency	Percentage
Sex		
Female	80	51%
Male	78	49%
Ethnicity		
Caucasian	110	70%
African American	29	18%
Hispanic	19	12%
Parental Education Level		
Less than high school	24	15%
High school diploma	40	25%
Greater than high school	94	60%
Age Bands		
6-6.11	24	15%
7-8.11	40	25%
9-10.11	37	23%
11-12.11	30	19%
13-14.11	19	12%
15-15.11	8	5%

Note. Percentages of age bands do not equal 100% due to rounding.

Procedure

Once IRB approval for the research study was obtained through Texas Woman's University (Appendix A), a research team was formed. All members were graduate students from Texas Woman's University in Denton, Texas and all were previously taught assessment administration and specifically trained to administer and score the TEA-Ch. The research team administered the TEA-Ch with 103 children. Additional data were obtained through Dr. Daniel C. Miller's Kids Inc. School Neuropsychology Post-Graduate Certification Program whose students provided 42 test protocols from around the United States. Texas Woman's University graduate students enrolled in School Neuropsychology courses in the School Psychology program obtained 13 additional test protocols as part of class requirements. A recruitment script was provided to all testers to aid in recruitment of participants (see Appendix B). Consent forms were completed with parents prior to testing and assent was obtained from the children (see Appendix C). Consent forms were also translated into Spanish to aid in Hispanic recruitment (see Appendix D). Following test administration, the parent was provided a feedback form on their child's test performance on the TEA-Ch with a description of the different types of attention and the child's performance in each area (see Appendix E).

Instrumentation

TEA-Ch

The TEA-Ch takes approximately one hour to administer and is intended for use with children ages 6 to 15.11 (Manly et al., 1999). Exclusionary criteria from the TEA-Ch normative sample included: prior head injury or neurological illness, sensory loss or developmental delays, referral for attention or learning problems, and prior assessment of special education (Manly et al., 1999). The TEA-Ch is based on theoretical models that propose attention is neurologically based, including those by Posner and Peterson (1990) and Mirsky and colleagues (1991). The test includes 9 subtests that are each proposed to measure different subtypes of attention, based on these theoretical models. The test also includes version A and B for a test/retest option.

Normative sample and standardization. The TEA-Ch normative sample consists of 293 children stratified in six age groups: 6-6.11, 7-8.11, 9-10.11, 11-12.11, 13-14.11, and 15-15.11. Exclusionary criteria were determined as mentioned previously. Standardization was established by transforming subtest raw scores into scaled scores with a mean of 10 and standard deviation of 3 (Manly et al., 1999).

Content. All subtests of the TEA-Ch are administered to all children, without ceilings, basals, or age-related starting or stopping points. The nine subtests that comprise the TEA-Ch, are described as follows:

The Sky Search subtest assesses selective/focused attention. The subtest is timed and requires the child to find as many "target" spaceships as possible (on a large sheet filled with similar distracter spaceships). The second part of the test requires the child to circle the spaceships without the distracters present. Subtracting the score of the second task from the score of the first task allows for an overall score that attempts to eliminate the influence of motor speed from the task.

The Score! subtest requires the child to keep track of scoring sounds (recorded on a CD or cassette tape). The sounds mimic computer scoring sounds and are spaced with random time gaps, requiring the child to maintain their attention to the task. Thus Score! is a measure of sustained attention.

Creature Counting measures attentional control/shifting attention by assessing time to complete the test and accuracy. The child is asked to count up and down following aliens in their burrows in a snake-like formation down the page. Arrows are placed in various spots to tell the child when to count up or down, requiring the student to change direction of counting frequently throughout the test.

Sky Search DT is a measure of sustained and divided attention. Combining the tasks from the previous two tests: Sky Search and Score!, the child must locate and circle spaceships on a large sheet while simultaneously keeping track of scoring sounds.

The Map Mission subtest is a timed test that assesses selective/focused attention. Map Mission requires the child to find as many target symbols on a map as possible within one minute.

Score DT measures sustained attention over time. The test combines the tasks of counting scoring sounds while also identifying an animal's name within an audio news report. The child is told to focus mostly on the counting and to report the number of scoring sounds along with the animal's name at the end of each news report.

The Walk, Don't Walk subtest requires the child to sustain their attention and inhibit a response. The child is asked to make a mark on a square "step" on a paper sheet for each tone they hear on a CD or cassette tape and to not make a mark when another sound is presented. The second sound comes at an unpredictable time during the test, which requires the child to inhibit a response that becomes more automatic as the test proceeds.

The Opposite Worlds subtest measures attentional control/shifting attention. In Same World, children must quickly name numbers that are formed in path on the page. In Opposite World, they must follow similar paths but say 'one' when a two is presented and 'two' when a one is presented. The timed format of the test is crucial in determining how quickly the child is able to make the cognitive switch.

The Code Transmission subtest measures sustained attention over 12 minutes. A long series of numbers are spoken on the audiotape or CD. The child is asked to listen for two 5s in a row and identify the number that came immediately before.

Reliability. Test-retest reliability was assessed utilizing versions A and B of the TEA-Ch. Fifty-five of the original 293 tested were retested on version B of the test from 6 to 15 days after version A was administered (Manly et al., 1999). Reliability coefficients on the subtests ranged from 0.57 to 0.87 when age was partialled out (see Table 3). Three subtests (Score!, Score DT, and Walk, Don't Walk) have ceiling effects making correlations difficult; therefore, percentage agreement values were found within one standard deviation (3 scaled points) for versions A and B. These are 76.2%, 71.4%, and 71.0%, respectively.

Table 3

Test/Retest Correlation Coefficients (Age Partialled Out) and Percentage Agreements for Measures with Ceiling Effects for 55 Children

Subtest	Correlation Coefficient
Sky Search (time per target)	0.90
Sky Search (attention score)	0.75
Score!	76.2%
Creature Counting (accuracy)	0.71
Creature Counting (timing score)	0.57
Sky Search DT	0.81
Map Mission	0.65
Score DT	71.4%
Walk, Don't Walk	71.0%
Same World (time)	0.87
Opposite World (time)	0.85
Code Transmission	0.78

Note. Adapted from *Test of Everyday Attention for Children (TEA-Ch)* manual by Manly, Anderson, & Nimmo-Smith, 1999, p. 34. Copyright 1999.

Validity. In line with theoretical models, the TEA-Ch revealed that certain subcomponents or factors of attention (i.e. selective attention, sustained attention, and attentional control/switching) are measured using a Structural Equation Model (SEM) utilizing Bentler & Wu's (1995) EQS programme (Manly et al., 1999). The SEM analysis included a three-factor apriori model of attention, where the 9 subtests of the TEA-Ch each loaded onto one of the three factors: Sky Search and Map Mission subtests load onto the selective attention factor; Creature Counting and Opposite Worlds load onto the Attentional Control/Switching factor; and Score!, Code Transmission, Walk, Don't Walk, Score DT, and Sky Search DT load onto the sustained attention factor.

Research Design and Analysis Plan

Once data collection of the current sample was complete, the raw scores of all test protocols were converted into scaled scores ($M = 10$; $SD = 3$). The factor structure of the Australian sample was compared to the American sample using Confirmatory Factor Analysis. Data were entered into Statistical Package for the Social Sciences (SPSS) 15.0 and SPSS Amos 19.0.0 statistical software programs for analysis. SPSS was utilized to determine eigenvalues. Eigenvalues for each given factor measured the variance in all of the variables that are accounted for by that factor and are used to condense the variance in a correlation matrix. Similar to the Australian study that utilized the EQS programme for SEM, the current study utilized SPSS Amos 19.0.0 software to determine the goodness of fit through a SEM process, specifically Confirmatory Factor Analysis (CFA). This allowed for a thorough look at the goodness of fit of the current data to the predetermined three-factor model.

Structural Equation Modeling and Confirmatory Factor Analysis

Structural equation modeling (SEM) is a theory-driven process that quantitatively tests relationships of observed variables using different types of models (Schumacker & Lomax, 2004). Latent variables, such as attention, are constructs that cannot be measured directly. Therefore, we utilize observable measures, such as tests, to measure latent variables. SEM helps determine which observable variables predict latent, unobservable variables. Essentially, one is able to assess how various constructs are related using SEM.

Factor analysis (FA) is a statistical process utilized when a researcher seeks to determine which variables in a data set form distinct factors that are independent of one another and represent underlying processes (Tabachnick & Fidell, 2007). There are two main types of factor analysis: exploratory and confirmatory. Exploratory factor analysis (EFA) is utilized when the researcher does not have prior knowledge regarding the underlying processes. Confirmatory factor analysis (CFA) is a more sophisticated SEM process and is utilized when the researcher does have prior knowledge of the underlying or latent processes in the data, which is often based on theory or research (Byrne, 1989; Tabachnick & Fidel, 2007). There are essentially four steps in the CFA process. First, the factor model is determined a priori, where the number of factors and the path structure is identified, generally determined by a specific research theory. Next, the model is fit to the data. It is presumed that some unobservable variables are responsible for the covariance of the observable variables. The model is then evaluated to determine the covariance of the observable variables on the latent unobservable variables. Because the observed variables do not always perfectly measure the latent variables, SEM software accounts for measurement error (Schumacker & Lomax, 2004). In CFA, the data are forced into a specific model based on theory. SEM software determines the goodness of fit of the data to that model. In cases where the data is not a good fit to the model, additional models may be suggested that are a better fit.

For purposes of the current study, the observable discreet variables included the TEA-Ch subtests and the latent variables included the three types of attention: selective, sustained, and attentional control/shifting. Based on attention theories discussed, the model matching the Australian and Chinese samples was utilized (Manly et al., 2001; Chan et al., 2008), where Sky Search and Map Mission loaded onto the selective attention factor; Creature Counting and Opposite Worlds loaded onto the attentional control/shifting attention factor; and Score!, Code Transmission, Walk, Don't Walk, Score DT, and Sky Search DT loaded onto the sustained attention factor. Once the CFA was performed, the chi-square statistic and additional fit indices were analyzed to determine goodness of fit of the current data to the apriori model. The following chapter includes those results, an analysis of the hypotheses, and comparison with the Australian and Chinese models.

CHAPTER IV

RESULTS

Results from the study are presented within this chapter. Analyses of the hypotheses include demographic data and a CFA model of the current sample is presented. Variable correlations were also analyzed.

Analysis of the Hypothesis

The first four hypotheses focused on differences between demographic groups (i.e., sex, age, ethnicity, and parent's education level, respectively) within the current sample. H5 stated that a latent three-factor solution consistent with the Australian and Chinese samples and suggested by Manly et al. (2001) would be retained. The three factors assumed include: selective/focused attention, sustained attention, and attentional control/shifting attention, where Sky Search and Map Mission subtests load onto the sustained attention measure; Creature Counting and Opposite Worlds subtests load onto the attentional control/shifting attention factor; and, Score!, Code Transmission, Walk, Don't Walk, Score DT, and Sky Search DT subtests load onto the sustained attention factor (see Figure 1).

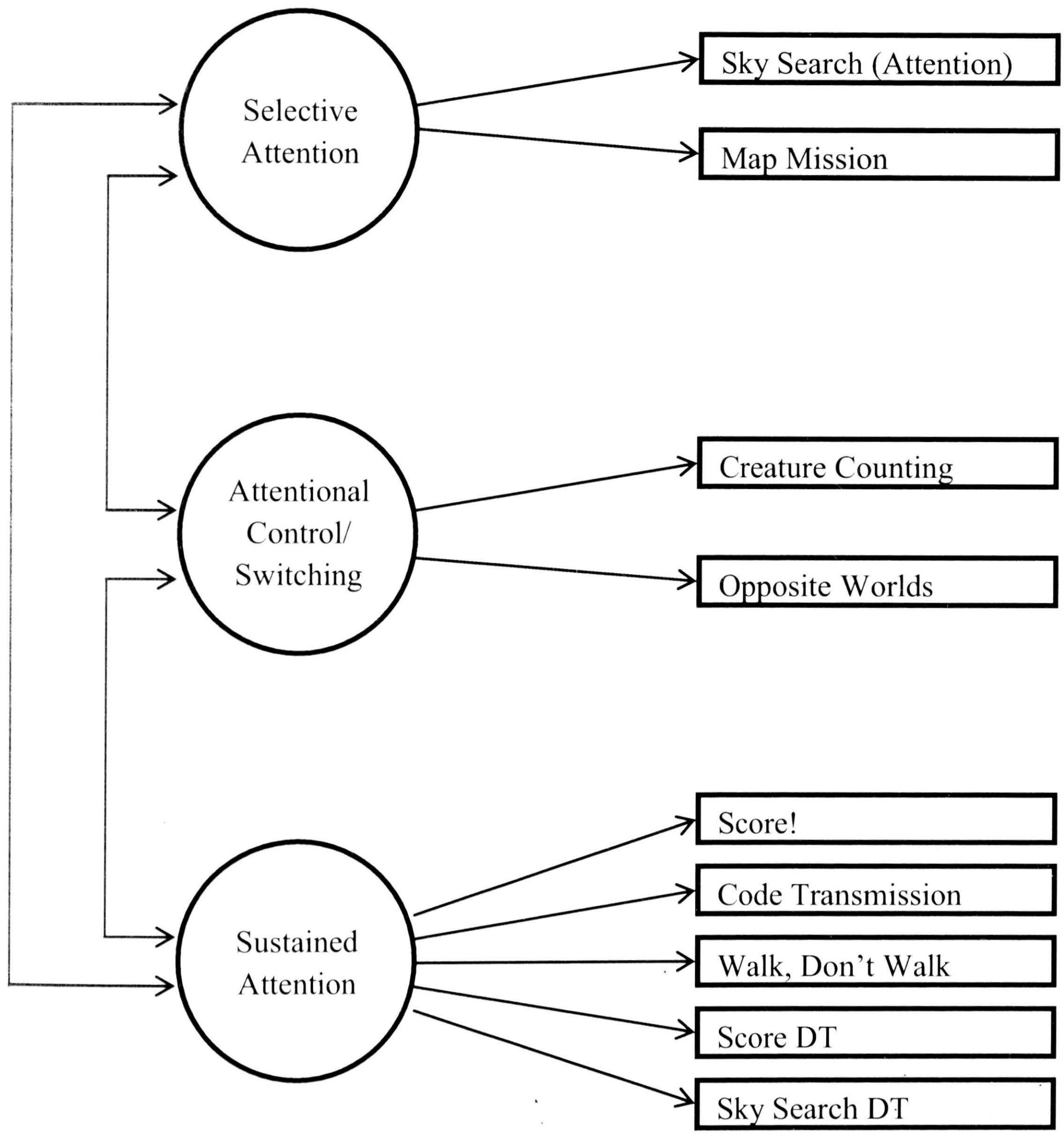

Figure 1. Structural Equation Model of the TEA-Ch

Data Analysis

Using SPSS, means and standard deviations were determined for the entire sample (see Table 4). Additionally, means and standard deviations were determined based on gender, ethnicity, parental education level and age groups. Multivariate analysis of demographic interactions was also performed.

Table 4

Means and Standard Deviations for the Entire Sample

Subtest	Mean (*SD*) (n = 158)
Sky Search	10.04 (2.80)
Score!	10.47 (3.38)
Creature Counting	10.51 (3.18)
Sky Search DT	8.27 (3.69)
Map Mission	9.75 (2.81)
Score DT	10.54 (3.32)
Walk, Don't Walk	10.91 (4.48)
Opposite Worlds	8.62 (3.28)
Code Transmission	9.68 (3.31)

Hypothesis one (H1). As illustrated in Table 5 multivariate analysis of variance (MANOVA) was computed to test for the main effects of sex on the TEA-Ch subtests. Using the Wilks Lambda criteria, there was not a significant main effect for sex (F (9, 85) = 1.69, p = .103). Therefore, there were no significant differences between males and females in mean subtest performance on the TEA-Ch, and H1 is supported in the current study. Additionally, all means were within the average range of functioning.

Table 5

Means and Standard Deviation Based on Sex

Subtest	Males (n = 78) Mean (*SD*)	Females (n = 80) Mean (*SD*)
Sky Search	10.19 (3.10)	9.89 (2.48)
Score!	10.09 (3.47)	10.84 (3.28)
Creature Counting	10.03 (3.20)	10.99 (3.10)
Sky Search DT	7.88 (3.83)	8.64 (3.53)
Map Mission	8.97 (2.68)	10.50 (2.75)
Score DT	10.09 (3.46)	10.98 (3.13)
Walk, Don't Walk	10.77 (4.63)	11.04 (4.35)
Opposite Worlds	8.26 (2.97)	8.89 (3.54)
Code Transmission	9.41 (3.51)	9.95 (3.11)

Hypothesis two (H2). A MANOVA was computed to test for the main effects of age on the TEA-Ch subtests. Using the Wilks Lambda criteria, there was a significant main effect for age group (F (45, 383) = 1.83, p = .001). Univariate analyses revealed significant age effects for the Map Mission and Opposite Worlds subtests (see Table 6). For the Map Mission subtest, post-hoc Tukey mean comparisons yielded significant differences between the 7-0 to 8-11 versus the 11-0 to 12-11 age groups (p = .019), 7-0 to 8-11 versus 13-0 to 14-11 (p = .010), and 9-0 to 10-11 versus 13-0 to 14-11 (p = .032).

H2 is not supported as there were differences for these age groups. For Opposite Worlds, despite the fact that there was a significant univariate F test for the effects of age, none of the post-hoc Tukey mean comparisons were significant.

Table 6

Means and Standard Deviations Based on Age Groups

Subtest	6-0 to 6-11 (*n* = 24) Mean (*SD*)	7-0 to 8-11 (*n* = 40) Mean (*SD*)	9-0 to 10-11 (*n* = 37) Mean (*SD*)	11-0-12-11 (*n* = 30) Mean (*SD*)	13-0 to 14-11 (*n* = 19) Mean (*SD*)	15-0 to 15-11 (*n* = 8) Mean (*SD*)	Univariate *F* Significance
Sky Search	10.00 (3.08)	9.60 (3.11)	9.73 (2.75)	10.63 (2.31)	10.42 (3.06)	10.63 (1.41)	.560
Score!	12.46 (3.39)	10.43 (3.55)	9.97 (3.44)	10.57 (2.94)	9.37 (3.00)	9.25 (2.96)	.119
Creature Counting	10.79 (3.70)	9.98 (3.24)	9.62 (3.55)	10.93 (2.43)	11.58 (2.52)	12.38 (1.85)	.507
Sky Search DT	8.75 (5.53)	8.53 (4.15)	8.43 (3.66)	8.03 (1.96)	7.47 (2.22)	7.50 (2.73)	.255
Map Mission	10.00 (1.69)	8.73 (2.40)	9.00 (2.84)	10.87 (3.18)	11.37 (3.30)	9.50 (1.60)	.002*
Score DT	11.00 (3.43)	11.20 (3.87)	10.00 (3.26)	10.53 (2.76)	9.21 (3.03)	11.50 (2.07)	.651
Walk, Don't Walk	11.42 (4.54)	10.98 (4.75)	10.38 (4.71)	11.93 (4.24)	9.16 (4.22)	11.75 (2.32)	.099
Opposite Worlds	10.21 (3.35)	8.05 (3.11)	7.92 (3.15)	8.87 (3.58)	7.95 (3.12)	10.63 (1.69)	.034*
Code Transmission	10.92 (3.66)	10.18 (3.73)	7.89 (2.83)	9.87 (3.17)	9.84 (2.39)	10.75 (1.49)	.214

Note. **p* < .05; However, post-hoc Tukey analysis revealed no significant differences based on age for the Opposite Worlds subtest.

Hypothesis three (H3). A MANOVA was computed to test for the main effects of ethnicity on the TEA-Ch subtests. Using the Wilks Lambda criteria, there was a significant main effect for ethnicity (F (18, 170) = 1.82, p = .027). Univariate analyses revealed significant ethnicity effects for the Sky Search DT subtest (see Table 7). One may glean from the data that Hispanics, with a mean score of 7.16, performed significantly lower than African Americans and Caucasians, with means of 8.69 and 8.35, respectively. However, despite the fact that there was a significant univariate F test for the effects of ethnicity for the Sky Search DT subtest, none of the post-hoc Tukey mean comparisons were significant. H3 is therefore supported as post-hoc analysis determined no significant effects were found based on ethnicity.

Hypothesis four (H4). Additional MANOVA was computed to test for the main effects of parent's education level on the TEA-Ch subtests. Using the Wilks Lambda criteria, there was not a significant main effect for parents' education level (F (18, 170) = 1.23, p = .239) (see Table 8). H4 is supported for the current sample as there were no significant differences based on the parental education level.

Table 7

Means and Standard Deviations Based on Ethnicity

Subtest	Caucasians (n = 110) Mean (SD)	African Americans (n = 29) Mean (SD)	Hispanics (n = 19) Mean (SD)	Univariate F Significance
Sky Search	9.89 (2.84)	10.17 (2.88)	10.68 (2.47)	.373
Score!	11.00 (3.43)	9.76 (3.17)	8.47 (2.48)	.061
Creature Counting	10.63 (3.20)	11.00 (2.77)	9.11 (3.40)	.164
Sky Search DT	8.35 (3.58)	8.69 (4.38)	7.16 (3.10)	.005*
Map Mission	9.84 (2.81)	9.62 (3.13)	9.42 (2.39)	.665
Score DT	10.95 (3.26)	9.97 (3.25)	9.00 (3.37)	.093
Walk, Don't Walk	10.63 (4.32)	11.76 (4.94)	11.21 (4.71)	.396
Opposite Worlds	8.95 (3.15)	8.07 (3.31)	7.58 (3.82)	.112
Code Transmission	10.10 (3.20)	8.31 (2.74)	9.37 (4.21)	.122

Note. *p < .05; However, post-hoc Tukey analysis revealed no significant differences based on ethnicity.

Table 8

Means and Standard Deviations Based on Parents' Educational Level

Subtest	Less than High School (n = 24) Mean (SD)	High School Education (n = 40) Mean (SD)	Greater than High School (n = 94) Mean (SD)
Sky Search	10.50 (2.96)	9.50 (2.92)	10.15 (2.70)
Score!	9.54 (2.73)	10.55 (3.84)	10.67 (3.32)
Creature Counting	9.17 (3.70)	10.73 (3.03)	10.77 (3.04)
Sky Search DT	8.54 (3.98)	8.40 (3.48)	8.14 (3.74)
Map Mission	9.75 (3.40)	10.63 (2.88)	9.37 (2.55)
Score DT	9.08 (2.96)	10.95 (4.08)	10.73 (2.96)
Walk, Don't Walk	11.21 (4.46)	10.65 (5.26)	10.94 (4.15)
Opposite Worlds	7.92 (3.48)	8.63 (3.51)	8.80 (3.14)
Code Transmission	8.54 (3.54)	9.73 (3.60)	9.96 (3.10)

Additional analyses were performed to determine if there were any significant interactions between the independent variables and no significant interactions were found (see Table 9). Overall, the only statistically significant difference in demographic data was by age for the Map Mission subtest.

Table 9

Multivariate Tests for Demographic Variable Interactions

Interaction	Multivariate *F*	Significance
Age X Ethnicity	.98 (81, 558)	.541
Age X Gender	1.09 (45, 383)	.326
Ethnicity X Gender	.74 (18, 170)	.770
Age X Ethnicity X Gender	1.15 (27, 249)	.287
Age X Parent Education Level	1.23 (90, 586)	.086
Ethnicity X Parent Educational Level	.89 (27, 249)	.622
Age X Ethnicity X Parent Educational Level	.82 (36, 320)	.764
Gender X Parent Educational Level	1.46 (18, 170)	.111
Age X Gender X Parent Educational Level	1.35 (54, 438)	.057
Ethnicity X Gender X Parent Educational Level	1.67 (9, 85)	.108

Hypothesis five (H5). Using Amos 19.0.0 statistical software, a confirmatory factor analysis was performed with maximum likelihood estimation. The chi-square statistic (χ^2) and fit indices, including the root mean square error of approximation

(RMSEA; Browne & Cudeck, 1993) were examined to determine the model fit to the data. A non-significant chi-square and smaller RMSEA generally indicates a good model fit. However, with larger sample sizes the chi-square may not be a reliable indicator of fit (Cohen, Cohen, West, & Aiken, 2003). Therefore, the RMSEA and other Comparative Fit Indices are better indicators of the goodness of fit (Byrne, 2001). The RMSEA and the Comparative Fit Index (CFI), like the chi-square statistic, are maximum likelihood (ML)-based measures (Hu & Bentler, 1999). ML determines likely parameter values based on the data set (Tabachnick & Fidell, 2007). Bentler and Bonnett (1980) reported .90 as a general cut-off for determining goodness of fit. RMSEA values of .06 or less indicate a good fit and greater than .10 indicates a poor fit (Browne & Cudeck, 1980; Hu & Bentler, 1999). Other researchers report that values less than or equal to .05 indicates a good fit, .05 to .08 is a reasonable fit, and .08 to .10 indicates a mediocre fit (MacCallum, Browne, & Sugawara, 1996). For purposes of the current study, a RMSEA of .08 or lower was sought for goodness of fit.

In addition to the RMSEA, other goodness of fit indices were also examined to determine the model fit to the established three-factor solution. The goodness of fit indices utilized included the Normed Fit Index (NFI), the Incremental Fit Index (IFI), and the Comparative Fit Index (CFI). These indices were chosen in order to compare with the Australian and Chinese results. Bentler-Bonett's (1980) NFI compares the χ^2 of the model to that of the independence model and results in an index ranging from 0 to 1 (Tabachnick & Fidell, 2007). The IFI (Bollen, 1989) helps in addressing problems associated with large variability by addressing the degrees of freedom of the model

(Tabachnick & Fidell, 2007). These indices generally indicate a good fit to the model at values of .90 or greater. The CFI utilizes a different approach and is especially beneficial with smaller sample sizes, with an index value of .95 or greater indicating a good fit to the model (Bentler, 1988; Tabachnick & Fidell, 2007).

Results of the CFA. The CFA was computed for the hypothesized three-factor model of selective attention, attentional control/switching, and sustained attention. The CFA produced a good fit to the hypothesized model, with a non-significant chi-square statistic, IFI and NFI goodness of fit indices of .90 or above, a CFI of .95 or above, and the RMSEA of less than .08: χ^2 (24, N = 158) = 10.70, p > .05; CFI = 1.00, IFI = 1.08, NFI = .94, and RMSEA = .00. Therefore, the hypothesis is supported and the current model is a good fit to the three-factor model indicated by the initial sample. Further, with a smaller sample size, the CFI at 1.00 is a reliable indicator of good fit to the model (Bentler, 1988). Table 10 indicates the goodness of fit summary for the current CFA model, thus supporting H5.

Table 10

Goodness of Fit Summary for the Current CFA Model

χ^2	*df*	*p*	IFI	CFI	NFI	RMSEA
10.70*	24	.99	1.08	1.00	.94	.00

Note. *Non-significant.

Factor loadings and error variances. Factor loadings of the discrete variables (i.e., the TEA-Ch subtests) on the latent variables (i.e., sustained attention, selective attention, and attentional control/shifting attention) were examined as illustrated in

Table 11. Because latent variables cannot be measured directly, they are linked to discrete variables that are presumed to measure that latent construct (Byrne, 2001). This is generally based on theory and in the case of the current study, the three-factor apriori model is based on the aforementioned attentional theories.

Table 11

Factor Loadings and Error Variances

	Factor Loadings			Error
Subtest	I	II	III	Variance
Sky Search	**.44**			.32
Map Mission	**.67**			.42
Score!		**.57**		.29
Code Transmission		**.64**		.28
Walk, Don't Walk		.22		.40
Score DT		**.76**		.27
Sky Search DT		**.36**		.33
Opposite World			**.46**	.54
Creature Counting			.23	.34

Note. I = Selective Attention;
II = Sustained Attention;
III = Attentional Control/Switching

Due to the smaller sample size of the current study, a minimal factor loading of .03 or greater was chosen, as recommended by Hair (1998). As predicted, Sky Search and Map Mission both loaded onto the selective attention scale with factor loadings greater than .03, where Map Mission = .67 and Sky Search = .44. Four of the five subtests loaded onto the sustained attention scale, with Score! = .57, Code Transmission = .64, Score DT = .76, and Sky Search DT = .36. However, the Walk, Don't Walk subtest did not load onto the sustained attention scale above a .30 level as predicted (Walk, Don't Walk = .22). Additionally, while the Opposite World subtest did load onto the Attentional Control/Switching scale (.46), Creature Counting did not have the same result as the hypothesis predicted (.23). This is discussed further in the following chapter. Figure 2 illustrates the three-factor path model with associated factor loadings.

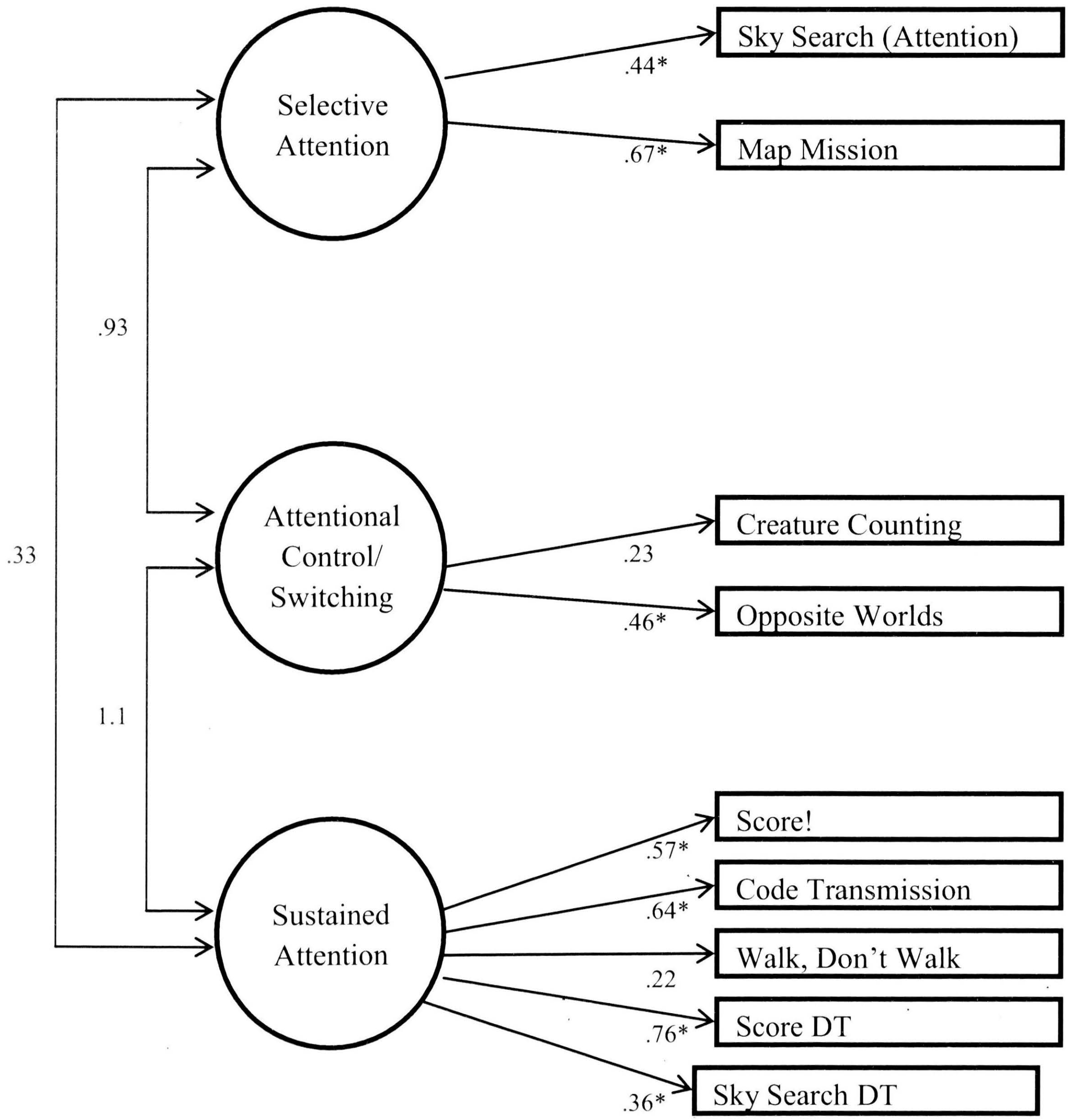

Figure 2. Hypothesized model of the TEA-Ch with Factor Loadings.
Note. *Adequate factor loadings of .30 or greater.

Additional analysis included a Pearson's correlation between the subtest variables. The value for a Pearson's correlation can fall between 0 (no correlation) and 1 (perfect correlation). Table 12 illustrates the correlation matrix. Multicollinearity among items may be determined by coefficients of .85 or greater (Kline, 2005). With correlation coefficients ranging from -.06 to .50, $p < .05$-.01, multicollinearity was not a concern for the current study.

It is reasonable to expect correlation of the subtest variables that load onto the same latent variable structure. First, analysis of the selective attention subtests, Sky Search and Map Mission, revealed high correlation, significant at the .01 level. Next, analysis of the attentional control/shifting attention subtests, Creature Counting and Opposite Worlds, did not reveal significant correlation ($r = .11$). Finally, the sustained attention subtests, Score!, Sky Search DT, Score DT, Walk, Don't Walk, and Code Transmission, were reviewed. Score! did not correlate with Score DT ($r = .43$); Sky Search DT did not correlate with Walk, Don't Walk ($r = .11$); and, Walk, Don't Walk did not correlate with Code Transmission ($r = .10$). Walk, Don't Walk correlated with Score! and Score DT significantly at the .05 level. All additional sustained attention subtests correlated significantly at the .01 level.

Table 12

Pearson Correlation Matrix of Individual Subtests of the Current TEA-Ch Sample

	1	2	3	4	5	6	7	8	9
1. Sky Search	-	.00	.14	.03	.29**	.13	.03	.17*	.09
2. Score!		-	.08	.21**	.13	.43**	.19*	.33**	.36**
3. Creature Counting			-	.12	.22**	.16*	.03	.11	.15
4. Sky Search DT				-	.14	.26**	.11	.23**	.22**
5. Map Mission					-	.17*	-.06	.25**	.16*
6. Score DT						-	.16*	.41**	.50**
7. Walk, Don't Walk							-	.11	.10
8. Opposite Worlds								-	.33**
9. Code Transmission									-

Note: *Correlation is significant at the .05 level (2-tailed). **Correlation is significant at the .01 level (2-tailed).

Summary

The results indicated that H1 was supported. There were no significant differences based on sex. H2 was not fully supported, with post-hoc analysis revealing differences by age on the Map Mission subtest. H3 was supported as post-hoc analysis determined there were no significant effects based on ethnicity. H4 was supported for the current sample with no significant differences based on the parents' education level. The results of H5 revealed a good fit to the original model, supporting the hypothesis. However, two subtests did not load onto the intended latent factor at a .30 value or greater. Furthermore, when using AMOS statistical software, models of better fit to the data would typically be suggested to control for differences in demographic data. When the current analysis was performed, no modification indices were provided suggesting additional CFA models controlling for the difference in age. Therefore, it is determined that the current model is the best fit to the data based on the fit indices that were established and the lack of additional models being suggested.

Additional analysis included a Pearson correlation matrix of the mean scores of the TEA-Ch subtests. The selective attention subtests correlated as expected. However, the attentional control/shifting attention subtests were not correlated and the sustained attention subtests were mixed, with only some correlation among the five subtests.

CHAPTER V

DISCUSSION

This chapter includes a discussion of the results of the current study. The three-factor solution and demographic hypotheses are discussed. A cross-cultural comparison of data is presented, including the current sample and those from Australia and China. Additional discussion includes the limitations of the current study as well as directions for future research and practice implications.

Preliminary Analysis

Preliminary analysis included determination of which parental age groups to assign participants to when the two parents' education levels differed. In an attempt to even out the data, when one parent had less than high school and the other had greater than high school, that child was assigned to the group with high school education, in essence averaging the two parents' education levels. Although not ideal, when additional differences occurred, such as when one parent reported less than high school education and the other parent reported high school education, an effort was made to alternate which group those participants were assigned to, thus attempting to distribute evenly across the data set. The assumption was made that the Australian and Chinese researchers made a similar attempt with their data; however, this information was not available in the research.

A preliminary examination of the mean subtest scores and standard deviations for the current sample revealed The Sky Search DT and Opposite Worlds mean standard scores were somewhat lower than would be expected, 8.27 and 8.62, respectively, given a sample of non-clinical participants. With the remaining subtest means ranging from 9.68 to 10.91, the reasons for this are unclear. Both of these tests rely heavily on timing, which may account for the some of the difference. Additional analysis of a Pearson's correlational matrix revealed multicollinearity of subtest data was not a concern for this study. Furthermore, demographic data revealed no significant interactions.

Hypotheses

Of the five hypotheses in this study, four were supported. Results of the demographic analysis revealed no significant differences in scores by sex (H1), ethnicity (H3), and parents' education level (H4), thus supporting those hypotheses. However, results reveal significant differences based on age (H2), which did not support the hypothesis. Finally, a CFA of the current sample data revealed a good fit to the original TEA-Ch factor structure model (H5); therefore, this hypothesis was also supported. The following section includes discussion of the hypotheses.

Differences Based on Sex (H1)

The multivariate analysis revealed no main effects of sex on the TEA-Ch subtests, supporting the hypothesis that there are no significant differences between males and females in TEA-Ch test performance. When considering the use of the TEA-Ch for the assessment of ADHD, it is interesting to note that boys are diagnosed with ADHD more often than girls with ratios ranging from 2:1 to 9:1 (APA, 2000). While boys and girls performed similarly on this measure, the TEA-Ch does not capture some aspects of ADHD that may account for sex differences in the diagnosis, such as hyperactivity.

Differences Based on Age (H2)

Even though standard scores were used in the analyses, which were based on age norms, the multivariate analysis revealed a main effect of age on TEA-Ch performance, with univariate analysis revealing the Map Mission and Opposite Worlds subtests as being significant. However, post hoc analysis was significant only for the Map Mission subtest. The lowest scores were found in the 7-0 to 8-11 age group ($M = 8.73$, $SD = 2.40$). One may speculate that with the attentional demands increasing at this age, some participants at this age level may in fact have attention problems that have not yet been identified. Furthermore, with the allure of receiving feedback on their child's performance on the test, parents may have consented to testing when attention problems may have been suspected. While the CFA process allows for controlling of variables, the small sample size of the current study did not allow for the controlling of age on the overall model. With a larger sample, it is likely the age variable could be controlled through the CFA process and could result in an alternate model.

Differences Based on Ethnicity (H3)

The multivariate analysis revealed differences in scores based on ethnicity and univariate analysis revealed differences for the Sky Search DT subtest. The data revealed a low mean score for Hispanics on this subtest ($M = 7.16$, $SD = 3.10$). However, post-hoc analysis revealed no significant differences based on ethnicity. Therefore, the hypothesis is supported. One may again speculate that with a larger sample size, all of the mean scores of the non-clinical population would be closer to a mean of 10.

Differences Based on Parents' Education Level (H4)

The multivariate analysis revealed no differences in scores based on parents' education levels, thus supporting the hypothesis. Since parental education attainment impacts social factors such as greater opportunity and access to resources (Dubow, Boxer, & Huesmann, 2009), one may glean from these results that attention is not affected by social opportunity. This is also consistent with the neuroanatomical theories of attention as previously noted.

Factor Structure of the Current Sample (H5)

The construct validity of the TEA-Ch is supported by the results of this study. The latent factor structure found in the current study is consistent with the hypothesized three-factor model. Test results indicate the non-clinical sample demonstrates latent variables of sustained attention, attentional control/switching, and sustained attention. This is consistent with the theoretical models of attention (Posner & Peterson, 1990; Mirsky, 1991) and supports the theoretical basis of the TEA-Ch (Manly et al., 2001). Additional discussion of the subtest correlations is also included in this section.

Selective Attention factor. The Sky Search and Map Mission subtests loaded onto the selective attention factor in the three-factor model, further supporting the hypothesis and endorsing the original factor structure. Additionally, the Sky Search and Map Mission subtests were highly correlated at the .01 level indicating they are likely measuring a similar construct ($r = .29$).

Attentional Control/Shifting Attention factor. The Opposite World and Creature Counting subtests were intended to load onto the attentional control/shifting attention factor. However, while the Opposite Worlds subtest did load, Creature Counting did not load at the .30 level. Additionally, these two subtests did not significantly correlate ($r = .11$). This factor appears to be the least supported of the three factors in the current study. It is possible that a larger sample size would produce a more robust loading of the discrete variables onto the factors.

Sustained Attention factor. Four of the five subtests loaded onto the sustained attention factor as intended. However, the fifth subtest, Score DT, did not load at the .30 level. Furthermore, there were some variables that correlated while others did not. The following subtests correlated at a .01 level: Score! and Code Transmission ($r = .36$); Score and Score DT ($r = .43$); Score! and Sky Search DT ($r = .21$); Code Transmission and Score DT ($r = .50$); Code Transmission and Sky Search DT ($r = .22$); Walk Don't Walk and Score DT ($r = .26$); and Score DT and Sky Search DT ($r = .26$). Score! and Walk, Don't Walk ($r = .19$), as well as Score DT and Walk Don't Walk ($r = .16$), correlated at a .05 level. Code Transmission did not significantly correlate with Walk, Don't Walk ($r = .10$) and Walk, Don't Walk did not correlate significantly with Sky Search DT ($r = .11$).

Summary. As discussed, while most of the subtests loaded onto the intended factors, the Creature Counting and Walk, Don't Walk subtests did not. Additional analysis was performed that included removing those two subtests from the model. However, once removed, an identifiable model was not produced. Removing the Creature

Counting subtest leaves only one variable to account for the attentional control/shifting attention scale and a minimum of two variables is necessary to measure a latent variable (Shumacker & Lomax, 2004). Overall, while not all subtests loaded onto a factor at a significant level, the overall three-factor model was supported.

Further analysis of the subtest correlations revealed that not all of the subtests for each factor correlated, except for the selective attention factor, which is only accounted for by two subtests. Attentional control/shifting attention is also accounted for by only two subtests and these did not correlate. This indicates they may not be measuring the similar construct as intended. Since Creature Counting did not load onto the attentional control/shifting attention factor as intended and it also did not significantly correlate with the Opposite Worlds subtest, one may speculate this subtest is a weak measure of shifting attention and an alternate subtest could be created to strengthen the measurement of this type of attention, thereby strengthening the overall model.

Cross Cultural Comparisons

The results of the current study can be compared to the results of the original Australian sample (Manly et al., 1999) as well as the Chinese study (Chan et al., 2008). All three samples produced a non-significant Chi-square statistic and incremental fit indices of .90 or greater, indicating all samples were good fits to the three-factor model with latent variables of selective attention, attentional control/switching, and sustained attention, where the Australian sample yielded χ^2 (24, N = 293) = 33.43, p = .10; NFI = .91; CFI = .97; NNFI = .96; and the Chinese study yielded χ^2 (24, N = 232 = 33.56, p =

.08; NFI = .97; CFI = .99; IFI = .99; NNFI = .99; RMSEA = .04. Table 13 summarizes the available results for each study for comparison.

While the Australian and Chinese samples additionally resulted in factor loadings of .30 or greater for all nine subtests, the current sample yielded two subtests below the .30 threshold, likely due to the smaller sample size of the study. Furthermore, an unidentifiable factor structure resulted when these two subtests were removed.

Table 13

Cross-Cultural Comparison of the Data

Sample	Non-Significant Chi-Square	Fit Indices
Current U. S.	χ^2 (24, N = 158) = 20.51, p = .67	NFI = .90 CFI = 1.00 IFI = 1.00 RMSEA = .05
Australian	χ^2 (24, N = 293) = 33.43, p = .10	NFI = .91 CFI = .97 NNFI = .96
Chinese	χ^2 (24, N = 232) = 33.56, p = .08	NFI = .97 CFI = .99 IFI = .99 NNFI = .99 RMSEA = .04

Limitations and Future Research

Several limitations of the study need to be addressed. While the sample did result in a three-factor solution that is consistent with the hypothesis, the sample size was a limitation. The factor loadings of two subtests did not load onto the intended latent variable factor. It is hypothesized that a larger sample would have resulted in a more robust loading of all factors. When the two subtests were removed, a model was no longer recognized. Furthermore, a larger sample size would provide a normative base for the TEA-Ch to be utilized in the United States to help in distinguishing attention difficulties for children. Furthermore, multivariate statistics rely on larger sample sizes. For example, with a larger sample size, the current research could control for age and possibly identify alternate models. Therefore, further data collection would be useful. Additionally, some research indicates confirmatory factor structures should have three or more variables loading onto each factor in the model (Hatcher, 1994). In this case, two of the three factors rely on only two variables.

Another limitation of the study is the potential for measurement error. When observed variables are utilized to measure a latent variable, it cannot be assumed that each observed variable perfectly measures the latent variable (Schumacker & Lomax, 2004). While measurement error is inevitable, it is important to mention that many factors may affect the results of the study. For example, student fatigue, distractions, nervousness, or misinterpretation of the test or instructions could all come into play during the assessment affecting the outcome.

With only 42 of the 158 participants tested outside of the Dallas and Fort Worth, Texas area, factors related to location may put the generalizability of the results to other U.S. geographical locations in question. The study could be enhanced with additional data collection evenly distributed around the country.

Manly et al. (2001) and Chan et al. (2008) added to their studies by administering the TEA-Ch to ADHD populations as well. Their findings were similar in that the results both supported a significant deficit in sustained attention for children with ADHD, with children performing poorly on six of nine subtests and five of nine subtests, respectively. Additional testing on a population of ADHD children would also be beneficial to this study to determine consistency with previous results and to demonstrate a typical TEA-Ch scoring profile of a child in the U. S. with clinical attention problems.

Furthermore, the current study intended to follow the Mirsky (1991) model of attention, with the following subtypes: execute/focused attention, sustained attention, shifting attention, and encoding or the Posner and Peterson (1990) model of orientation, selection, and sustained attention. While the current model does not precisely follow these models, the overall general neuropsychological theory is endorsed. This proposes that multiple neurobiological processes are implicated in various types of attention.

Practice and Research Implications

While the normative population consisted of Australian children, results of the current study endorse the same structural model implying that the test validity is generalizable to a U.S. population. Research on the neuroanatomical basis of attention also supports a multi-factor model with different types of attention requiring unique and complex neural activity. However, with two subtests not loading onto intended latent factors and statistically significant differences based on age, one cannot fully endorse the validity of the use of the TEA-Ch in the U.S. It is important to note, however, that many school psychologists utilize rating scales as the primary standardized measure in assessing attention. Rating scales also have their limitations and interrater reliability is often a problem. The TEA-Ch may serve as an additional measure used in conjunction with other measures (i.e., rating scales) to assess for attention problems, while also providing the assessment professional with qualitative one-on-one observational data during the one-hour test administration.

It is interesting that the TEA-Ch authors chose not to include clinical cluster scores that corresponded to the Mirsky subtypes of attention (e.g., sustained, shifting, divided, etc.) or at least to include clinical cluster scores based on the three-factor solution of the test scores. The present study supports the three-factor solution to the TEA-Ch which is consistent with the original Australian sample (Manly et al., 2001) and a Chinese sample (Chan et al., 2008). Given this convergence validity of the TEA-Ch, it would be helpful if the test publishers included the factor scores to aid in the clinical interpretation of the test results. Future research could confirm the clinical utility of those clinical summary scores based on correlations with other measures of attention and potential performance difference between clinical groups (e.g., ADHD).

Conclusion

The present study examined the cross-validity of the Test of Everyday Attention for Children (TEA-Ch) in the U. S. with the original Australian sample. Comparison with a Chinese sample is also examined. The TEA-Ch is a unique test that measures attention directly with the student, setting it apart from the checklists and rating scales that are widely used. The TEA-Ch was previously standardized on an Australian population of 293 children between the ages of 5 and 16. The measure is based on theoretical models of attention, including those by Posner and Peterson (1990) and Mirsky (1991). However, it endorses a broader neuropsychological view of attention as a multidimensional system with different types of attentional processes at work. The current study further supported the three-factor structure model proposed by Manly and his colleagues. Therefore, the study contributes to the literature on the measurement of attention and the data therein serves as preliminary normative data for the use of the TEA-Ch in the United States. Furthermore, the study adds to the field of school psychology/neuropsychology by providing data that supports the use of the TEA-Ch by professionals assessing attention difficulties to be used in conjunction with additional data.

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APPENDIX A

IRB Approval Letter

TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378 FAX 940-898-4416
e-mail: IRB@twu.edu

February 16, 2011

Dr. Daniel Miller
CFO 708

Dear Dr. Miller:

Re: Cross Validation Study of the Test of Everyday Attention for Children (TEA-Ch) (Protocol #: 15019)

The request for an extension of your IRB approval for the above referenced study has been reviewed by the TWU Institutional Review Board (IRB) and appears to meet our requirements for the protection of individuals' rights.

If applicable, agency approval letters must be submitted to the IRB upon receipt PRIOR to any data collection at that agency. A copy of all signed consent forms and an annual/final report must be filed with the Institutional Review Board at the completion of the study.

This extension is valid one year from March 15, 2011. Any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any unanticipated incidents. If you have any questions, please contact the TWU IRB.

Sincerely,

Dr. Kathy DeOrnellas, Chair
Institutional Review Board - Denton

cc.

APPENDIX B

Recruitment Script

Test of Everyday Attention (TEA-Ch) U.S. Validation Study

Recruitment of Participant Script

Note to Examiner: After you have identified a possible child to test, please read the following script to the parent:

Based on your child's sex and age, I would like to see if [insert child's name here] qualifies to participate in a research study. The purpose of the study is to have a broad group of U.S. children take a test called the Test of Everyday Attention. The test was originally developed in Australia and the purpose of this study is to determine if children in the U.S. perform similarly on the test.

If you would agree to have your child participate in this study, the Test of Everyday Attention would be individually administered to your child by me, a trained examiner. The test would take about 45 to 60 minutes to administer. After the test was scored, I would provide you with a summary sheet showing how your child scored on the test in several areas of attention. There would be no charge to you for having your child participate in this study.

In order to see if your child qualifies to participate in this study, I need to ask you a few questions to see if your child matches the characteristics of children the researchers are looking for to complete the U.S. sample. Your answers to these questions will be kept confidential and are used only to see if your child qualifies for the study.

Are you willing to answer a few questions to see if your child qualifies for the study?

If the parent says No.

That's fine. Thank you for talking to me today. If you have any questions about the study you can call the Principal Investigator, Dr. Dan Miller at 940-898-2251.

If the parent says Yes, go on..........

Thank you. Here are the questions to see if your child qualifies to participate in the study.

1. *Has your child ever been evaluated for having special educational needs?*

____ If yes, stop questions and go to the non-qualified statement at the bottom.

____ If no, continue with question #2

2. *Has your child's teacher ever expressed any serious concerns to you about your child's ability to pay attention?*

____ If yes, stop questions and go to the non-qualified statement at the bottom.

____ If no, continue with question #3

3. *Has your child's teacher ever expressed any serious concerns to you about your child's ability to learn at school?*

____ If yes, stop questions and go to the non-qualified statement at the bottom.

____ If no, continue with question #4

4. *Has your child ever been diagnosed as being developmentally delayed or having a serious sensory (e.g., hearing or vision) loss?*

____ If yes, stop questions and go to the non-qualified statement at the bottom.

____ If no, continue with question #5

5. *Has your child ever had a serious head injury that resulted in a loss of consciousness or had any serious neurological illness such as epilepsy, meningitis, or cerebral palsy?*

____ If yes, stop questions and go to the non-qualified statement at the bottom.

____ If no, continue with question #6

6. *What is [insert child's name here]'s principle ethnicity?*

____ Caucasian
____ Hispanic
____ African American
____ Other
Examiner: Does the child's ethnicity match a targeted child in the validation sample?
____ If no, stop questions and go to the non-qualified statement at the bottom.
____ If yes, continue to question #7

7. *What is your relationship to the child?*
____ Mother
____ Step-mother
____ Father
____ Step-father
____ Other (specify: ____________________)

8. What category would best describe the your highest educational training?
____ did not complete High School
____ Completed High School
____ Completed 2 or more years of college or completed a trade school
____ Completed 4 years of college
____ Completed a graduate degree
Examiner: Does the parent/guardian's educational level match a targeted child in the validation sample?
____ If no, stop questions and go to the non-qualified statement at the bottom.
____ If yes, read the following statement:
Great, it looks like your child qualifies to participate in this study. What happens next is that I will need you to sign and permission slip to allow me to administer the Test of Everyday Attention to your child and to schedule a time for the testing. When the testing if completed and I have a chance to score the test, I will provide you a summary of the results. [Work out the logistics with the parent] I appreciate you talking to me today and if you have any questions about this study, you can call the principal investigator, Dr. Dan Miller at 940-898-2251.

Non-Qualified Statement:

Based on your answer(s), your child does not qualify to participate in this study. I appreciate you talking to me today and if you have any questions about this study, you can call the principal investigator, Dr. Dan Miller at 940-898-2251.

APPENDIX C

Consent Form (English version)

TEXAS WOMAN'S UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: Cross-Validation Study of the Test of Everyday Attention for Children (TEA-Ch)

Principal Investigators: Daniel C. Miller, Ph.D. 940/898-2251

Kristen Belloni, M.A.

Joy Whitehead, M.A.

Explanation and Purpose of the Research

You are being asked to allow your child to participate in a research study for faculty research, dissertation purposes, and for Pearson Assessment. The purpose of this research is to determine the validity of using the Test of Everyday Attention for Children (TEA-Ch) with children in the United States. The test has been normed on an Australian population, which may or may not make the test appropriate for use with children in the United States.

Research Procedures

For this study, scores on the TEA-Ch will be collected from a variety of sources. Research investigators will gather data by testing students in the United States. The administration will be done at a private location agreed upon by you and the investigator. The test is comprised of nine subtests, and your maximum total time commitment in the study is approximately one hour.

Potential Risks

Potential risks related to your child's participation in the study include fatigue and physical or emotional discomfort during the testing. To avoid fatigue and physical discomfort, your child may take a break (or breaks) in between subtests as needed. If your child experiences fatigue, physical or emotional discomfort regarding the testing, he/she may stop at any time. The investigator will provide all participants with a referral list of names and phone numbers that you may use if you feel as though you or your child need to discuss this discomfort with a professional.

Another possible risk to your child as a result of your participation in this study is a release of confidential information. There is a potential risk of loss of confidentiality in all email, downloading, and internet transactions. Confidentiality will be protected to the extent that is allowed by law. The test administration will take place in a private location agreed upon by you and the researcher. A code name, rather than your child's real name, will be used on the test materials. Only the investigator and research investigators will have access to the testing materials. The materials will be shredded within two years. It is anticipated that the results of this study will be published in the investigators' (Daniel Miller, PhD, Kristen Belloni and Joy Whitehead) research publications and dissertations, and by Pearson Assessment in the re-norming of the TEA-Ch. However, no names or other identifying information will be included in any publication.

The researchers will try to prevent any problem that could happen because of this research. You or your child should let the researchers know at once if there is a problem and they will help you. However, TWU does not provide medical services or financial assistance for injuries that might happen because your child is taking part in this research.

Participation and Benefits

Your child's involvement in this research study is completely voluntary, and you or your child may discontinue participation in the study at any time without penalty. As a benefit of your participation in this study **you will receive a summary of the results** and your child will receive a small age-appropriate reward at the completion of the test administration.

Questions Regarding the Study

If you have any questions about the research study you may ask the principal investigator; his phone number is at the top of this form. If you have questions about your rights as a participant in this research or the way this study has been conducted, you may contact the Texas Woman's University Office of Research and Sponsored Programs at 940/898-3378 or via email at IRB@twu.edu. You will be given a copy of this signed and dated consent form to keep.

By signing this form, the child participant is assenting to participate in this testing and the parent/guardian is consenting to the child participant's involvement.

______________________________ ________________

Signature of Participant Date

______________________________ ________________

Signature of Parent/Guardian Date

If you are interested in having your child participate in the study, please complete the following information to determine if he/she qualifies for the study and return the form to your child's teacher/after school program/ or summer program in the attached sealed envelope.

Please remember that your child **does not** qualify for the study if:
-the child has been identified as learning disabled OR has identified attention problems
-the child has been evaluated for special education services
-the child has experienced a serious head injury (resulting in loss of consciousness) or had a serious neurological illness (such as epilepsy, cerebral palsy, etc.)

Child's Name: ____

Child's gender: ☐ Male ☐ Female
Child's Date of Birth: _______________ Child's Age: ____________
Child's Ethnicity: ___________________________

Mother's Highest Level of Education: (check one)
☐ Less than a High School Education
☐ Completed High School
☐ Completed 2 or more years of college or completed a trade school
☐ Completed 4 years of college
☐ Completed a graduate degree

Father's Highest Level of Education: (check one)
☐ Less than a High School Education
☐ Completed High School
☐ Completed 2 or more years of college or completed a trade school
☐ Completed 4 years of college
☐ Completed a graduate degree

APPENDIX D

Consent Form (Spanish version)

TEXAS WOMAN'S UNIVERSITY

CONSENTIMIENTO PARA PARTICIPAR EN UNA INVESTIGACIÓN

Título del estudio: Estudio de validación cruzada de la prueba de atención diaria para los niños (TEA-ch – por sus siglas en ingles)

Investigadores principales:	Daniel C. Miller, Ph.d.	940/898-2251
	Kristen Belloni, M.A.	
	Joy Whitehead, M.A.	

Explicación y propósito de la investigación

Estamos solicitando permiso para que su niño/ a participe en una investigación para estudios de la facultad, para las disertaciones o tesis y para la evaluación de Pearson. El propósito de esta investigación es para determinar la validez del uso de la Prueba de Atención Diaria para Niños (TEA-ch) con niños en los Estados Unidos. La prueba ha sido normalizada en una población australiana, que puede o no puede hacer que la prueba sea apropiada para su uso con niños en los Estados Unidos.

Procedimientos de investigación

Para este estudio, se recopilarán puntuaciones en el TEA-ch de una variedad de fuentes. Los investigadores reunirán datos mediante pruebas a los estudiantes en los Estados Unidos. La administración se llevará a cabo en un lugar privado acordado por usted y el investigador. La prueba está compuesta por nueve subpruebas y el de tiempo total para completar la evaluacion es de aproximadamente una hora.

Posibles riesgos

Posibles riesgos relacionados con la participación de su hijo en el estudio incluyen la fatiga y el malestar físico o emocional durante las pruebas. Para evitar la fatiga y el malestar físico, su hijo puede tomar un descanso (o descansos) entre subpruebas según sea necesario. Si su niño siente fatiga, malestar físico o emocional, con respecto a las pruebas, pueden detener las pruebas en cualquier momento. El investigador ofrecerá a todos los participantes una lista de nombres y números de teléfono que usted puede utilizar si siente que su niño/a necesita discutir la molestia con un profesional.

Otro riesgo posible a su hijo como resultado de su participación en este estudio es que él o ella ofrezca información confidencial. Existe un riesgo potencial de pérdida de confidencialidad en todo correo electrónico, las descargas y las transacciones de internet. La confidencialidad será protegida en la medida en que es permitido por la ley. La administración de la prueba se llevará a cabo en un lugar privado acordado por usted y el investigador. Un nombre en código será usado en lugar del nombre real de su hijo en los materiales de prueba. Sólo los investigadores tendrán acceso a los materiales de pruebas. Los materiales serán destruidos dentro de dos años. Anticipamos que los resultados de este estudio salgan en publicaciones y disertaciones de los investigadores (Daniel Miller, PhD, Kristen Belloni y Joy Whitehead) y en la re normalización de la evaluación de Pearson de la TEA-ch. Sin embargo, nombres u otra información de identificación no se incluirán en las publicaciones.

Los investigadores tratan de evitar cualquier problema que pueda suceder debido a esta investigación. Usted o su niño/a deben dejarle saber a los investigadores si hay un problema y ellos les ayudarán. Sin embargo, TWU no proporciona servicios médicos o de asistencia financiera para las lesiones que podrán suceder debido a la participación de su hijo/a en esta investigación.

Participación y beneficios

La participación de su hijo en este estudio de investigación es totalmente voluntaria y usted o su niño puede retirase del estudio en cualquier momento sin ser penalizado. Como beneficio de su participación en el estudio, **usted recibirá un resumen de los resultados** y su hijo recibirá una pequeña recompensa apropiada para la edad de él o ella al finalizar la administración de la prueba.

Preguntas acerca del estudio

Si tienes alguna pregunta sobre el estudio puede hacérselas al investigador principal; su número de teléfono está en la parte de arriba de este formulario. Si tiene preguntas acerca de sus derechos como participante en esta investigación o la forma en que se ha llevado a cabo este estudio, puede comunicarse con la Oficina de Investigaciónes y Programas Patrocinados de Texas Women's University al 940/898-3378 o a través de correo electrónico a IRB@twu.edu. Se le dará una copia de este formulario de consentimiento firmado y fechado para sus archivos.

Al firmar este formulario, el niño está aceptando participar en esta prueba y el padre o tutor está de acuerdo con la participación del niño en la investigación.

______________________________ __________

Firma del participante Fecha

______________________________ __________

Firma del padre/guardián Fecha

Si les interesa que su hijo/a participe en la investigación, por favor complete la siguiente información para determinar si califica para el estudio y regrese el formulario al maestro de su hijo, al programa después de la escuela o al programa de verano en el sobre sellado que está adjunto a estas hojas.

Por favor, recuerde que su niño **no** califica para el estudio si:
-el niño ha sido identificado como estudiante con problemas de aprendizaje o de atención
-el niño ha sido evaluado para determinar si necesita servicios de educación especial
-el niño ha sufrido una lesión grave en la cabeza (la cual resultó en la pérdida de la conciencia) o hubo una enfermedad neurológica grave (como parálisis cerebral, epilepsia, etc..)

Nombre del niño/a: ____

☐ Niño ☐Niña
Fecha de nacimiento: _______________ Edad: ____________
Etnicidad del niño/a: ______________________________

Nivel de educación más alto que ha obtenido la mamá: (circule uno)
Menos que la educación secundaria
Terminó la escuela secundario
Completó 2 años o más de universidad o
completó una escuela de comercio
Completó 4 años de universidad
Obtuvo un título de posgrado

Nivel de educación más alto que ha obtenido la papá: (circule uno)
Menos que la educación secundaria
Terminó la escuela secundario
Completó 2 años o más de universidad o
completó una escuela de comercio
Completó 4 años de universidad
Obtuvo un título de posgrado

APPENDIX E

Feedback Results Page

Test of Everyday Attention (TEA-Ch) U.S. Validation Research Study

Summary of Individual Child's Results

Child's Name: ______________________ Child's Age: ________ Date of Testing: ______________________

	Scaled Score																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Selective/Focused Attention																			
• Sky Search																			
o Number of correctly identified targets																			
o Time per target																			
o Attention Score																			
• Map Mission																			
Sustained Attention																			
• Score!																			
• Score DT																			
• Walk, Don't Run																			
• Code Transmission																			
Divided Attention																			
• Sky Search DT																			
Attentional Control / Shifting Attention																			
• Creature Counting																			
o Total Correct																			
o Timing Score																			
• Opposite Worlds																			
o Same World Total																			
o Opposite World Total																			

Scaled scores between 7-13 are classified as average or at an expected level for your child's age. Scaled scores less than 7 are below an expected level for your child's age and scaled scores greater than 13 are above an expected level for your child's age.

Selective/Focused Attention – the ability selectively focus attention on something "important" to pay attention to, while ignoring things that are not important to pay attention to. An example would be paying attention to a school lesson rather than noises of cars driving by the school.

Sustained Attention – the ability to stay of task for a prolonged period of time. An example would be a child's ability to concentrate on a video game for a long period of time.

Divided Attention – the ability to respond to more than one task or an event at a time. An example would be a child responding to a question while playing a video game.

Attentional Control / Shifting Attention – the ability to consciously reallocate attentional resources from one activity to another. An example would be a child transitioning from one school task to another.

These results are intended for research purposes and are not to be used for diagnosing attentional processing disorders. If you have concerns about your child's performance on this test, consult with a school psychologist, an educator, or a family physician.