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Factor Structure of the CPT-II

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THE FACTOR STRUCURE OF THE CPT-II

By

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ABSTRACT

The current study investigates the factor structure of the Conners' Continuous Performance Test-II (CPT-II) in four pediatric samples of participants: (a) patients with traumatic brain injury, (b) healthy controls, (c) patients with various clinical diagnoses, and (d) all of the previously mentioned subjects combined. Confirmatory factor analyses (CFA) were used to investigate a one-, three- and four-factor model fit of the data. None of the models examined were an adequate fit for the data; however, it appears that the four-factor model seemed to be the best fitting of the models examined. Failure to find reasonably adequate fit precluded further analyses.

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CHAPTER 1: INTRODUCTION

Impairment in attention is a common presenting complaint in pediatric populations associated with impairments in several reals of functioning. Attentional problems in children have been linked to academic underachievement, lower overall educational attainment, delinquency, social difficulties, and familial problems, to name a few (Hinshaw, 1992; Low & Feldman, 2006; Dupaul, McGoey, Eckert, & Vanbrakle, 2001). Pediatric traumatic brain injury (TBI) is often associated with long-term impairment in several cognitive processes, with attentional difficulties being the most frequently reported. Head trauma in pediatric populations is the leading cause of death and disability in the United States, and requires 450,000 emergency room visits per year (Keenan & Bratton, 2006).

Attention is a complex, neurocognitive construct consisting of several components. As William James (1890) elegantly put it:

> Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of the consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state… (p. 403)

James's description highlights two important elements of attention: making a decision to narrow the stimuli in one's awareness and focusing on the chosen stimuli while excluding others. Theories of attention have forged the way for empirical exploration of the components of attention. Zubin (1975) proposed a three factor model of attention: Focus, Sustain, and Shift. Mirsky and colleagues (1991) built upon Zubin's work and proposed a four factor model of attention: Focus/Execute, Sustain, Shift and Encode. This model of attention was empirically supported using principle component analysis and confirmatory factor analyses in several clinical populations (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Park, Allen, Barney, Ringdahl, & Mayfield, 2009). Additionally, factor scores based on this model have been proven to differentiate clinical from non-clinical populations (Thaler, Allen, McMurray, & Mayfield, 2010).

The Conners' Continuous Performance Test-II (CPT-II; Conners & MHS Staff, 2000) is a widely-utilized, convenient, and well established test of attention. The CPT-II is among the most commonly administered neuropsychological tests, particularly with regard to assessment of attention (Rabin, Barr, & Burton, 2005). It is easy to administer and has well-established psychometric properties (Conners & MHS Staff, 2000). The CPT-II belongs to the larger category of continuous performance tests (CPT's) which were initially created to test sustained attention, or vigilance. Many CPT's require the participant to respond to relatively infrequent targets selected from a larger set of non-targets. The CPT-II is a "non-X" test, meaning that a response is required for the majority of the presented stimuli and withheld for X's. Non-X paradigms are a relative minority among CPT's: in a review of tests of continuous performance listing over 150 different tests, only seven of them were non-X CPT's (Riccio, Reynolds, & Lowe, 2001).

While non-X CPT's of continuous performance are often grouped with other CPT's, it is worthwhile to consider how differences in signal to noise ratio may alter the constructs measured. For example, by having the participant respond to all of the letters presented with the exception of the "X," the CPT-II increases the motor demands of the task and relies more heavily on response inhibition. Ballard (2001) makes a compelling argument that CPT-II commission errors, or responses to an "X", more closely resemble failures in inhibition after a pre-potent response has been established than impulsivity. Others, however, conceptualize commission errors on the CPT-II as inattention or impulsivity (Strauss, Sherman, & Spreen, 2006). Thus, there is some disagreement about the construct commission errors represent.

Factor analysis is an effective methodology for exploring how the variables of the CPT-II relate to each other to better understand the relationship between the construct and the variables. Factor analysis is a statistical technique that is commonly used to analyze the validity of psychological and neuropsychological measures. As factor analysis allows for the grouping of several variables, it has the benefits of providing data reduction, decreasing the probability of making a Type I error by grouping variables into factors and reducing the number of comparisons, and investigating construct validity (Thompson, 2004). Additionally, factor analysis has been used in theory development and to parsimoniously summarize relationships between variables (Fabrigar, Wegener, MacCallum, & Strahan, 1999). Exploratory factor analyses (EFA) is generally considered more useful in the early stages of research. Confirmatory factor analysis is used when there is adequate theory to provide expectations about the nature, number, and correlations of the underlying factors (Thompson, 2004).

To date, there has only been one published study examining the factor structure of the CPT-II. An EFA of a clinically heterogeneous adult sample reported a five-factor solution for the CPT-II scores (Egeland & Kovalik-Gran, 2010a). The total sample consisted of 376 people between the ages of 14 and 77 who met various DSM-IV-TR (American Psychiatric Association, 2000) criteria for various disorders, including attention deficit hyper activity disorder (ADHD), schizophrenia, affective disorders, learning disorders, traumatic brain injury, mild mental retardation, and healthy control subjects. Results of the factor analysis yielded five factors that were labeled Focus, Hyperactivity/Impulsivity, Sustain, Vigilance, and Change in Control. All of the factors except Vigilance differentiated between the clinical and non-clinical groups (Egeland & Kovalik-Gran, 2010b). In terms of the criterion validity, scores on the Focus factor were the only scores that correlated with other neuropsychological tests of attention. Overall, these results lend some support for a four or five factor solution of the CPT-II.

This work will use CFA to determine if the factor structure of the CPT-II can be replicated in clinical and non-clinical pediatric samples, or if the data are better accommodated by other models. Previous research has demonstrated that neuropsychological tests can have different factor structures in healthy controls and children who have sustained TBI (Woodward & Donders, 1998; Allen, Thaler, Barchard, Vertinski, & Mayfield, 2012), therefore, the factor solution obtained cannot be assumed to extend to other populations without empirical support.

Understanding the constructs measured by the CPT-II is especially important in light of its relatively less common paradigm and the frequency of its use.

The aim of the current study is to apply CFA to examine the latent factor structure of the CPT-II in four pediatric groups: 1) TBI; 2) heterogeneous clinical group presenting for neuropsychological evaluation; 3) healthy controls; and 4) an overall sample of all of these populations combined. This study is intended to provide factor support and refinement; testing the fit of a known factor structure in a new population and testing the fit of alternative factor models (DiStefano & Hess, 2005). Comparing the factor structure derived from each of the four samples is intended to shed light on how the CPT-II factor structure is impacted by the homogeneity of the population and the extent to which clinical conditions may impact the abilities being tested. In addition to exploring the factor structure of the CPT-II, the current study aims to provide external validation for the factor solutions by correlating the derived factor scores with well-established neurocognitive measures and behavioral assessment scales. Thus, the current study extends the findings of prior research by examining CPT-II factor structure and construct validity in children affected by TBI, and other pediatric clinical populations and healthy controls.

CHAPTER 2: LITERATURE REVIEW

Before delving into the specifics of the study, it is important to establish what is intended by the term "attention." Next this literature review will discuss the mechanisms of traumatic brain injury (TBI) and its effects on attention in children and adolescents. Finally, the CPT-II itself will be introduced. This section will focus on studies that have explored its psychometric properties, with specific focus on research looking at factor analyses of the CPT-II.

Theories of Attention

It is important to theoretically and empirically disentangle the concepts of attention and executive function. Ricco and colleagues (2002) define attention as a multi-component process that consists of initiation/focus, sustainment, and shifting of attention, and inhibition of irrelevant stimuli. These components of attention are interrelated and interdependent, therefore testing them in isolation can be challenging. Additionally, attention is difficult to disentangle from executive function which is an umbrella term for constructs such as inhibition, set shifting, working memory, planning, and fluency, to name a few (Sergeant, Geurts, & Oosterlaan, 2002). Review of pediatric journals revealed that numerous neuropsychological instruments were listed as both measures of attention and executive functioning, with tests of continuous performance among them (Morris, 1996). Overall, a sound theoretical basis that provides heuristic value and lends itself to scientific investigation is helpful when conceptualizing the cognitive functions assessed by neuropsychological instruments.

Zubin (1975) proposed that attention consists of three distinct components: Focus, Sustain, and Shift. This model was established on the basis of six observations: 1) attention is continuous; 2) it fluctuates in intensity; 3) it varies with arousal level; 4) it can be divided among different attributes of a situation; 5) it can be directed towards internal or external stimuli; and 6) responses to stimuli have different propensities. Focus is the component of attention that separates relevant and irrelevant stimuli. Sustain is the maintenance of focus once an attentional target is selected. Lastly, Shift is the mechanism that allows for switching between items. Zubin

(1975) found differential impairment in attentional processes by demonstrating that individuals with schizophrenia had significantly slower response times when asked to switch between responding to auditory or visual stimuli, compared to response times to stimuli presented in only one sensory modality. Differences in response times between the switching and unitary stimuli presentations were significantly greater for schizophrenia patients compared to healthy controls, which Zubin interpreted to indicate that the patients found the switching task to be more difficult and concluded that the patients are impaired on the Shift component relative to the healthy controls. No impairment was detected for Sustain or Focus, suggesting that attention is a non-unitary process.

Other theories of attention have been based in neurobiology and cognitive science, drawing from work with healthy controls, individuals who have sustained TBI, and macaque monkeys. Despite methodological differences, like Zubin, Posner and Petersen (1990) proposed three components of attention: orientation of the sensory systems, detection of signals, and maintenance of vigilance each supported by distinct neurobiological regions. Posner and Petersen (1992) proposed that the orienting component of attention is supported by the parietal lobe, midbrain, and pulvinar. The anterior cingulate system and medial frontal cortex are involved in target detection, while sustained alertness depends on the norepinephrine pathways that arise in the locus coeruleus and are more lateralized in the right hemisphere. Posner and Petersen reasoned that localized damage should lead to distinct neurocognitive impairments in attention.

Mirsky (1996) proposed a system of restricted taxonomy of attentional functions, identifying specialized systems of neural structures underlying each of the aspects of attention and allowing for distributed attentional functioning. Mirsky used principle component analysis on tests of attention completed by a heterogeneous clinical sample of neuropsychiatric adult patients and healthy controls (*n*=203) and a large, non-clinical sample of school children (*n*=435) (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991). The factor structures obtained from these groups of subjects were quite similar to each other (some differences were expected as different testing batteries were used to test the adults and children). The obtained factor solutions confirmed the presence of the three factors proposed by Zubin, and suggested a fourth factor, Encode*,* which consisted of variables measuring recall, sequential registration, and mental manipulation.

Mirsky and colleagues (1991) presented a model based on human and animal research of the cerebral regions associated with components of attention. Within the Focus/Execute component, Focus was reliant on the superior temporal and inferior parietal cortices, and corpus striatum, while inferior parietal and corpus striatal regions were hypothesized to carry out the Execute component. The Focus/Execute component maintains the processing of task elements and motoric responding in distracted conditions. The Sustain component of attention, or the ability to sustain alertness and consciousness, was hypothesized to be sub served by rostral midbrain structures, including the mesopontine reticular formation and midline and reticular thalamic nuclei. The prefrontal cortex was associated with the shift component of attention, or the capacity to switch one's attention from one stimulus to another. Encode is defined as sequential registration, recall, and mental manipulation, and is supported by the hippocampus and amygdala.

Traumatic Brain Injury: Mechanisms and factors affecting severity

TBI in children differs in many ways from adult TBI. The plasticity of the developing skull is both a risk and a protective factor. Greater plasticity allows the child skull to better absorb initial impact and accommodate more intracranial swelling than an adult skull (Pinto, Poretti, Meoded, Tekes, & Huisman, 2012). While this may be a protective factor in accidents involving mild to moderate force, in accidents with greater force the plasticity of a child's skull provides less resistance likely results in greater neuronal sheering of the internal structures relative to an adult skull.

Another distinguishing factor is that children's heads are proportionally larger in relation to their bodies than adults'. Larger heads relative to smaller bodies and weak neck muscles make infants more susceptible to whip-lash and counter-coup injuries than adults (Pinto, Poretti, Meoded, Tekes, & Huisman, 2012). Children also have higher water content in their brain relative to adults, which makes their brains softer, and more susceptible to injury. This vulnerability decreases with age as the brain continues to mylinate and becomes more structurally sound.

The brain mylinates in a predictable manner, with the central and occipital regions mylinating first, and the frontal lobes mylinating last. These developmental factors may explain why components of attention may be differentially vulnerable to TBI depending on when TBI was sustained (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991). Thus, adult and child TBI are distinct phenomena that must be examined separately. Additionally, the role of the factors (e.g., ratio of head to body) discussed varies with age in early development, warranting a closer examination of how age and force of impact may affect cognition following TBI.

There are several harmful neurological processes associated with TBI. Because a thorough discussion is beyond the scope of this literature review, only a brief overview of the most common mechanisms of injury is provided. Subdural hematomas (SDH) form in the space between the arachnoid and dura matter and could result from direct impact, inertia shearing, or rotational forces. Pediatric SDH's are more likely to occur bilaterally and tend to cause more extensive damage relative to SDH in adults because child brains have less adhesive structures (Pinto et al., 2012). Diffuse axonal injury (DAI) is characterized by widespread axonal damage across several brain regions and is the result of sheer forces in the brain. DAI more typically affects the subcortical white matter in the frontal and parietal regions, corpus callosum, basal ganglia and internal capsules, while sparing the overlying cortex (Pinto et al., 2012). DAI is associated with worse functional outcome than focal injury and physical signs of DAI are detectable in the chronic phases of pediatric TBI following mild, moderate and, severe injury particularly in the inferior frontal, superior frontal, and super collosal regions (Suskauer & Huisman, 2009). Extent of DAI has been shown to be directly correlated with neurocognitive performance, motor speed, and parental ratings of behavior in the expected direction (Wozniak et al., 2007). Given the variability in the types of injuries incurred, these mechanisms are useful to keep in mind as contributing to the damage observed.

Severity and age of injury, and time since injury have been proposed as mediating factors on the effects of TBI on attention. There are several challenges to drawing conclusions based on the current state of the field of TBI research, including considerable variability in how authors define attention, the measures used, differences in the ages of the children in the studies, time since injury, the type of injury acquired, and how the participants are classified. The most commonly researched factors are age of injury, severity, and time since injury. Babikian and Asarnow's (2009) meta-analysis of 28 studies examining neurocognitive functioning following pediatric TBI report impaired attention following mild, moderate, and severe TBI. There was insufficient data to examine the relationship between age of injury and neurocognitive performance. Various degrees of attentional impairment persisted 2 years after injury. The authors reported that impairment in attention after severe TBI became more pronounced 2 years following injury, which may result from either missed opportunity to learn and develop age appropriate skills (possibly due to hospitalization), or that damage to neural systems was previously undetected because abilities relying on these neural systems were not examined because they were not expected to emerge, or a combination of the two processes.

Preliminary functional magnetic resonance imaging (fMRI) findings suggest that moderate to severe TBI in early childhood may cause lasting changes in neurological functioning. Kramer et al. (2008) examined five children who sustained moderate to severe TBI in early childhood years after the injury. Children recovering from TBI achieved the same level of performance as age-matched orthopedically injured controls on a test of continuous performance that requires the participant to respond to the second of two matching numbers. Additionally, the two groups performed comparable on other tests of attention and behavioral ratings completed by parents were comparable. The fMRI findings indicate that the children who have sustained TBI recruited the same brain regions as the control to complete the task, and that over activation was detected in the parietal and frontal regions. Over activation in chronic phases of TBI in the context of intact behavioral performance has also been reported on tests of working memory in adults (McAllister, Sparling, Flashman, Guerin, Mamourian, & Saykin, 2001) and a verbal generation task in children (Karunanayaka et al., 2007).

Findings regarding the impact of moderate to severe TBI on attentional processes are varied. The majority of studies currently estimate injury severity using the Glasgow Comma Scale (GCS; Teasdale & Jennet, 1974) which yields a score reflecting injury severity based on level of consciousness and ocular, motor, and verbal responsiveness at time of injury. Scores range from 3-15 with injuries in the range of 3-8 typically considered severe, 9-12 moderate, and 13-15 considered mild. Impairment in the Sustain component of attention is associated with injury severity across auditory and visual modalities in children 6 years following moderate to severe TBI (Anderson, Fenwick, Manly, & Robertson, 1998). Children who sustained severe TBI exhibited worse performance on the Focus/Execute and Shift components than children who suffered mild or moderate injury (Ewing-Cobbs et al., 1998). Furthermore, significant differences were detected between healthy controls, mild-to moderately injured children, and severely injured children on the Shift component of attention, while the Focus, Encode, and Sustain only differentiated between the TBI and healthy control group (Park, Allen, Barney, Ringdahl, & Mayfield, 2009). Additional analysis revealed that greater injury severity was associated with worse performance on the Shift and Focus components only. Only one study reviewed by Babikian and Asarnow (2009) reported neurocognitive impairment five years after mild TBI in children who were injured between the ages of 2-7; however, findings for long-term impairment in attention following severe TBI were consistently reported (Catroppa, Anderson, Morse, Haritou, & Rosenfeld, 2007).

Several lines of evidence indicate that injury severity and age of injury may combine in ways that exacerbate TBI in children. A “double hazard” model of brain injury postulates that younger age of injury and more generalized injury are more likely to result in less neurocognitive recovery and reduced general intellectual capacity (Anderson, Catroppa, Morse, Haritou, & Rosenfeld 2005). It is not clear to what extent these findings apply to attention. Aggregate findings in neurobiology indicate that injury to the pediatric brain undermine vulnerable processes of developmental plasticity by causing faulty transmission, alterations in molecular signals, necrotic and apoptotic cell death, changes in neural conductivity and function, inhibition of experience dependent ‘good’ plasticity, and activation of self-propagating ‘bad’ plasticity, which includes several processes that can lead to seizures caused by over excitation (Giza & Prins, 2006).

Assessment is further complicated by the fact that some deficits are not always readily apparent following TBI and may emerge years after injury. Several factors may contribute to this finding, including reduced rates of skill acquisition, which results in under performance when the child is compared to normally developing peers. “Growing into the lesion,” or the idea that damage will not be apparent until an ability is supposed to be demonstrated, may also explain this phenomena.

Overall, TBI is a heterogeneous process. Younger age of injury and greater injury severity have been consistently associated with worse neurocognitive prognosis. Methodological differences between studies and the practical difficulty of recruiting children with comparable injuries complicate progress in this area of study.

Tests of Continuous Performance

Tests of continuous performance have been widely utilized since Rosvold developed the first version in 1956 (Rosvold, Mirsky, Sarason, Branson, & Beck, 1956). Initially, CPT’s were used to investigate “microsleeps,” or periods of inattention, in soldiers with combat related brain injury. Gradually, use of CPT’s expanded to include other neuropsychiatric and clinical populations including patients with epilepsy, schizophrenia, ADHD, narcolepsy, sleep disturbances, and uremia (Mirsky & Duncan, 2009). Traditional tests of continuous attention require the participant to watch a computer screen, monitoring the appearing stimuli for the target, or sequence of targets, and respond. In this context, the participant's failure to respond to the target is considered an omission error. When the subject responds when no target is present this is referred to as commission error. There are many variations of this paradigm including degraded stimuli, auditory presentation of stimuli, a stimulus becoming a target only in the context of a preceding signal (i.e., AX-CPT; Rosvold et al.,1956), or a stimuli being a target only if it is repeated (CPT-Identical Pairs; Cornblatt, Risch, Faris, Friedman, & Erlenmeyer-Kimling, 1988).

Factors that affect performance on traditional CPT's have been broadly categorized as one of the following: 1) task parameters; 2) participant characteristics; or 3) environmental conditions (Ballard, 1996; Ballard, 2001). Longer task duration, infrequent target presentations, low signal-to-noise ratios, multiple sources of information, difficult to detect stimuli, faster speed of stimuli presentation, shorter inter-stimulus interval (ISI), and shorter duration of stimuli presentation are task parameters that increase difficulty and are associated with worse performance on CPT's (Ballard, 2001). In terms of individual factors, age, general alertness (as could be influenced by level of fatigue, medications, etc…), socioeconomic status, academic achievement, and diagnosis, affect CPT performance. Lastly, environmental effects on CPT's are not well understood, as inconsistent effects have been reported. Overall, it is useful to keep in mind that CPT performance is sensitive to several environmental and subject related factors.

Tests of continuous performance demonstrate sensitivity to brain damage or dysfunction, with diffuse damage resulting in worse performance than localized lesions (Ricco, Reynolds, Lowe, & Moore, 2002). Findings in several clinical populations, including adult and pediatric TBI, seizure disorders, and individuals with strokes, concluded that impaired performance on CPT's reflects degree of damage, as opposed to being process specific (Ricco, Reynolds, Lowe,

& Moore, 2002). Disorders associated with non-localized neural dysfunction are associated with worse CPT performance, including schizophrenia, ADHD, Autism, mental retardation, and seizure disorder (Riccio & Reynolds, 2003). Generally, it is found that CPT's have good sensitivity to attentional problems, but lack specificity, and cannot be used as a diagnostic tool (McGee, Clark, & Symons, 2000; Homack & Reynolds, 2005). Collective findings suggest that CPT's are sensitive to general dysfunction in the central nervous system. Children with TBI have been reported to have slower response time, greater standard errors of response time, and a make more errors on CPT's (Fenwick & Anderson, 1999).

Conners' Continuous Performance Test-II

The second version of Conners' Continuous Performance Test (CPT-II) has several strengths as both a research and a clinical tool. First, the standardization sample has been expanded with the addition of more adult cases and a neurologically impaired group, which can be used as a reference group. The standardization sample consists of 2,686 healthy controls and clinical comparison subjects, which allows for the clinician to compare a subject's performance to both healthy and impaired populations. It is appropriate for use with people who are 6 years old and older.

The CPT-II may yield more reliable findings than other versions of the CPT. Letters are presented on the screen one at a time and the subject is instructed to respond by either clicking the mouse or space bar to every letter except for the "X" as quickly as possible. The authors of the test reason that increasing the number of responses (relative to traditional CPT's which require only occasional responding) reduces floor effects, and increases confidence in the conclusions drawn from the results because they are based on a greater set of responses (Conners & MHS, 2000). The test takes 14 minutes to complete.

The CPT-II assesses performance at inter-stimulus intervals of 1, 2, and 4 seconds, with a stimulus presentation time of 250 milliseconds. The letters are organized into six blocks, which are composed of three randomly ordered sub-blocks each containing 20 letters. Each sub-block presents stimuli at the same inter-stimulus interval (ISI). Thirty-six out of a total of 360 letters presented during the test are X's, which means that 90% of the stimuli are targets. Each sub-block has two targets. The CPT-II produces several variables summarized in Table 1. Additionally, the CPT-II creates a performance index that indicates how closely a participant's performance matched a clinical group. These indices are not included in Table 1 since they were not available for this study.

Table 1

CPT-II Variables

Type of Measure	Variable and Classification	Definition	Interpretation
Error	Omission (A)	Number of targets that were not responded to	High t-score indicates more omissions
	Commission (A, M)	Number of X's responded to	High t-score indicates more commissions
	Perseveration (A, M)	Response occurring less than 100 ms after stimulus presentation	High t-score indicates more perseverations
Signal Detection	Delta (A)	Difference between distribution of responses to X and non-X stimuli	High t-score indicates poor ability to discriminate X and non-X
	Beta	Response Style ; speed-accuracy trade off	Higher values (t-score >60) reflect more cautious response style
Response Time	Overall Hit Rate Response Time (A, M)*	Mean response time to targets	High t-scores indicate slow responding Low t-scores indicate fast responding
	Hit Response Time Block Change (A)*	Slope of response times by block	High t-scores indicate increased response time as test progressed
	Hit Response Time ISI Change (A)*	Slope of response time by ISI	High t-cores indicate increased response time with longer ISI
Variability of Response Time	Standard Error of Response time (A)*	Standard error of response times	High t-scored indicate high variability
	Variability of Standard Error (A)*	Standard deviation of the standard error values for each sub block	High t-scores indicate low consistency
	Hit Standard Error Block Change (V)*	Slope of change in reaction time standard error over block (1, 2, 3)	High t-scores indicate less consistency as test progresses
	Hit Standard Error ISI Change (V)*	Slope of change in reaction times standard errors over the three ISI's (1, 2, and 4 ms)	High t-scores indicate more erratic responding with longer ISI's

Note. * = Log transformed; A= Inattention; M = Impulsivity; V = Vigilance; ISI= inter-stimulus interval.

The CPT-II measures three aspects of performance: errors, reaction time, and response time consistency. Response time is used as an index of target processing efficiency (Conners & MHS, 2000). The variable ISI's utilized in the CPT-II are believe to force the participant to keep adjusting anticipatory set, which changes reaction time variability (Conners & MHS, 2000). However, Ballard (2001) argues that while the ISI varies between sub-blocks, its consistency within sub-blocks gives the participant enough (there are 20) trials to adjust and may not have an effect on performance (Ballard, 2001).

Response inconsistency has been linked to both developmental and disease related processes. Response inconsistency, or variability in reaction time, may be a result of a population difference (e.g., older adults have more response variability than younger adults), within-person task variability (e.g., different levels of variation on separate tasks), or within-person variability on a single task (e.g., fatigue) (Williams, Hultsch, Strauss, Hunter, & Tannock, 2005). Variability due to a specific process (e.g., inattention or fatigue) can be difficult to disentangle from an individual's baseline level of variability. A U-shaped function best captures the relationship between reaction time inconsistency and age on a measure of inhibitory control, with both younger (6-8 year old) and older (60-81 year old) participants having highest levels of variability (Williams, Hultsch, Strauss, Hunter, & Tannock, 2005). It was also found that younger children had more variability in conditions requiring slower responses compared to older children and young adults (Williams et al., 2005; Leth-Steensen, King Elbaz, & Douglas, 2000). For example, boys with ADHD had higher levels of response inconsistency in their slow responses compared to healthy controls (Leth-Steensen, King Elbaz, & Douglas, 2000). This finding remained significant even after controlling for the effects of processing speed, practice, and fatigue. The authors hypothesize that this may be due to age related changes in neural-noise of the catecholamine system. If this link is accurate, investigating changes in response consistency would be a good tool in clinical populations.

Variables of the CPT-II based on reaction time were log transformed (as indicated in Table 1; Conners & MHS, 2000). The scores are expressed as t-scores and percentiles. The obtained t-scores are relative to an age and gender matched subsample of subjects. The age intervals are as follows: 6-7, 8-9, 10-11, 12-13, 14-15, 16-17, 18-34, 35-54, and 55+. T-scores of 65 and over reflect markedly atypical performance, while T-scores under 40 are very good in most cases with some exceptions: low scores on hit response time may reflect impulsive responding, while lower scores on Beta may reflect a more conservative response style (Conners & MHS, 2000).

As previously mentioned, the CPT-II requires the participant to respond to all of the letters presented except for the “X,” therefore the desired behavior is to withhold an established response, otherwise known as a pre-portent response. According to the authors of the CPT-II, increasing the number of responses has the benefit of increasing the number of correct responses, and decreasing floor and ceiling effects (Conners & MHS Staff, 2000). Due to the change in paradigm, definitions of several variables are fundamentally different. Omission errors reflect a failure to maintain a habitual response and commission errors represent failure to inhibit the habitual response. Also, due to the change in signal to noise ratio, reaction time captures the subject’s ability to maintain a pre-potent response, as opposed to reflecting speed of detection as is true for traditional CPT’s. Therefore, it is important to understand what the CPT-II is measuring in order to accurately interpret the variables it produces.

There is also concern that variable ISI’s can have unknown effects on subject performance. Variable ISI’s are not typical in CPT’s, therefore this aspect of the test is not well researched. Because the CPT-II is composed of blocks that each contain the same ISI, a participant will spend more time on the blocks that have a longer ISI, which may present a task duration confound. To address these differences Ballard (2001) compared the performance of healthy undergraduates on the CPT-II and two versions of the AX test: AX slow and AX fast tests, and found that participants had higher omission error rates, slower response times, less variability, and a different decrement in the vigil pattern on the CPT-II than were observed on the either of AX test. Based on these differences Ballard (2001) concluded that the CPT-II more closely measures executive control of attention in a population of college students than other CPT’s. It is unclear if these findings generalize to pediatric or clinical populations.

Response inhibition is a multifaceted construct. Evidence for dissociable processes of inhibition comes from unique developmental trajectories for processes of inhibition, and distinct patters of inhibition failure in clinical populations (Dimoska-DiMarco, McDonald, Kelly, Tate, & Johnstone, 2014; Sinopoli, & Dennis, 2012). The ability to withhold a prepotent response is a form of effortful inhibition called response restraint and is indirectly measured by the number of commission errors on go/no-go tasks (Sinopoli & Dennis, 2012). More commission errors on go/no-go paradigms following TBI have been found in children with severe TBI but not milder injuries (Sinopoli Schachar, & Dennis, 2011; Levin, Hanten, Zhang, Swank, & Hunter, 2004).

Several studies have used variables of the CPT-II to represent Sustain factors in investigations of attention in pediatric populations. In the models of attention investigated by Park and colleagues (2009) Variability and Block Change Standard Error composed the Sustain factor in the best fitting model of attention in a sample of pediatric TBI. This factor, as well as the other factors examined, was sensitive to brain damage when compared to a sample of healthy control children. Similarly, Thaler and colleagues (2010) used the same variables to represent the Sustain factor and demonstrated significant differences on sustain in various clinical pediatric populations. It is feasible that these measures of response variability over the duration of the test represent Sustained attention, however, this is difficult to conclude based on these studies, as these were the only variables from the CPT-II and may have loaded on the same factor due to method effects.

Psychometric Properties of the CPT-II

The consistency of the scores of the CPT was examined using split-half reliability, test-retest reliability, and standard error of measurement. Split-half reliability for the first version of the CPT-I was examined in a sample of 520 healthy controls; results of the first nine sub-blocks were compared the last nine (Conners & MHS, 2000). The best reliability was for hit reaction time (*r* =.95), while the lowest was for variability (*r* =.66). The rest of variables were intermediate: omissions (*r* =.94), standard error (*r* =.87), commissions (*r* =.83), *d'* (*r* =.83) and Beta (*r* =.73). As the task parameters have not changed between the CPT and CPT-II, these results are expected to apply to the majority of the variables of the CPT-II as well. However, *d'* and Beta may be less consistent since new formulas were used to compute them. Test-Retest reliability over an average of three months was based on a total of 23 individuals (10 healthy controls and 13 individuals with "a variety of clinical diagnoses"; Conners & MHS, 2000). In this sample, two subjects were excluded for highly inconsistent results. The variables with highest test-retest reliabilities were: the Confidence Indices (Neuro: r =.92; ADHD: r =.89), Omissions (r =.84) and Detectability (r =.76). Scores with the lowest reliability were Hit SE ISI Change (r =.05), Hit SE BC (r =.08), Hit RT BC (r =.28). These results suggest that these variables may have poor reliability across administrations. The rest of the scores had highly satisfactory split-half reliability. Omission errors were found to have good test-retest reliability in a sample of adults diagnosed with ADHD (Soreni, Crosbie, Ickowicz, & Schachar, 2009). Internal consistency was examined in a sample of 39 healthy control children and adolescents over a mean of 6.4 months. Interclass coefficients were reported to be .39 for errors of commission, .48 for variability of standard error, .57 for commissions, .65 for hit rate reaction time, and .33 for '*d*. Given the normal variability in attention, lower test-retest reliability is somewhat expected.

Factor Structure of the CPT-II

There has been only one study examining the latent factor structure of the CPT-II (Egland and Kovalik-Gran, 2010a). The importance of this type of investigation stems from the observation that attention is a multicomponent construct, and that the CPT-II produces a number of scores which relate to different aspects of attention. Thus, a clearer understanding of the factor structure of the CPT-II would allow for more precise and informative interpretation of test results in clinical settings and more targeted application of the CPT-II in research of attention. Egland and Kovalik-Gran used EFA in a sample of 376 participants with various diagnoses: 310 participants referred for neuropsychological assessment and 66 individuals referred for assessment on an in-patient ward for early onset psychosis. The sample was clinically heterogeneous, and included diagnoses of ADHD, schizophrenia spectrum disorders, affective disorders, mild cognitive disorder, nonverbal learning disorder, learning disorder, TBI, and people without any diagnoses. The subjects were an average of 32.9 years old (*sd*= 13.8).

To better interpret the factor solution, variables used in the EFA will be reviewed next. In addition to using the majority of the CPT-II variables, the authors computed two new variables: change in omissions and change in commissions by subtracting performance on the last third of the test from that on the first third. Age- and sex-corrected T-scores for omissions, commissions, hit reaction time, hit reaction time standard error, variability of standard errors, perseverations, hit reaction time by block, hit reaction time standard error by block, hit reaction time ISI, and hit reaction time standard error ISI change. Detectability *(d')* was excluded from analysis to reduce the number of variables and because it was considered redundant as both omissions and commissions contributed to it. Although the authors reasoned that both omissions and commissions contribute to *'d,* no analyses investigating the relationship between the measures were reported. No other variables were reported to be considered for removal. No statistical tests were run to rule out the possibility of co-linearity.

A five factor solution was selected on the basis of Eigen values and scree plot examination. The scree plot lacked a decisive elbow and indicated between four and six factors and the Eigen value for the fifth factor was 0.99. The factors accounted for 74.4% of the variance. Additionally, two of the variables had salient loadings on more than one factor. Perseverations had significant loadings on Factors 1 and 2, and hit standard error block change loaded significantly on Factors 3 and 5, with a greater loading on Factor 3. Because hit rate block change's higher loading on Factor 3, it should rightfully load there, leaving Factor 5 as a "singlet," or a factor composed of only variable (change in commissions). The authors did not explain why they decided to include hit rate block change on Factor 5. The factors, listed in order of greatest to least variance accounted for, were named Focus, Hyperactivity/impulsivity, Sustain, Vigilance, and Change in Control.

Next, the validity of the factors obtained was examined in a mixed clinical sample and healthy controls (Egeland & Kovalik-Gran, 2010b). All clinical groups, including ADHD-combined type (ADHD-C), ADHD-inattentive type (ADHD-I), schizophrenia spectrum, affective disorders, brain injury, and people diagnosed with language disorders had differential patterns of performance on the factors derived. All of the clinical groups scored below the healthy control group on the Focus factor. Additional comparisons revealed that the ADHD-C group scored below the brain injury and schizophrenia spectrum group. The ADHD-C type group scored higher on the Hyperactivity/Impulsivity factor than the healthy control, brain injury, schizophrenia, and affective disorders groups. ADHD-I group scored lower than all of the other groups on Sustain; ADHD-C group scored below the brain injury group. No group differences were found on Vigilance. Both of the ADHD groups scored below the healthy controls, and the ADHD-C and brain injury groups scored below the schizophrenia and affective disorder groups on Change in Control. Factor scores where then compared to performance on criterion variables of Konx-cubes (Shum, McFarland, & Bain, 1990), Digit Forwards and Digit Backwards from WMS-R or WAIS-III (Wechsler, 1987; Wechsler 1997, respectively), Trail Making Test A & B (Reitan & Wolfson, 1993), Paced Auditory Addition Test (PASAT: Gronwall & Wrightson, 1975), and Stroop Color/Word Test (Golden, 1978). It was found that only Focus had significant correlations with performance on Digit Backwards, Trail Making Tests A & B, PASAT, and all three conditions of the Stroop (Color, Word, Color/Word). This was interpreted to suggest that the CPT-II does not simply measure a unitary construct of attention, but instead found support for construct validity for measured of focused attention, hyperactivity/impulsivity, sustained attention, and Change in Control.

There has yet to be an evaluation of the CPT-II factor structure in pediatric populations. As a result, it is not possible to disambiguate the various constructs that are assessed by this measure and how, in turn, these constructs are susceptible to disruption following TBI or other disturbance. Therefore, the current study has two main purposes. First, we aim to clarify the factor structure of the CPT-II in a large, well-characterized sample of children and adolescents who have sustained TBI, a mixed clinical sample, healthy controls, and all of the samples combined. Second, we aim to clarify these constructs by examining them in relation to other neuropsychological tests whose validity is well established, in order to provide evidence for convergent and discriminant validity of the CPT-II factors.

Hypotheses

Based on the literature it is hypothesized that:

1) The CPT-II will be composed of three factors reflecting focus, impulsivity, and vigilance constructs in the four samples tested.
2) In terms of convergent validity:
    a. Focus is predicted to correlate with PSI, PRI, and WMI on the WISC-IV; WJ-III Calculation; and CTMT scores. Additionally, it is predicted that this factor will be related to clinical variables (GCS).
    b. Impulsivity is predicted to correlate with BASC-II Hyperactivity rated by both the Teacher and Parent; Trials 3-5 on the CTMT.
    c. Vigilance is predicted to correlate with WJ-III Broad Reading and WMI on the WISC-IV.

CHAPTER III: METHODS

Subjects

Four pediatric samples were used for the current analyses: 1) children and adolescents with a number of clinical diagnoses, primarily neurological, or neurodevelopmental disorders; 2) a subset of the clinical cases consisting of children or adolescents who had sustained TBI only; 3) a sample of healthy control participants who were age and gender matched to the TBI sample; and 4) all of the subjects combined. The clinical samples were comprised of archival data of adolescents and children referred for neuropsychological evaluation at Our Children's House at Baylor in Dallas, Texas. Diagnosis of TBI was confirmed by medical examination. All of the evaluations were performed in a rehabilitation setting. The participants were medically stable and capable of completing assessment procedures at the time of the evaluation, which consisted of both neuropsychological and behavioral components. Identifying information was removed to protect participant privacy and a unique subject number was assigned. Demographic variables such as age, gender, ethnicity, and years of education, and clinical information, including diagnosis, date of injury, type of injury, and Glasgow Coma Scale Rating (Teasdale & Jennett, 1974) were also included.

The mixed clinical sample (MC) had participants with several diagnoses. A large portion of the participants had a primary and only diagnoses of TBI (*n* = 185). The remaining individuals had a primary diagnosis of anoxic episode (*n* = 7), attention deficit hyperactivity disorder (ADHD) (*n* = 40), arteriovenous malformation (AVM/stroke) (*n* = 27), cerebral palsy (*n* = 1), tumors (*n*=1), seizure disorder (*n* = 6), autism spectrum disorder (*n*=5), educational disturbance (*n* = 8), conduct or oppositional defiant disorder (*n* = 4), learning disorder (*n* = 15), and children with other neurological diagnoses (*n*=27).

Thirty-six people had a secondary diagnosis of ADHD (*n*=6), AVM/stroke (*n*=1), seizure disorder (*n*=2), autism spectrum disorder (*n*=1), conduct or oppositional defiant disorder (*n*=2), learning disorder (*n*=4), and other disorders (*n*=10). It is not known which patients were taking medications.

The second set of analyses included children with TBI who did not have any other complicating factors (*n*=173). This group was included to examine the stability of the CPT-II factor structure in a homogeneous clinical population. The majority of the subjects sustained a closed head injury (91.9%). The injuries had several causes: motor vehicle accident (49.1%), pedestrian hit by a car (14.5%), gunshot (4.0%), fall (11.0%), 4-wheeler accident (9.2%), bike accident (1.7%), skiing (1.7%), and other ways (7.5%). The mean Glasgow Comma Scale score was 6.29 (*sd* =3.29). Testing took place between one and 115 months after injury (mean = 17.4, *sd* =20.4).

The healthy control sample was age and gender matched to the TBI sample. The data were provided by Multi-Health Systems. The subjects in the sample were a mean of 12.41 (*sd*=3.06) years-old and 153 were males.

Data Analyses

Preliminary Analyses

Before proceeding with the main analyses the data set was examined for completeness and appropriateness of testing. Subjects with missing values were not included in further analyses. Normality, independence, and homoscedasticity were examined the all data. Skewness and kurtosis were also examined. T-scores exceeding 81 were changed to 81, while t-scores below 19 were changed to 19. Additionally, correlations between the variables were examined and compared across the four samples of subjects.

Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) was used to examine the latent variables of the CPT-II in the samples of children and adolescents described above. These models were run using EQs (Bentler, 1990). The main analyses included application of CFA procedures to available CPT-II variables in the four samples of subjects to determine the best fitting model in each of the groups. Model consistency will be used to evaluate factor invariance of the CPT-II across pediatric populations.

Three models were tested in each sample separately. The first model was a one-factor model that evaluates if the variables of the CTP-II measure the broad construct of attention. This model was considered an informed baseline model as it provides the most parsimonious solution. Additionally, CFA is not recommended if the unitary model cannot be ruled out (Kline, 1993). The next model tested was based on Zubin's (1975) theory of attention and contained three factors that reflected the constructs of focus, inhibition, and attention sustainment. Finally, a four factor model was examined. This model replicated the one reported by Egeland and Kovalic-Gran (2010a) using the variables available. The current work excluded the fifth factor reported by Egeland and Kovalic-Gran, since it consisted of a single variable, Change in Commissions. See Table 2 for summary of variable loadings in each of the models proposed. The three or four factor models applied to the data are expected to provide a better fit than the unitary model if the CPT-II variables are influenced by multiple constructs (e.g., vigilance, shifting) and their loadings are accurately specified.

Table 2

Proposed Analysis of the CPT-II

CPT-II Variable	Egeland & Kovalik- Gran	Hypothesized models		
		One Factor	3 Factor	4 Factor
Variability	1-Focus	1-Unitary	1-Focus	1-Focus
Hit RT SE	1-Focus	1-Unitary	1-Focus	1-Focus
Perseveration	1-Focus	1-Unitary	1-Focus	1-Focus
Commissions	2-H/I	1-Unitary	2-Shift	2-Shift
Hit RT	2-H/I	1-Unitary	2-Shift	2-Shift
BC SE	3-Sustain	1-Unitary	3-Sustain	3-Sustain
BC	3-Sustain	1-Unitary	3-Sustain	3-Sustain
Hit RT ISI	4-Vigilance	1-Unitary	1-Focus	4-Vigilance
Hit RT ISI SE	4-Vigilance	1-Unitary	1-Focus	4-Vigilance
Detectability	Not Used	1-Unitary	2-Shift	2-Shift

Note. RT = reaction time; SE = standard error; ISI = inter-stimulus interval; BC = Block change

Four statistics were used to assess model fit: Sartorra-Bentler Chi-Square (Satorra, 1990), Comparative Fit Index (CFI; Bentler, 1990), Root-Mean-Square Error of Approximation (RMSEA; Steiger & Lind, 1980), and the Akaike Information Criterion (AIC; Akaike, 1987). These indices were selected to measure different aspects of the model fit of the data. Sartorra-Bentler Chi-Square is used to assess model fit. To reduce the probability of making a Type I error, robust statistics were used to evaluate the solutions including the Sartorra-Bentler Chi-Square (Satorra, 1990) method of estimation. The Sartorra-Bentler Chi-Square multiplies the normal theory chi-square by a constant, which is determined as a function of the multivariate kurtosis, degrees of freedom, and residual weight matrix. It has been demonstrated to perform well in skewed and non-skewed data (Curran, West, & Finch, 1996; DiStefano & Hess, 2005). Non-significant chi-square indicates good model fit. The comparative fit index is an incremental measure comparing present model fit a baseline model represented on a scale between 0-1 with higher values indicating better fit of the current model. Adequate model fit is indicated by a CFI .95 for continuous data (Hu & Bentler, 1999). The RMSEA accounts for the complexity of the model and measures the degree of fit of the current model to the population covariance matrix. RMSEA also ranges from 0-1, with lower values indicating better fit. Values lower than .06 indicate good fit (Hu & Bentler, 1998). The AIC is a measure of model parsimony; lower values indicate better fit.

CHAPTER IV: RESULTS

The data were screened for missing variables and extreme scores. The mixed clinical (MC) sample consisted of 332 cases. Six cases were removed from further analyses due to missing data, leaving a total of 326 cases for analysis. To minimize the effect of outliers, all t-scores greater than 81 were changed to 81 and all T-scores less than 19 were changed to 19. This allowed the variables to retain their extreme positions, and reduce their impact on measures of central tendency. See Table 3 for the number of variables that were changed.

Table 3

Number of Outliers Changed by Group

	MC		HC	
Variable	Low	High	Low	High
Commissions	7	7	0	0
Hit RT	1	23	0	0
Hit RT SE	3	23	0	0
Variability	2	19	0	0
Detectability	6	8	2	0
Perseveration	0	27	7	0
BC	7	16	0	2
BC SE	4	10	0	0
Hit RT ISI	4	29	0	3
Hit RT ISI SE	2	14	0	1

Note.MC= Mixed clinical sample; HC = Healthy control sample; HR = Response time; SE= Standard error; ISI = Inter-stimulus interval; BC= Block change.

The results of the data after the outliers were changed are summarized below. Table 4 contains the mean, standard deviation, range, minimum and maximum values, and minimum and maximum z-scores for each of the CPT-II T-score normed variables.

Table 4

Descriptive Statistics for the Variables of the CPT-II

Variable	Mean	*SD*	Range	Min	Max	*z*-score	*z*-score
Commissions	49.79	11.65	62.00	19.00	81.00	-2.64	2.68
Hit HR	53.85	12.47	62.00	19.00	81.00	-2.79	2.18
Hit RT SE	54.84	12.33	62.00	19.00	81.00	-2.91	2.12
Variability	54.34	11.87	62.00	19.00	81.00	-2.98	2.25
Detectability	51.34	10.62	62.00	19.00	81.00	-3.05	2.79
Perseverations	51.98	10.38	53.04	27.96	81.00	-2.31	2.80
Hit RT BC	50.72	11.55	62.00	19.00	81.00	-2.75	2.62
SEBC	51.06	10.97	62.00	19.00	81.00	-2.92	2.73
RTISI	54.14	12.33	62.00	19.00	81.00	-2.85	2.18
SEISI	53.04	11.43	62.00	19.00	81.00	-2.98	2.45

Note. HR =Response time; SE= Standard error; ISI = Inter-stimulus interval; BC= Block change.

The data were assessed for normality by examining the skewedness and kurtosis of each variable. Values ranging from -1 to +1 are considered within normal range. See Table 5 for the skewness and kurtosis values of the CPT-II.

Table 5

Skewness and Kurtosis of the CPT-II Variables

Variable	Skewness	Kurtosis
Commission	-0.11	0.28
Hit RT	0.34	-0.28
Hit RT SE	0.23	-0.33
Variability	0.05	-0.18
Detectability	-0.26	1.18
Perseverations	1.53	1.85
Hit RT Block Change	0.29	1.08
Block Change SE	0.27	0.72
Hit RT ISI	0.39	0.10
Hit RT SE ISI	0.22	0.03

Note. HR =Response time; SE= Standard error; ISI = Inter-stimulus interval; BC= Block change.

Perseveration scores were marginally outside of this range for skewness (1.53) and kurtosis (1.85), and Detectability was marginally outside of the expected range on kurtosis only

(1.18). Since confirmatory factor analytic procedures are generally robust to these small variations from normality, variable transformation was not performed.

Linearity in the data set was assessed by examination of scatterplots. Due to the opposite directions of their skew, Perseverations (skew =1.53) and Detectability (skew = -0.26) are the variables most likely to have a curvilinear relationship. Examination of the scatterplot did not suggest a curvilinear relationship.

Correlations were examined in each sample to check for multicollinearity. The correlations between variability of standard error and hit rate standard error exceeded 0.9 in each of the samples (see Table 6). In the case of correlations of 0.9 or greater, Kline (1998) advised removing one of the variables as the two are considered redundant. Therefore, variability of standard error was removed from further analysis.

The consistently high correlation between variability of standard error and hit response time standard error across the four samples suggests that high correlation is not a function of idiosyncratic performance in clinical populations, but is rather a function of similarity of variable computation. Hit reaction time standard error is the standard error of the response targets, while the variability of standard error is standard deviation of the standard error values for each of the 18 sub-blocks. The CPT-II manual explained that the two measures usually produce similar results and advised that discrepancies between them be used to examine differences in overall response consistency and response variability over time (Conners & MHS, 2000).

Table 6

Pearson *r* Correlations between CPT-II Variables by Sample

Variable	Sample	HR	Com	HRSE	Var	P	RTBC	SEBC	RTISI	SEISI	D
HR	All	1									
	HC	1									
	MC	1									
	TBI	1									
Com	All	-.41 **	1								
	HC	-.37**	1								
	MC	-.45**	1								
	TBI	-.43**	1								
HRSE	All	.64**	.14**	1							
	HC	.62**	.22**	1							
	MC	.59**	.12*	1							
	TBI	.57**	.15*	1							
Var	All	.47**	.24**	.94**	1						
	HC	.43**	.32**	.94**	1						
	MC	.41**	.22**	.94**	1						
	TBI	.40**	.24**	.93**	1						
P	All	.24**	.36**	.64**	.61**	1					
	HC	.11	.46**	.60**	.58**	1					
	MC	.23**	.33**	.64**	.60**	1					
	TBI	.20**	.42**	.66**	.61**	1					
RTBC	All	.15**	.21**	.37**	.39**	.29**	1				
	HC	.11	.25**	.40**	.42**	.24**	1				
	MC	.14*	.20**	.35**	.37**	.29**	1				
	TBI	.07	.32**	.25**	.25**	.29**	1				
SEBC	All	.08*	.18**	.41**	.46**	.33**	.72**	1			
	HC	.04	.26**	.43**	.48**	.35**	.64**	1			
	MC	.07	.14*	.40**	.45**	.31**	.75**	1			
	TBI	.07	.24**	.42**	.44**	.44**	.64**	1			
RTISI	All	.47**	.07	.72**	.62**	.45**	.29**	.30**	1		
	HC	.49**	.18**	.76**	.65**	.48**	.31**	.29**	1		
	MC	.39**	.03	.65**	.55**	.39**	.27**	.29**	1		
	TBI	.29**	.11	.67**	.58**	.45**	.15*	.31**	1		
SEISI	All	.33**	.16**	.71**	.74**	.36**	.32**	.37**	.69**	1	
	HC	.39**	.14*	.74**	.70**	.34**	.31**	.40**	.70**	1	
	MC	.24**	.18**	.67**	.73**	.33**	.31**	.35**	.66**	1	
	TBI	.19**	.18*	.61**	.69**	.30**	.21**	.31**	.67**	1	
D	All	-.21*	.84**	.28*	.12**	.45**	.26*	.21**	.25**	.22**	1
	HC	-.22**	.83**	.23**	.29**	.37**	.26**	.19**	.20**	.13*	1
	MC	-.28**	.84**	.20**	.28**	.32**	.23**	.14*	.07	.24**	1
	TBI	-.25**	.85**	.23**	.32**	.36**	.33**	.23**	.15*	.27**	1

Note. Overall = all four samples combined; HC = Healthy Control; MC = Mixed Clinical; TBI = Traumatic Brain Injury; HR = Hit Rate Reaction Time; Com= Commissions; HRSE = Standard Error of Hit Rate Reaction Time; VAR= Variability of Standard Error;P= Perseverations; RTBC= Hit Rate Reaction Time by Block; SEBC = Hit Rate Reaction Time Standard Error; RTISI = Hit Rate Reaction Time by Interstimulus Interval; SEISI= Hit Rate Reaction Time by Interstimulus Interval; D = Detectability (‘*d*); * p<.05; ** p <.01

Confirmatory Factor Analysis

Model fit indices are presented in Table 7. Review of the results reveals that all of the models are a poor fit for the data as evidenced by the fact that all of the goodness of fit indices are out of acceptable ranges. The fit indices across the samples indicate improvement in fit for the three and four factor models over the unitary model, even though none of the values are in an acceptable range. These values also suggest that the four factor model may be a better fit than the three factor model in all four of the samples examined. Because none of the models were of adequate fit, no factor scores were obtained.

Table 7

Goodness of Fit Indices for the One-, Three-, and Four-Factor Models

Groups	Model	SB χ^2	df	CFI	RMSEA [90% CI]	AIC
Overall	Unitary	859.06	27	.54	.23 [.22-.25]	805.06
	3 Factor	348.69	24	.82	.16[.14-.17]	300.69
	4 Factor	274.36	21	.86	.15[.13-.16]	232.37
MC	Unitary	702.77	27	.40	.29[.27-.31]	648.77
	3 Factor	497.25	24	.74	.19[.17-20]	449.25
	4 Factor	476.93	21	.75	.20[.18-.21]	434.93
TBI	Unitary	355.94	27	.37	.26 [.23-.29]	281.94
	3 Factor	182.86	24	.67	.19[.17-.22]	134.86
	4 Factor	167.07	21	.70	.20[.17-.23]	125.07
HC	Unitary	604.19	27	.45	.30[.27-.32]	550.19
	3 Factor	324.52	24	.72	.23[.20-.52]	276.53
	4 Factor	297.64	21	.74	.23[.20-.26]	255.64

Note. SB χ^2 = Sartorra-Bentler Chi-Square; df = degrees of freedom; CFI = Comparative Fit Index; RMSEA = Root-Mean-Square Error of Approximation; AIC = Akaike Information Criterion; Overall = all of the samples combined; MC = mixed clinical sample; TBI = Traumatic brain injury sample; HC = healthy control sample.

CHAPTER V: DISCUSSION

None of the CFA models provided a good fit for the CPT-II data in the four participant samples analyzed. It is unclear from the current results why the CFA models did not fit the CPT-II data. Failure to find adequate model fit is unlikely due to the number of variables included, the sample size, or heterogeneity of the samples of the subjects. First, the models examined are all over identified; there are an adequate number of degrees of freedom (21 for the four factor, 24 for the three factor, and 27 for the four factor) to find a unique solution if a plausible fit existed (Kline, 1993). Simply put, the number of variables exceeds the number of parameters estimated. However, it is still possible that there are not enough variables *per factor* to reach a solution. While a common recommendation for factor analysis is that each factor should have a minimum of three variables (Kline, 1993), meta-analysis revealed that 23% of CFA studies included latent variables measured by less than three variables (Distefano & Hess, 2005). Thus, while a factor composed of two variables is possible, having more variables to reflect the constructs would have increased the probability of finding a satisfactory solution. Failure to find a solution in the overall sample is unlikely due to sample size as 572 subjects is considered *very good* (Comrey & Lee, 1992). Another concern when using CFA is the population used. If the sample is overly homogenous there may not be enough variance to reach a factor solution. On the other hand, if a population is included in the analysis that does not adequately represent a factor (for example, if children were included in a survey about occupational satisfaction) the factor solution may also fail to converge (Tabachnik & Fidell, 2001). Considering the four groups of subjects in the current study, with some being very homogenous (HC) to very diverse (Overall), group homogeneity is unlikely to be the reason adequate model fit was not obtained.

It is possible that failure to find a solution is due to inadequate sampling of the construct of overall attention and an overreliance of the CPT-II on reaction time. While there are arguably an adequate number of variables, they are unlikely to be representative of the entire construct of attention as outlined by theories of attention based on several measures. This is partially due to the response format of the CPT-II. The CPT-II is unlikely to have variables that are sensitive to the Encode factor proposed by Mirsky and colleagues (1991), which consists of abilities of recalling, sequencing, and manipulating information. In the CPT-II each response is treated independently of previously presented stimuli; thus the only demand to retain information is to keep the directions of the test in mind. The majority of the variables produced by the CPT-II rely on reaction time, which is interpreted as an indicator of target processing efficiency (MHS & Conners, 2000). Chiaravalloti and colleagues (2003) report a simple speed/reaction time factor and a second complex processing factor while examining the constructs of attention, processing speed, and reaction time. The simple factor encompassed basic elements of attention and a motor reaction, and the complex factor relied on working memory and placed greater demands on cognitive resources. Thus, the conditions of the CPT-II, or how attention influences reaction time in response to task duration and ISI change, may not provide enough variability in the demands placed on the attentional system to adequately represent the full construct of attention.

The CTP-II may be a poor instrument for CFA analysis due to heavy reliance on reaction time. With the exception of omissions, perseverations, and detectability, all of the variables in the current analysis are various aspects of reaction time. CFA assumes that the shared loadings on a single factor are due to the influence of the factor itself, therefore EFA derived models are not always sucessfully replicated using CFA (Van Prooijen & Van Der Kloot, 2001). The fact that several of the variables are derivatives of reaction time may make it difficult to separate the variance due to methodology from the effect of the factor itself. Other factor analyses of attention are based on several neuropsychological instruments that require different types of responses (e.g., verbal, written, button presses; see Mirsky 1991; Park, Allen, Barney, Ringdahl, & Mayfield, 2009). This may allow the effect of one attentional process to be detected against the background of other cognitive components.

Variables measuring several constructs are not good candidates for factor analyses, since they are likely to load on multiple factors. This could be true for response time in general, as slow response time could reflect cognitive sluggishness or inattention while fast response time may be related to hyperactivity or impulsivity (Conners & MHS, 2000). Similarly, commission errors in classic CPT paradigms have been conceptualized to reflect inattention, impulsivity, hyperactivity, or random error (Halperin, Wolf, Greenblatt, & Young, 1991; Halperin Sharma, Greenblatt, & Schwartz, 1991). Combinations of the commission and omission errors have been used to construct indexes of Dyscontrol, Impulsivity, and Inattention/Passivity (Halperin et al., 1988; Halperin et al., 1991). Therefore, both error types and reaction time can be the result of several processes, making it difficult for each to load on a single factor, and complicating interpretation when salient loadings are established.

Limitations

The obtained factor solution did not include all of the CPT-II variables and so it is unclear how including omission errors and Beta would impact the factor solution.

Another potential limitation is that it is unknown what medications the subjects are taking. While some medications may have deleterious effects on cognitions, others have been demonstrated to improve performance. It is unlikely that medication status accounts for systematic errors, and therefore the medications likely did not alter the present factor structure. Further support is offered by the fact that the factors observed in the clinical populations did not differ from the ones found in the healthy controls. Also, despite medication status, these subjects are representative of the clinical population seeking neuropsychological assessment. Nevertheless, future studies should make efforts to characterize the clinical population and examine how medication status impacts performance on a factor level.

Another possible limitation is the fact that t-scores were used. As t-scores are age corrected, they reduce the age related variability, which makes accurate data fit less likely. T-scores may also obscure how the interaction of a traumatic brain injury and age of injury may interact.

Future Directions

Future studies would benefit from extending this form of analysis. While the current study only used CFA, future studies may benefit from applying a more liberal methodology to explore factor structure in the current data. It may be recommended to use EFA to the current data in order to be able to more directly compare the factor structure of the current samples of subjects to the one that has been obtained in an adult sample (Egeland & Kovalik-Gran, 2010a). While conducting the EFA, it would be wise to consider application of updated procedures for evaluation of the number of component to retain, as retention rules often do not yeild the same number of components. Ford and colleagues (1986) have noted that despite advances in statistical practice, the application of new techniques has not been common practice in psychological journals. Thus, the application of parallel analysis (Horn, 1965) and minimum average partial matrix correlation test (Velicer, 1976). When compared directly in a Monte Carlo study, these two methods were superior to the eigen value greater than 1 rule in data sets of various sizes and compositions (Zwick & Velicer, 1986) and have been widely recommended (Hayton, Allen, & Scarpello, 2004; Henson & Robers, 2006).

Examining groups of children with comparable brain injuries may increase understanding regarding the factors that affect performance such as injury severity, type, age of injury, or times since injury. It could also be useful to compare sets of homogenous clinical populations to examine differences in performance.

The third version of the Conner's Continuous Test of Performance, the CPT-III, was recently released (Multi-Health Systems, Inc, 2014).It includes more variables than the CPT-II and is advertised to measure inattentiveness, impulsivity, sustained attention, and vigilance. Vigilance includes measures of omissions and commissions by ISI and hit response time by ISI change. It is not explained how these statistics are computed. Examining how errors are affected by ISI may be useful, as it has been demonstrated that boys with ADHD have greater response variability with longer ISI's (Leth-Steensen et al., 2000), thus it would be of interest to determine if rates or types of errors are also affected by ISI. Omissions and commissions by block are included as measures of sustained attention along with hit response time by ISI. Impulsivity is measured by hit response time, commissions, and omissions. Lastly, inattentiveness is measured by detectability, omissions, commissions, hit reaction time, hit reaction time standard deviation, and variability.

A new ratio of targets to non-targets is used in the third version, although it is not clear if this ratio has changed to include an increased or a decreased number of targets (Multi-Health Systems, Inc, 2014). The duration of the test and the number of stimuli in the new version are the same as the old version. Given these changes and the possibility that commission errors reflect impulsivity, it is recommended that a factor analysis of the new CPT should be performed. Additionally, performance on the CPT-II should be compared to performance on the CPT-III. It would be particularly interesting to examine how a change in the ratio of targets to non-targets impacts performance in healthy control participants and clinical groups. As variability in response time has been examined in clinical and healthy control populations, it would be interesting to how error rates change by block and ISI.

Future studies may also benefit from comparing variables that are more direct measures of inhibition for validating inhibition based factors. Similarly, neuropsychological variables that reflect simpler processes are advised to use for validation. Also, the CPT-II only allows one to examine reaction time in reaction to successful responding. Because responding is withheld on non-X CPT's, failure in inhibition can only be studied as an inappropriate response. It may be helpful to add measures of reaction time to commission errors, this may be particularly interesting to examine with respect to ISI and blocks because it could help in classifying commission errors as can fit into different categories. Finally, it would be advised that future factor analytic studies of attention that use CPT-II or variables from the CPT-II should include other measures of attention and impulsivity for variability of data type and more variables for each fact

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Wozniak, J. R., Krach, L., Ward, E., Mueller, B. A., Muetzel, R., Schnoebelen, S., Kiragu, A., et al. (2007). Neurocognitive and neuroimaging correlates of pediatric traumatic brain injury : A diffusion tensor imaging (DTI) study. *Archives of Clinical Neuropsychology, 22*, 555–568. doi: 10.1016/j.acn.2007.03.004

Zubin, J. (1975). *Problem of attention in schizophrenia.* In M.L Kietzman, S. Sutton, & J. Zubin (Eds.). *Experimental Approaches to Psychopathology* (pp. 139-166). New York, NY: Academic Press.

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CURRICULUM VITAE

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EDUCATION

Ph.D. (In progress), Clinical Psychology, University of Nevada, Las Vegas, NV
Advisor: Daniel Allen, Ph.D.

M.A., Clinical Psychology, University of Nevada, Las Vegas
December 2012
Advisor: Daniel Allen, Ph.D.

B.A., Psychology, University Of California, San Diego, La Jolla, CA,
May 2007
Provost's Honors awarded spring of 2005 through spring of 2007

AWARDS

11/2012: Travel Grant ($300)
11/2012: Sponsorship Winner (NAN)
05/2012: Patricia J. Sastaunik Scholarship ($2,500)
10/2011: Travel Grant ($500)

Student Poster Award, Nevada Psychological State Association, 2013 Annual Conference: Spring 2013. ($100). Second place student poster award.

Outstanding Poster Presentation Award (2nd Place), UNLV Graduate & Professional Student Association: Spring 2012. Poster: **Vertinski, M.**, Allen, D., Thaler, N., Heisler, D., Park, B., Barney, S. (March, 2012). Construct Validity of the Search Identification Task.

Theodore Blau Student Poster Award (1st place), American College of Professional Psychology: Spring 2012. Poster: Thaler, N. S., **Vertinski, M.,** Ringdahl, E. N., Woolery, H., & Allen, D. N. (March, 2012). Affect identification impairments in bipolar disorder with and without psychotic features.

PROFESSIONAL AFFILIATIONS

Student Cohort Representative	08/2013-Present
Student Representative Consortium Committee	08/2013-08/2014
UNLV Student Representative NPA	05/2013- 05/2013
Society of Teaching Psychology	07/2013- 05/2014
Nevada Psychological Association	09/2010- Present
Diversity Committee Member	08/2011-05/2012
American Psychological Association	09-2011-Present
National Academy of Neuropsychology	09/2011-Present
International Early Psychosis Association	10/2012-Present

PREDOCTORAL PRACTICUM

Southern Nevada Adult Mental Health Services/Rawson-Neal Psychiatric Hospital
Las Vegas, Nevada August 2014-Present
Supervisor: Paula Squitieri, Ph.D.

Doctoral Practicum Student: Served on a multidisciplinary treatment team, provided diagnostic interviewing, psychological assessments, individual and group therapy, and consultation services. Assessment opportunities included differential diagnosis, assessment of intelligence, behavioral analysis, risk assessment, neuropsychological screening, malingering, and evaluation of social and emotional functioning. Treatment modalities used include, but are not limited to, CBT and DBT. Worked with a wide range of psychiatric diagnoses and levels of functioning. Exposed to the process of legal holds and involuntary commitment to a psychiatric hospital.

PRACTICE, UNLV Student Clinic August 2014- Present
Las Vegas, Nevada Supervisor: Noelle Lefforge, Ph.D.

Graduate assistant and Doctoral Practicum Student: Provided individual therapy to a caseload of four to seven clients. Worked with adults and teenagers diagnosed with affective disorders, adjustment disorders, autism spectrum disorders, and severe mental illness bipolar disorder. Primary theoretical approach used was integrative therapy. Supervision was comprised of weekly individual meetings utilizing case discussion and session recordings, and weekly group meetings. Additional supervisory responsibilities were assumed during group supervision, including tape review of novice practicum students.

Innovative Psychological Solutions July 2013-December 2013
Las Vegas, Nevada Supervisor: Danielle Bello, Ph.D.

Doctoral Practicum Student: Conducted neuropsychological assessments with children, adolescents, adults, and elderly adults in an outpatient setting using a flexible neuropsychology battery. Cases were typically psychiatric, medical, and academic with referral sources generally including medical doctors, psychiatrists, and school counselors. Responsibilities also included test scoring and interpretation, assisting in clinical interviews, and report writing. Commonly presented patient diagnoses included learning disorders, ADHD, adjustment disorders, affective disorders, cognitive impairment secondary to medical conditions, stroke, traumatic brain injury, dementia, epilepsy, substance abuse, and pervasive developmental disorders. Supervision consisted of weekly individual and group meetings and in vivo co-assessment.

PRACTICE, UNLV Student Clinic May 2013- August 2013
Las Vegas, Nevada Supervisor: Noelle Lefforge, Ph.D.

Doctoral Practicum Student: Provided individual therapy to a caseload of four to seven clients. Worked with adults and teenagers diagnosed with affective disorders, adjustment disorders, autism spectrum disorders, and severe mental illness bipolar disorder. Primary theoretical approach used was integrative therapy. Supervision was comprised of weekly individual meetings utilizing case discussion and session recordings. Attended a weekly practicum seminar, which included didactic and clinical case conferences.

Center for Applied Neuroscience June 2012-August 2013
Las Vegas, NV Supervisor: Sharon Jones-Forrester, Ph.D.

Doctoral Practicum Student: Conducted neuropsychological assessments with children, adolescents, adults, and elderly adults in an outpatient setting using a flexible neuropsychology battery. Cases were typically psychiatric, medical, and academic with referral sources generally including medical doctors, psychiatrists, and school counselors. Responsibilities also included test scoring and interpretation, assisting in clinical interviews, and report writing. Commonly presented patient diagnoses included learning disorders, ADHD, adjustment disorders, affective disorders, cognitive impairment secondary to medical conditions, stroke, traumatic brain injury, dementia, epilepsy, substance abuse, and pervasive developmental disorders. Supervision consisted of weekly individual and group meetings and in vivo co-assessment.

Private Practice, Lisa Linning Ph.D. January 2012-October 2013
Las Vegas, Nevada Supervisor: Lisa Linning, Ph.D.

Doctoral Practicum Student: Co-led two 18-week adolescent dialectical behavior therapy groups with Dr. Linning. These groups are comprised of adolescents with severe emotional dysregulation and histories of self-harm, suicide attempts, substance abuse and hospitalization for mental health reasons. Facilitated discussion in group, managed the group dynamics, taught DBT concepts, created handouts, and lead mindfulness activities, in addition to writing group notes and behavioral observations for each session.

Center for Individual, Couple, and Family Counseling August 2011–August 2012
University of Nevada, Las Vegas Supervisor: Noelle Lefforge, Ph.D.

Doctoral Practicum Student: Provided long-term individual therapy to a caseload of seven to eight clients. Diagnoses included personality disorders, affective disorders, adjustment disorders, and severe mental illness such as schizophrenia and bipolar disorder. Primary theoretical approach used was eclectic, drawing heavily from psychodynamic, behavioral, and interpersonal orientations. Supervision was comprised of weekly individual and small-group meetings utilizing case discussion and videotape review. Attended a weekly practicum seminar, which included didactic and clinical case conferences.

Psychological Testing Clinic August 2011–May 2012
University of Nevada, Las Vega Supervisor: Michello Carro, Ph.D.

Doctoral Practicum Student: Conducted intakes, psychodiagnostic assessments, written reports, and feedback of adults presenting for learning and psychiatric disorders. Diagnoses included personality disorders, affective disorders, adjustment disorders, pervasive developmental disorders, ADHD, and learning disabilities.

OTHER CLINICAL EXPERINCE

2011-2012	Neuropsychological Test Administrator, Harmony Health Care – Supervisor Michelle Humm, Ph.D., Las Vegas, NV
2010-2010	Volunteer, Nevada PEP – Director Dr. Christa Peterson, Las Vegas, NV
2008-2009	Sexual Assault Counselor, Rape Trauma Services – Director Sarah Jarvis, San Bruno, CA
2007-2008	In Home Supportive Services Worker, Department of Adult and Aging Services, City and County of San Francisco, San Francisco, CA
2006	Intern, San Francisco Police Department, Psychiatry Liaison Unit – Mentor Officer Kelly Dunn, San Francisco, CA
2006	Intern, Healthy Within – Director Dr. Divya Kakaiya, La Jolla, CA

INSTRUCTIONAL & MENTORING EXPERIENCE

May-Aug of 2014	Clinical Supervisor Supervised by Michelle Paul, Ph.D. University of Nevada, Las Vegas
2013- 2014	Part-time Undergraduate Instructor University of Nevada, Las Vegas

2010-2014 Mentor, Undergraduate Outreach Mentorship Program
University of Nevada, Las Vegas

2007 Instructional Assistant, Developmental Psychology
University of California, San Diego, La Jolla, CA

2004-2006 Conversation Leader, English Language Institute, La Jolla, CA

PUBLICATIONS

Thaler, N. S., Allen, D. N., Sutton, G. P., **Vertinski, M.,** & Ringdahl, E. N. 2013. Differential impairment of social cognition factors in bipolar disorder with and without psychotic features and schizophrenia. *Journal of psychiatric research*, *47*(12), 2004-2010.

Thaler, N. S., Strauss, G. P., Sutton, G. P., **Vertinski, M**., Ringdahl, E. N., Snyder, J. S., & Allen, D. N. 2013. Emotion perception abnormalities across sensory modalities in bipolar disorder with psychotic features and schizophrenia. *Schizophrenia research*.

Allen, D. N., Strauss, G. P., Barchard, K. A., **Vertinski, M.,** Carpenter, W. T., & Buchanan, R. W. 2013. Differences in developmental changes in academic and social premorbid adjustment between males and females with schizophrenia. *Schizophrenia research*.

Allen, D. N., Thaler, N. S., Barchard, K. A., **Vertinski, M**., & Mayfield, J. 2012. Factor structure of the Comprehensive Trail Making Test in children and adolescents with brain dysfunction. *Psychological assessment*, *24*(4), 964.

Durazzo TC, Fryer SL, Rothlind JC, **Vertinski M**, Gazdzinski S, Mon A, Meyerhoff DJ. 2010. Measures of learning, memory and processing speed accurately predict smoking status in short-term abstinent treatment-seeking alcohol-dependent individuals.*Alcohol and Alcoholism,* 45(6): 507-513.

Dale CL, Findlay AM, Adcock RA, **Vertinski M**, Fisher M, Genevsky A, Aldebot S, Subramaniam K, Luks TL, Simpson GV, Nagarajan SS, Vinogradov S. 2010. Timing is everything: Neural response dynamics during syllable processing and its relationship in schizophrenia and healthy comparison subjects. *International Journal of Psychophysiology,* 75(2): 183-93.

Twamley EW, Woods SP, Zurhellen CH, **Vertinski M**, Narvaes JM, Mausbach BT, Patterson TL, Jeste DV. 2008. Neuropsychological substrates and everyday functioning implications of prospective memory impairment in schizophrenia. *Schizophrenia Research* 106 (1): 46-9.

PRESENTATIONS

Vertinski, M, Allen, D, Mayfield, J. Factor Structure of the CPT-II In a Pediatric TBI Sample. Poster Session Presentation in: Nevada Psychological Association Annual Conference; 2013 May 10; Las Vegas, NV.

Vertinski, M, Allen, D, Mayfield, J. Factor Structure of the CPT-II In a Pediatric TBI Sample. Poster Session Presentation in: 33rd Annual Scientific Meeting of the National Academy of Neuropsychology; 2013 October 16-19; San Diego, CA.

Vertinski, M. Factor Analysis of the Premorbid Adjustment Scale (PAS) and its Potential for Predicting Long Term Outcome in Schizophrenia. Talk Presented in: 32nd Annual Scientific Meeting of the National Academy of Neuropsychology; 2012 November 7-10; Nashville, TN.

Vertinski M, Allen DN, Strauss GP, Thaler NS, & Buchanan R. Relations Between Memory Abilities and Premorbid Adjustment Abnormalities in Patients with Schizophrenia. Poster Session Presented in: 32nd Annual Scientific Meeting of the National Academy of Neuropsychology; 2012 November 7-10; Nashville, TN.

Ringdahl E, Thaler N, Sutton G, **Vertinski M**, & Allen D. Selective Impairments in Recognizing Emotions are Present in Bipolar Disorder with Psychotic Features. Poster Session Presented in: 32nd Annual Scientific Meeting of the National Academy of Neuropsychology; 2012 November 7-10; Nashville, TN.

Lee BG, Barney SJ, Catalano LT, Ringdahl EN, **Vertinski M**, Adams JL, Shugarman YY, Snyder JS, Allen DN, & Strauss GP. Anhedonia is Associated with Impaired Long-Term Memory for Positive Emotional Stimuli in Individuals with Schizophrenia. Poster presented in: 26th Annual Meeting of the Society for Research in Psychopathology, 2012 October 4-7; Ann Arbor, Michigan.

Stuart BK, Ford D, **Vertinski M**, McPherson M, Vinogradov S, Loewy RL. The Discrepancy between the Experience and Expression of Emotion as a Risk Marker for Conversion to Psychotic Disorder. Poster presented in: 8th Annual International Conference on Early Psychosis on 2012 October 11-13; San Francisco, CA.

Ringdahl E, Thaler N, Sutton G, **Vertinski M**, & Allen D. Deficits in Functional Capacity are Associated with Psychotic Symptoms in Bipolar Disorder. Poster presented in: 4th Annual Meeting of the American College of Professional Neuropsychology; 2012 March 8-11 Las Vegas NV.

Ringdahl EN, Thaler NS, **Vertinski M**, & Allen DN. Is the WAIS-III Picture Arrangement subtest sensitive to psychosis? Poster presented in: 4th Annual Meeting of the American College of Professional Neuropsychology, 2012 March 8-11; Las Vegas, NV.

Verbiest R, Thaler NS, Ringdahl EN, **Vertinski M**, & Allen DN. Tone discrimination impairment is uniquely linked to bipolar disorder with psychotic features. Poster to be presented at the 4th Annual Meeting of the American College of Professional Neuropsychology, 2012 March 8-11; Las Vegas, NV.

Hart JS, Thaler NS, **Vertinski M**, Baldock D, & Allen D N. Facial Discrimination Uniquely Predicts Visual Affect Recognition in Bipolar Disorder with Psychotic Features. Poster presented in: 4th Annual Meeting of the American College of Professional Neuropsychology, 2012 March 8-11; Las Vegas, NV.

Thaler NS, **Vertinski M**, Ringdahl EN, Woolery H, & Allen DN. Affect identification impairments in bipolar disorder with and without psychotic features. Poster presented in: 4th Annual Meeting of the American College of Professional Neuropsychology, 2012 March 8-11; Las Vegas, NV.

Vertinski M, Allen D, Thaler N, Heisler, D, Park B, Barney S. Construct Validity of the Search Identification Task. Poster Session Presented in the 31st Annual Scientific Meeting of the National Academy Neuropsychology; 2011 November 15-19; Marco Island, Florida.

Vertinski, M., Terranova, J., Mayfield, J., Allen, D. Factor Structure of the Connor's Test of Continuous Performance II in Children with TBI. Presented at the 3rd Annual American Board of Professional Neuropsychology Conference; 2011 March 10-13th; Las Vegas, Nevada.

Vertinski, M., Hadland, C., Thaler, N., Strauss, G., Allen, D. The Relationship Between Long-term Smoking and Memory and Motor Skills in Clinical Populations. Presented at the 3rd Annual American Board of Professional Neuropsychology Conference; March 10-13th; Las Vegas, Nevada.

Vertinski M, Smith L, Thaler N, Mayfield J, Allen D. Criterion Validity of the TOMAL in Pediatric TBI. Poster Session Presented in: 30th Annual Scientific Meeting of the National Academy of Neuropsychology; 2010 October 13-16; Vancouver, Canada.

Gazdzinski S, **Vertinski M**, Durazzo TC, Mon A, Meyerhoff DJ. The Role of Nutrition and Physical Activity in Alcohol-Associated Brain Injury. Poster Session Presented In: 33rd Annual Scientific Meeting of the Research Society on Alcoholism; 2010 June 26-30; San Antonio, TX.

Dale CL, Findlay AM, Adcock RA, Genevsky A, **Vertinski M**, Luks TL, Simpson GV, Nagarajan SS, Vinogradov S.(2009, June). Perceptual interference exacerbates Voice Onset Time-dependent syllable discrimination and alters performance-related MEG response dynamics in patients with schizophrenia. Poster presented at Cogntive Neuroscience Society, San Francisco, CA.

Hinkley LBN, Guggisberg AG, Findlay AM, **Vertinski M**, Fisher M, Adcock RA, Vinogradov S, Nagarajan SS. (2009, June). Alpha Band Resting-State Functional Connectivity Maps in Patients with Schizophrenia. Poster presented at Organization for Human Brain Mapping, San Francisco, CA.

Herman AB, Nagarajan SS, Findlay A, **Vertinski M**, Vinogradov S. (2009, June).Neural Correlates of phoneme production preparation in schizophrenic patients and healthy controls. Poster presented at Organization for Human Brain Mapping, San Francisco, CA.

Khatibi K, Findlay AM, Adcock RA, Subramaniam K, Aldebot S, Hearst A, **Vertinski M**, Marco EJ, Nagarajan SS, Vinogradov S. (2008, April). Neuroplasticity-Based Cognitive Training in Schizophrenia Normalizes Magnetoencephalography Auditory Duration Mismatch Responses in Cortex. Poster presented in Cognitive Neuroscience Society, San Francisco, CA.

CLINICAL TRAININGS AND WORKSHOPS

Dialectical Behavioral Therapy with Parents, Couples, and Families
Featuring: Allen Fruzzetti, Ph.D.
April 4, 2014

Diagnosing Autism and Related PDD's, Pediatric Bipolar Disorder, ADHD, and Applications of BASC-2 in Behavioral RTI: An Advanced Training on the BASC-2
Featuring: Cecil Reynolds, Ph.D
September 25, 2013

Adventures on the Electronic Frontier: Ethics and Risk Management of the Digital Era
Featuring: Jeffery Yunggren, Ph.D.
September 7, 2013

DSM-V: What You Need to Know
Featuring: Dodge Slagle, Ph.D. & Barry Cole, M.D., DFAPA
July 20, 2013

Navigating the Changing Landscape of Psychology
Featuring: Katherine Nordal, Ph.D., David Antonuccio, Ph.D., & Stacey Tovino, J.D., Ph.D.
May 10, 2013

Comprehensive Training in Dialectical Behavioral Therapy
Featuring: Alan Fruzzetti, Ph.D.
Nov. 29-Dec. 1, 2012; Feb. 21-Feb. 23, 2013; Apr. 19-20, 2013

Ethics and Decision Making for Nevada Psychologists
Featuring: Stephen Behnke, J.D., Ph.D.
November 17, 2012

Everything Clinicians Should Know About Brain Development, Gambling, Eating and Related Process Addictions with Young Adults
Featuring: Ken Winters, Ph.D., Larry Ashley, Ed.S., Corney Warren, Ph.D., Cynthia Briggs, Ph.D
January 21, 2012

Eating Disorders and Obesity: Outpatient Assessment and Treatment
Featuring: Lindsey Ricciardi, Ph.D.
November 12, 2011

Working with Challenging Couples
Featuring: John Friel, Ph.D.
October 8, 2011

Psychopharmacology Update: Integration of Medication and Psychological Treatments
Featuring: Morgan Sammons, Ph.D., APBB, & Steven Tulkin, Ph.D., M.S.
April 29, 2011