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Latent Structure of the Wisconsin Card Sorting Test in Psychiatrically Hospitalized Youth

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by

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by

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Abstract

The aims of this study were to explore the latent factor structure of WCST performance in psychiatrically hospitalized youth, and to investigate associations between latent factors and various psychiatric, psychological, and neuropsychological variables. The results revealed a three-factor solution that is broadly attributed to executive abilities of problem solving, cognitive flexibility, and inhibitory control. The resulting three-factor solution accounted for 96% of the variance in the present study's sample, and was comparable to results from similar studies in adult populations. Latent factors were associated with performance on a brief test of intelligence as well as to several measures of executive functioning. Latent factors were not associated with psychiatric variables including length of hospitalization or number of diagnoses, but were associated with self-report symptom inventories for depression, anxiety, and post-trauma symptoms. The latent structure revealed in the present study, as well as the associations to self-report symptom questionnaires have important clinical implications that are discussed in detail. Continued multivariate research will be necessary to better clarify the processes underlying WCST performance and their relationships to one another as well as to other psychiatric and neuropsychological variables.

Keywords: children, executive function, inpatient, factor analysis

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Literature Review

Executive Functions

Executive functions refer to a family of top-down mental processes that make it possible for us to (a) mentally manipulate ideas, (b) consider different possibilities, (c) take the time to think before acting, (d) think of novel solutions to problems, (e) resist temptations, and (f) stay focused on tasks (Burgess & Simons, 2005; Espy, 2004; Miller & Cohen, 2001). Executive function was first described as a “central executive” in the brain by Baddeley and Hitch (1974) but was later defined as a domain of human behavior that deals with behavioral expression (Lezak, 1983). Historically, definitions of executive functions have differed widely, and there continues to be significant discrepancy between current definitions and theoretical models of executive functioning. Earlier theories of executive functioning defined core components as volition, planning, purposive action, and effective performance (Lezak, 1983). More recent definitions highlight the important components of solving novel problems, modifying behavior in light of new information, generating strategies, sequencing complex actions (Elliott, 2003) or purposeful and coordinated organization of behaviors and the ability to reflect and analyze the success of such behavioral strategies.

At present, detailed definitions of executive functioning continue to differ, though a core understanding of executive functions is now widely accepted. Current concepts of executive functions can be broken down into their core components: (a) inhibition, (b) working memory, and (c) cognitive flexibility (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000). Confirmatory factor analyses have suggested that the three target executive functions are moderately correlated with one another, though clearly distinguishable (Miyake et al., 2000).

Moreover, core executive functions are considered separate functions but cannot exist without the others. Aspects of fluid intelligence differentiate higher order executive functions that are implicated by core executive abilities. These higher order functions include reasoning, problem solving, and planning and are most directly influenced by working memory, cognitive flexibility, and inhibitory control, respectively (Collins & Koechlin, 2012; Diamond, 2013; Lunt et al., 2012). Most widely researched higher order executive functions include verbal fluency and planning, both of which are found to tap several processes in the executive domain (e.g., Goel & Grafman, 1995; Rende, Ramsberger, & Miyake, 2002). Given the complexity of such tasks and their diffuse but significant executive demands, higher order executive tasks involve multiple cognitive demands and so often do not represent single executive functions or abilities.

Moreover, executive functions are often broken down into “hot” and “cold” components. Hot executive functions involve decision-making processes that are associated with emotional, affective, or visceral responses. Cold executive functions are associated with rational and logical decision-making processes. Most typically, executive functions are divided based on hot/cold criteria when evaluating the effects of affective impairments or impairments in behavioral functioning related to executive processes. Important abilities related to cold executive functions include contrasting various alternatives and analyzing risk/benefit ratios (Séguin, Arseneault, & Tremblay, 2007) as well as the ability to keep focus and attention, to be cognitively flexible, and effectively plan and organize goal-directed behavior (Burgess, 2000; Stuss, Shallice, Alexander, & Picton, 1995). In contrast, hot executive functions that involve processes with more distinct emotional salience (Kerr & Zelazo, 2004; Zelazo & Müller, 2002) have a strong impact on daily behaviors and everyday decision-making, especially when stimuli carrying distinct emotional salience interfere with logical (i.e., “cold”) decision making (Sonuga-Barke, 2003).

A basic understanding of the development of executive functions is critical for understanding their functions across the lifespan. The first executive function to emerge in children is the ability to inhibit overlearned behavior (e.g., try a new approach to an old problem) and the last to appear is verbal fluency (e.g., generate words based on phonemic cues or semantic categories). The sequential development and decline of these functions has been paralleled with the anatomical changes of the frontal lobe and its connections with other brain areas (Jurado & Rosselli, 2007). Moreover, the development and decline of executive functions also parallel the development and decline of behavioral, emotional, and cognitive functioning across the lifespan (Diamond, 2013).

Inhibitory control. Inhibition includes inhibitory control, including self-control (or, behavioral inhibition) and interference control (or, selective attention and cognitive inhibition), and involves the ability to resist temptations and impulses and selectively attending to particular stimuli (Diamond, 2013). As one of the core processes of inhibitory control, selective attention involves focusing on a selected stimulus while suppressing attention driven towards other stimuli. Inhibitory control creates the possibility of making changes to our patterns of responses and to make choices about our behaviors, thoughts, and/or emotions. Without the ability to override often strong impulses, we would likely act through conditioned responses or learned patterns of behaviors (Diamond, 2013). Instead, inhibitory control gives way to the ability to ignore or disregard impulsive tendencies in order to do what may be more appropriate or necessary. Often referred to as cognitive inhibition, our ability to resist irrelevant or unwanted thoughts or memories serves to promote adaptive functioning despite the history of our learned experiences (Diamond, 2013). Cognitive inhibition often involves processes of intentional forgetting (Anderson & Levy, 2009), resisting proactive interference from information previously learned (Postle, Brush, & Nick, 2004), and resisting the retroactive interference of subsequent information. Self-control and persistence are notable aspects of inhibitory control. Self-control refers to the ability to control one's behaviors or to control one's emotions in order to control one's behavior. Without self-control, individuals are more prone to act immorally (e.g., cheat, steal, lie, etc.) or impulsively (e.g., speak without thinking, act without considering alternatives; Diamond, 2013). Persistence, on the other hand, refers to the discipline of staying on task despite distractions, temptations, or alternative impulses. Without persistence and the secondary processes of delaying gratification, individuals are less likely to complete time-consuming tasks such as writing a book, running a marathon, completing a house renovation, and more (Louie & Glimcher, 2010; Mischel, Shoda, & Rodriguez, 1989).

Working memory. Working memory involves mentally working with information that is no longer perceptually available (Smith & Jonides, 1999). Working memory is implicated in problem solving in that it requires holding onto information and relating it to subsequent information or events. Working memory is crucial for effective communication (i.e., understanding and articulating language) as well as mathematical computations that require mental math operations. Working memory drives reasoning and, more specifically, transient holding, processing, and manipulating information. As such, working memory serves to incorporate past information and consider future information when planning, organizing, or making decisions. Factor analytic studies show that working memory is distinct from short-term memory, which involves strictly the process of holding information for a short period of time usually spanning several seconds, as each clustered onto separate factors (Alloway et al., 2004; Gathercole, Pickering, Knight, & Stegmann, 2004). However, short-term memory is considered to be a precursor to working memory and, without it, working memory would not develop.

Though considered to be distinct executive functions, working memory and inhibitory control cannot exist without the other, and typically co-occur (Diamond, 2013). For example, working memory is required for selective attention needed in specific processes of inhibitory control.

Cognitive flexibility. Cognitive flexibility refers to the ability to switch attention between two different activities or concepts and to think about multiple concepts simultaneously. Cognitive flexibility involves the capacity to be mentally flexible. This involves being able to think outside the box, see different perspectives, think of different possible outcomes or solutions, and quickly and flexibly adapt to changes in circumstances or events. Cognitive flexibility is often called set-shifting, mental flexibility, or mental set-shifting, and is closely related to creativity (Diamond, 2013). Skills related to cognitive flexibility allow one to learn from experiences, adapt or modify their behavior in response to errors, and interpret information in various ways utilizing different perspectives or different patterns of thinking. Cognitive flexibility is thought to be the opposite of rigidity (Diamond, 2013). Cognitive flexibility is often considered more complex and demanding than other executive processes and is built on the processes of working memory and inhibitory control (Davidson, Amso, Anderson, & Diamond, 2006; Garon, Bryson, & Smith, 2008). Moreover, cognitive flexibility develops only after working memory and inhibitory control, and continues to develop until as far as one's mid-20s (Morton, Bosma, & Ansari, 2009).

Neural Correlates of Executive Functions

Executive functions are assumed to be critical for planning and organizing behavior and have traditionally been linked to frontal lobe function (Eling, Derckx, & Maes, 2008; Stuss & Levine, 2002), but are also associated more widely across subcortical structures and thalamic pathways (Kassubek, Juengling, Ecker, & Landwehrmeyer, 2005; Lewis, Dove, Robbins, Barker,

& Owen, 2004; Monchi et al., 2007). Dysfunction in different regions of the prefrontal cortex could account for the variety of interpersonal and behavioral problems associated with executive abilities. Both the frontal and posterior association cortices have been suggested to mediate functions of the executive system (Collette & Van der Linden, 2002).

Several studies have demonstrated that different executive processes are associated with specific cerebral areas. The ability to manipulate information to complete a task is mediated by the right inferior prefrontal cortex, while the superior frontal cortex is mediated when temporal organization is required to sequence new versus old information (Wager & Smith, 2003). As a whole, working memory is thought to rely on the dorsolateral prefrontal cortex (D'Esposito, Postle, Ballard, & Lease, 1999). The right dorsolateral frontal area is suggested to mediate the process of monitoring behavior while the left dorsolateral area is implicated in verbal processing (Stuss & Levine, 2002). The subthalamic nucleus appears to play an important role in preventing impulsive responses and is implicated in inhibitory control processes (Frank, 2006). Lesions in the frontal lobe lead to difficulties in self-control, attention shifting, and impairments in goal-directed sequencing and action (Lezak, Howieson, Loring, & Fischer, 2004).

Cognitive flexibility—often-measured using set-shifting tasks such as the Wisconsin Card Sorting Task (WCST)—is implicated in the dorsolateral prefrontal cortex (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006). Moreover, the dorsolateral prefrontal cortex is also associated with cold executive processes (Castellanos et al., 2006; Moreno-López, Soriano-Mas, Delgado-Rico, Rio-Valle, & Verdejo-García, 2012). In contrast, hot executive processes have increasingly been associated with the orbitofrontal cortex (Anderson, Barrash, Bechara, & Tranel, 2006; Kerr & Zelazo, 2004).

More recently, neuropsychological and neurobiological literature suggests that a collection of these neural components in the same cortical regions are involved in many forms of cognitive control and, together, form a functionally connected cognitive control network (e.g., Cole & Schneider, 2007; Duncan & Owen, 2000). These regions that make up the cognitive control network include the anterior cingulate cortex/pre-supplementary motor area, dorsal premotor cortex, anterior insular cortex, inferior frontal junction, and posterior parietal cortex (Cole & Schneider, 2007).

Executive Functions Contribute to Mental and Physical Wellness

Executive functions are crucial for mental and physical wellness; success in school and daily life; and cognitive, social, and psychological development. Executive functions are central to the development and maintenance of normal and abnormal behavior patterns (Etkin, Gyurak, & O'Hara, 2013). Moreover, executive functions are suggested to impact psychiatric functioning through involvement in emotional regulation processes (Etkin et al., 2013). Poor executive functioning predicts rumination (e.g., Demeyer, De Lissnyder, Koster, & De Raedt, 2012; Zetsche, D'Avanzato, & Joormann, 2012), worry (Crowe, Matthews, & Walkenhorst, 2007), and poor emotion regulation strategies (e.g., Andreotti et al., 2013), which all play a significant role as risk factors for developing psychopathology (Snyder, Miyake, & Hankin, 2015). Executive function and emotional regulation deficits are pervasive and constituent to psychiatric disorders and psychopathology (Etkin et al., 2013). Neurobiological support of this notion is indicated through empirical evidence that the neural circuitry that supports executive functioning and emotional regulation are largely overlapped and include the dorsal anterior cingulate cortex, medial prefrontal cortex, lateral prefrontal cortex, and ventral anterior cingulate cortex (Etkin et al., 2013). Executive functions are impaired in many psychiatric disorders including addictions

(Baler & Volkow, 2006; Smith, Mattick, Jamadar, & Iredale, 2014), attention deficit hyperactive disorder (AD/HD; Diamond, 2005; Lui & Tannock, 2007), oppositional-defiant disorder/conduct disorder (Fairchild et al., 2009; Ogilvie, Stewart, Chan, & Shum, 2011), major depressive disorder (Tavares et al., 2007), bipolar disorder (Snyder et al., 2015), obsessive-compulsive disorder (Penades et al., 2007), and schizophrenia (Barch, 2005). Executive deficits have been identified in groups of individuals with panic disorder, social anxiety disorder, and generalized anxiety disorder (Airaksinen, Larsson, & Forsell, 2005; Mantella et al., 2007). Though not entirely conclusive, preliminary studies suggest that executive functions are impaired in persons with post-traumatic stress disorder (Polak, Witteveen, Reitsma, & Olff, 2012). A meta-analytic review of childhood disorders by Willcutt and colleagues (2008) identified and highlighted the significance of the executive functioning deficits associated with diagnoses of AD/HD, autism, and childhood-onset schizophrenia. Although more mild, associations between executive deficits and juvenile bipolar disorder, oppositional-defiant disorder/conduct disorder, and Tourette syndrome and other tic disorders are observed in children as well (Willcutt, Sonuga-Barke, Nigg, & Sergeant, 2008).

Overall physical health may be compromised when executive functions are limited or impaired. Poorer executive functions are associated with obesity, overeating or impulsive eating, substance abuse, and poor treatment adherence (Crescioni et al., 2011; Miller, Barnes, & Beaver, 2011; Riggs, Spruijt-Metz, Sakuma, Chou, & Pentz, 2010). Moreover, intact executive functions are implicated in overall quality of life such that people with strong executive functions enjoy a better quality of life (Brown & Landgraf, 2010; Davis, Marra, Najafzadeh, & Liu-Ambrose, 2010). Executive functions are associated with academic and intellectual success (Diamond, 2013) and are considered better predictors of school readiness than IQ composite scores or reading or math performance (Blair & Razza, 2007; Morrison, Ponitz, & McClelland, 2010). Executive functions can be predictive of both verbal and nonverbal competence (e.g., reading and math, respectively) throughout school years (Borella, Carretti, & Pelegrina, 2010; Duncan et al., 2007; Gathercole et al., 2004).

Executive functions are inextricably linked with adaptive daily functioning. Evidence of preliminary executive processes early in life appears to be predictive of outcomes throughout adulthood. Poor executive functions lead to poor productivity and issues of employment including difficulty finding, and subsequently keeping a job (Bailey, 2007). Marital satisfaction is also associated with executive functions, and poorer executive functions often predict marital difficulties or relational strain (Eakin et al., 2004). Poor executive functions may also lead to social problems such as criminal behavior, reckless behavior, violence, and emotional outbursts (Broidy et al., 2003; Denson, Pedersen, Friese, Hahm, & Roberts, 2011). In a longitudinal study, children at ages 3-11 who exhibited better inhibitory control were more likely to persist with later schooling, less likely to engage in risk-taking behaviors in later years, and had better physical and mental health outcomes in adulthood as compared to those with poor childhood inhibitory control (Moffitt et al., 2011). Recent studies have supported the notion that as long as executive functions are intact, a person who has sustained considerable cognitive loss or damage can still continue to be independent and productive (Lezak et al., 2004).

Executive Functions can be Assessed Through Neuropsychological Measures

The ongoing debate over a formal definition of executive functions and the questioned existence of a central executive construct make it difficult to accurately assess these functions through neuropsychological measures. However, the study of executive functions in clinical practice, as well as research science, relies on tests that have been historically defined as measures of executive functions or frontal lobe functions. Considerable progress has been made over the last decade with regards to theories and models of executive functioning and the neuropsychological assessments of such functions. Some of the most common tests of executive functioning include the Controlled Oral Word Association Test (COWAT), the Trail Making Test (TMT), the Stroop task, Tower of London (TOL), and the Wisconsin Card-Sorting Task (WCST), to name a few. Moreover, such tests can be broken down by specific executive functions that they are purported to measure—for example, the TMT is thought to assess cognitive flexibility while the Stroop task is believed to assess inhibitory control (Miyake et al., 2000). Many of the current conventional tests of executive functioning tend to be unspecific in terms of the cognitive processes they engage (Burgess, 1997). For example, the TMT is thought to be a direct measure of cognitive flexibility but impairments in visuospatial ability or processing speed can impair overall performance (Jurado & Rosselli, 2007). Such findings are relatively consistent across executive measures, suggesting that such tasks do not measure executive functions exclusively but likely also measure underlying cognitive processes that are required for such complex executively-driven tasks. Moreover, very few tests of executive functioning are designed to capture executive functions within specific contexts or situations. Such assessment commonly relies on self-report measures. The Behavior Rating Inventory of Executive Functioning (BRIEF) is a self-report questionnaire that assesses everyday executive functioning and executively-driven problems in the context of a person's daily life and functioning.

The past decade has been dedicated to developing measures that isolate specific component processes of executive functions (Burgess, 1997; Chan, Chen, & Law, 2006; Lin, Chan, Zheng, Yang, & Wang, 2007). Given that executive functions build progressively on one another (e.g., cognitive flexibility requires working memory and inhibitory control), it is often hard to conclusively argue that any measure taps into one executive function or process exclusively. For example, the WCST is considered a test of cognitive flexibility, however, given the nature of this novel problem-solving task, other executive processes as well as related cognitive processes are required for successful completion. Moreover, failure on one measure of executive functioning may not necessarily yield failure on a subsequent measure, suggesting that executive functions are not completely unitary (e.g., Godefroy, Cabaret, Petit-Chenal, Pruvo & Rousseaux, 1999). Individual differences studies show that intercorrelations among different executive function tasks are generally low (Miyake et al., 2000; Salthouse, 2005). Exploratory factor analysis tends to yield multiple separate factors for a battery of executive tasks, suggesting that executive functions are separate constructs but remain moderately correlated (Miyake et al., 2000). Relatively low correlations between executive tasks may be due to the influence of non-executive processes or to confounding variables that suggest that there are dissociable executive functions rather than a unitary construct (Miyake & Shah, 1999; Salthouse, Atkinson, & Berish, 2003). However, confounding nonexecutive processes may mask the existence of possible underlying commonalities among executive tasks (Miyake & Shah, 1999).

WCST is a Widely Accepted Measure of Executive Functioning

The WCST was introduced as a test of problem-solving and decision-making in 1948 (Berg, 1948; Grant & Berg, 1948). Currently, the WCST is one of the most widely used neuropsychological tests of executive functions (Rabin, Barr, & Burton, 2005). It exists as both a hand-administered measure as well as in a computerized form. Hand-administration is available in both the full form (WCST-128) and short form (WCST-64), which was developed to accommodate levels of frustration, particularly for individuals in clinical populations. General guidelines of this test are based on the premise that each card in this test can be sorted by color, shape, or number. The task for the participant is to determine the correct sorting criterion on the bases of hypothesis testing and integrating feedback so to flexibly switch between sorting rules whenever the sorting criterion is changed.

Seventy-five percent of neuropsychologists reported using the WCST as part of their battery (Butler, Retzlaff, & Vanderploeg, 1991). Over 115 articles have reported using the WCST as a primary measure of executive functioning between 1981 and 1994, and this number has only grown exponentially in the most recent decade (Axelrod, Greve, & Goldman, 1994). In its current form, the WCST is a specific measure of cognitive flexibility, however, given the discrepancy between definitions and theories of executive functions, it has also been suggested as a measure of “mental set-shifting,” “inhibition,” “problem solving,” and “categorization,” just to name a few (Miyake et al., 2000). Cognitive flexibility is often investigated using a battery of set-shifting tasks. As such, the WCST requires the ability to engage in conceptual problem solving by exploring different possible solutions to a task and modifying a solution or strategy in response to given feedback (Kizilbash & Donders, 1999). Processes of cognitive flexibility imposed include the ability to form abstract concepts and to shift and maintain set (Anderson, 2001).

Although the WCST was originally designed for use with adults, the most recent manual for the WCST lists added norms for children from 6 to 12 years of age (Heaton, Chelune, Curtiss, Kay, & Talley, 1993). The measure is sensitive to development and maturational changes of executive functions, with recent findings suggesting that such development continues well into adolescence and beyond (Heaton et al., 1993; Lin, Chen, Yang, Hsiao, & Tien, 2000). Impaired performance on the WCST has been noted in individuals with various diagnoses including head injury (Bassett & Slater, 1990; Pentland, Todd, & Anderson, 1998), cranial irradiation/chemotherapy (Anderson, Godber, Smibert, & Ekert, 1997), Tourette syndrome (Harris et al., 1995), and AD/HD (Boucugnani & Jones, 1989; Chelune, Ferguson, Koon, & Dickey, 1986).

WCST studies in adults. The WCST has been widely studied in a variety of adult populations. Performance on the WCST has been found to be sensitive to adults with TBI (Merrick, Donders, & Wiersum, 2003), adults with AD/HD (Romine et al., 2004), individuals with learning disabilities (Lazar & Frank, 1998; Snow, 1998), high-functioning adults with autism (Rumsey, 1985), adults with depression (Channon, 1996; Martin, Oren, & Boone, 1991) and adults with schizophrenia (Beatty, Jocic, Monson, & Katzung, 1994). In some populations, including adults with TBI, there appears to be a correlation between diagnosis severity (e.g., TBI severity) and WCST performance in patients providing good effort (Ord, Greve, Bianchini, & Aguerrevere, 2010). For example, individuals in the mild TBI group did not differ from healthy controls, while increased levels of impairment on the WCST were observed in the moderate/severe TBI group (Ord et al., 2010). Despite the WCST's utility across diverse clinical groups, studies have found that the WCST is not entirely effective in discriminating malingering from nonmalingering in clinical populations (e.g., Greve, Heinly, Bianchini, & Love, 2009).

Prior studies have found correlations between some WCST variables and intelligence (as predicted by tests such as the Wechsler Intelligence Scale for Children; Ardila, Pineda, & Rosselli, 2000; Chase-Carmichael, Ris, Weber, & Schefft, 1999; Kizilbash & Donders, 1999). Salthouse (2005) observed that performance on two common tests of executive functioning—the WCST and the COWAT—was strongly correlated to reasoning ability and perceptual speed. The little common variance shared by these tests was also significantly related to performance on the

Ravens Progressive Matrices, suggesting that there is no unitary executive construct and measures of executive functioning rely on underlying non-executive processes (Salthouse, 2005; Salthouse & Davis, 2006). Furthermore, analyses of performance on other traditional measures of executive functioning and on measures of intelligence have concluded that both groups of tests essentially measure general intellectual abilities (Obonsawin et al., 2002). One important study found no significant correlations between IQ scores and executive function measures, however, and concluded that formal intelligence tests do not appraise executive processes, and nonexecutive intellectual processes do not directly contribute to executive ability (Ardila et al., 2000).

Several studies have tried to determine factor structure of the WCST in adult samples (Goldman et al., 1996; Greve, Ingram, & Bianchini, 1998; Paolo, Troster, Axelrod, & Koller, 1995; Wiegner & Donders, 1999), however, findings based on adult samples have been inconsistent, which may be the result of using different sets of WCST variables, variations in sample size and composition, and different factor analytic techniques. A meta-analytic review of 17 factor analytic studies of the WCST suggests that a three-factor solution likely best accounts for the cognitive processes underlying performance on the WCST (Greve, Stickle, Love, Bianchini, & Stanford, 2005). These processes include the ability to shift set, problem solve/test hypotheses, and maintain response patterns. Results of a 2005 study by Greve and colleagues generally support the three-factor solutions reported in the exploratory factor analysis literature. However, only the first factor, which reflected general executive functioning, was statistically sound. The secondary factors, which likely reflected meaningful cognitive abilities, were less stable on the WCST-128.

WCST studies in children. Past researchers have suggested that executive functions cannot be accurately measured in childhood given the progressive development of executive functions that extends into early adulthood. However, recent studies provide compelling evidence that these skills can be assessed even in preschool-aged children when appropriate measures are employed (Anderson, 2001). Though the WCST was initially developed for use with adults, validity of the WCST has also been demonstrated in several pediatric samples (Liss et al., 2001; Seidman, Biederman, Faraone, Weber, & Ouelette, 1997) and by 10 years of age, children perform on the WCST at levels that approximate those of adults (Chelune & Baer, 1986; Chelune & Thompson, 1987). Though the WCST is sometimes thought of as a frontal lobe test, research suggests that localizing specificity may be imprecise, particularly with children (Chase-Carmichael et al., 1999). This is in part due to the developmental changes that occur and mature throughout childhood, but is also due to multiple overlapping executive and non-executive demands of the WCST (Snyder et al., 2015). Given the developmental hallmarks of executive functions and their precursory non-executive cognitive correlates that are prominent in children, addressing the WCST as a specific test of cognitive flexibility is questioned, however, it is generally accepted that the WCST measures cognitive flexibility and its related processes even in developing children. Task requirements on the WCST are similar to those of other measures of executive functioning (e.g., Halstead Category Test for children; Reitan & Wolfson, 1992), but modest common variance between these two tests suggests that they assess different cognitive constructs (Fisher, DeLuca, & Rourke, 1997). Studies of the WCST in pediatric populations have determined specific weaknesses that are not relevant in adult populations. For example, the abbreviated WCST-64 is not very successful in heterogeneous pediatric samples (Smith-Seemiller, Arffa, & Franzen, 2001). In fact, Smith-Seemiller et al.

found that a fairly high proportion of their pediatric participants were misclassified in terms of level of performance as a result of the WCST-64 (and urged more caution about the concurrent validity of the WCST-64).

The WCST has shown to be sensitive to cerebral dysfunction and acquired brain injury in children (Chelune et al., 1986; Kizilbash & Donders, 1999; Schneider & Asarnow, 1987; Seidman et al., 1997). Performance on the WCST in learning disabled children follows a developmental trend whereby performance between learning disabled and non-disabled children and adolescents is similar, but overall performance for children with learning disabilities at each age level is lower than that for non-disabled children (Helland & Asbjørnsen, 2000; Snow, 1998). Children and youth with disruptive behavior disorders (e.g., conduct disorder, oppositional defiant disorder) have been shown to demonstrate deficits in executive function and decreased performance on the WCST (Lueger & Gill, 1990; Morgan & Lilienfeld, 2000). Children with autism and normal range IQ scores perseverated significantly more on the WCST than a matched group of children with learning disabilities (Ozonoff, Pennington, & Rogers, 1991). However, another study comparing individuals with autism to matched controls demonstrated impaired overall performance on the WCST but no significant differences in perseveration (Rumsey & Hamburger, 1988). Children with autism show a significant increase in impaired WCST performance when compared to a normal control group (Ozonoff, 1995). Children with anxiety disorders also show decreased performance on the WCST with more total errors and perseverative responses and observed difficulties with set-shifting as compared to healthy controls (Toren et al., 2000).

A study investigating the factor structure of the WCST in a clinical sample of children with TBI supported a three-factor structure with dimensions of response accuracy, self-monitoring, and learning (Kizilbash & Donders, 1999). The presence of a reliable factor structure on the WCST across adult (Wiegner & Donders, 1999) and pediatric samples (Kizilbash & Donders, 1999) with the same diagnosis (TBI) also lends further support to the contention of Chelune and his colleagues that by the age of 9-10 years, the WCST measures very similar constructs in children as in adults (Chelune & Baer, 1986; Chelune & Thompson, 1987). Though factor analyses of the WCST have been conducted in several adult populations, replications of such studies in child populations have not yet been fully considered.

Statement of Purpose

Knowledge Gap. Despite the frequent use of the WCST as a clinical and research tool, debates continue concerning the nature of the cognitive processes that impact WCST performance and the relationship among the various scores derived from the test. Similar factor analyses of the WCST have not been as widely attempted in children as in the adult population. Pediatric studies on the WCST are variable and document the impact that symptom severity and demographic differences have on WCST performance in children (Kizilbash & Donders, 1999). Moreover, the adult literature has proposed one-, two-, and three-factor models that support the WCST, with independent groups of variables loading into each separate factor. Though the three-factor model has been the most widely accepted, recent research has been unable to dispute other factor analytic findings that provide alternative models of the latent structure of the WCST. Inconsistent findings in adult samples have been purported to be the result of the use of different sets of the WCST variables, variability in the sample's composition and size, and the use of different factor analytic techniques.

Present Study. One highly debated topic regards which executive processes (e.g., working memory, inhibitory control, or cognitive flexibility) are specifically required for successful completion of any test proposed to measure executive functioning (Diamond, 2013). Given the wide-ranging utility of the WCST in pediatric research and clinical practice, it is necessary to establish consistent models that help to define its structure. The goal of the current investigation is to evaluate the latent structure of the WCST in pediatric patients with acute mental illness. Given discrepant findings in the literature, the use of a large heterogeneous clinical population in this study served to avoid isolated results that are difficult to generalize over a larger pediatric population. Additionally, this study aimed to add to the pre-existing literature to further our understanding of the WCST latent structure to better understand its utility for assessment and interpretation in pediatric practice.

Method

The current principal components analysis examined the latent structure of the WCST.

Participants

IRB approval was obtained to conduct this medical chart review study. Children and adolescents referred for a neuropsychological evaluation at a children's inpatient psychiatric program within a medical school-affiliated children's psychiatric hospital were initially considered for inclusion in the present study. Participants were generally referred for neuropsychological evaluation to characterize neurocognitive functioning and guide treatment planning. Although the program admits children ages 3-12, and adolescents 13-18, the majority of the children referred for neuropsychological evaluation are between 6 to 18 years of age. Only children who completed the computerized WCST-128 version as part of their neuropsychological evaluation were considered for this study (*n*=199). Given that the WCST is normed for persons aged 7-89 (Heaton et al., 1993) and the inpatient program only admits children up to 18 years of age, children must have been 7-18 years of age at the time of the neuropsychological evaluation. Only those with sufficient information available in hospital medical records to extract key variables necessary to complete descriptive statistics on the sample were included. Such variables include age, sex, race, diagnoses, medication status and medications, and insurance status (public vs. private) as a proxy for socioeconomic status. Of note, the majority of children for whom such data was available were between the ages of 7 and 14. Children who completed the hand administered WCST-64 were excluded from the present study in order to strictly evaluate the computerized form of the test that is most commonly used in current clinical practice. Children who had notable difficulty comprehending instructions to the task, were unable to independently engage in the task, or who were unable to complete the entire task were excluded from the present study.

Neuropsychological Measures

Wisconsin Card Sorting Test. The Wisconsin Card-Sorting Test (WCST; Heaton et al., 1993) is a test of executive function that assesses skills in abstraction, shifting and maintaining focus, goal orientation, and interference control (Baron, 2004; Strauss, Sherman, & Strauss, 2006). The WCST-128 is the only version of the test that will be included in the current study.

Interscorer reliability studies have been conducted with well-trained clinicians (r_{ICC}=.88 to .93 across specific scores) and novice scorers (r_{ICC} =.83 to .95 across scores) within an adult psychiatric inpatient sample. Replicated studies in child/adolescent samples found similarly high interscorer reliability across scores (r=.895 to 1.00 across scores). Intrascorer reliability studies have also been conducted in normative adult (r_{ICC}=.91 to .96 across specific scores) and child/adolescent samples (r=.828 to 1.00 across scores). Generalizability coefficients for WCST scores based on a single test administration ranged from .39 to .72 and averaged .57 with a median of .60 which, according to Cicchetti and Sparrow (1981), demonstrates good scale reliability. According to these guidelines, the WCST scores of Percent Perseverative Responses and Percent Perseverative Errors showed only fair reliability while the remainder of the WCST scores showed moderate to good reliability in a sample of normal children and adolescents. The standard error of measurement (SE_M) in a sample of children and adolescents ranged from 7.94 to 11.91.

Evidence for the construct validity of the WCST as a measure of executive function has been explored factor analytically across various clinical and nonclinical samples (Heaton et al., 1993). One such study including a sample of 58 undergraduates who were administered the WCST as well as five other executive tasks found a four-factor solution that best fit the data (Shute & Huertas, 1990). A number of validity studies, in particular, correlational and discriminant function analyses, are described in the manual (Heaton et al., 1993) to support the use of the WCST for a variety of neurological and psychological problems, and with a variety of populations. Such studies have been conducted with clinical groups including those with seizure disorders, Parkinson's disease, focal brain damage, and psychiatric illnesses in adults (Heaton et al., 1993). Results of research studies that examined WCST performance in children and adolescents who have been diagnosed as having attention deficit hyperactivity disorder, learning disability in reading, seizure disorder, or traumatic brain injury suggest that the WCST may be helpful in evaluating executive function in these conditions (Heaton et al., 1993).

Wechsler Abbreviated Scale of Intelligence. The Wechsler Abbreviated Scale of Intelligence (WASI-I/II; Wechsler, 1999; Wechsler, 2011) is a test of intellectual functioning. The current study utilized the WASI's Full Scale Intelligence Quotient (FSIQ) score to assess for associations between WCST factor scores and general intelligence.

Controlled Oral Word Association Test. The Controlled Oral Word Association Test (COWAT) is a task of verbal fluency (Baron, 2004; Strauss et al., 2006). The phonemic condition, FAS, asks the participant to produce words starting with letters F, A, and S for 1 minute per letter. The semantic condition, Animals, asks the participant to name as many animals as they can in 1 minute. The current study utilized COWAT-FAS and COWAT-Animals to assess for associations between WCST factor scores and phonemic and semantic verbal fluency and the executive demands of such tasks.

Rey Complex Figure Test – Copy Condition. The Rey Complex Figure Test-Copy Condition is a drawing task with constructional, perceptual, spatial, and executive components (RCFT-Copy; Baron, 2004; Strauss et al., 2006). As part of the clinical neuropsychological battery, the RCFT-Copy condition is scored using the standard Taylor Scoring Criteria (Kolb & Whishaw, 1990). The RCFT is a constructional task (Baron, 2004), yet it contains inherent perceptual/constructional and executive demands (Baron, 2004; Kavanaugh & Holler, 2015). The current study utilized the RCFT-Copy to assess for associations between WCST factor scores and executively-demanding perceptual/constructional ability.

Trail Making Test – Part B. The Trail Making Test-B is a task of attention, speed, and cognitive flexibility (TMT-B; Baron, 2004; Strauss et al., 2006). The current study utilized the TMT-B to assess for associations between WCST factor scores and cognitive flexibility.

Stroop Color and Word Test – Children's Version. The Stroop Color and Word Test is a test that assesses cognitive flexibility and the ability to inhibit cognitive interference, which occurs when the processing of a stimulus feature impedes the simultaneous processing of another attribute of the same stimulus (Golden, Freshwater, & Golden, 1985). The current study utilized the Stroop Test Color-Word Condition to assess for associations between WCST factor scores and both cognitive flexibility and interference control.

Psychiatric Measures

The Children's Depression Inventory. The Children's Depression Inventory (CDI) is a 27-item measure that assesses depressive symptoms on a four-point scale (Kovacs, 2010). Independent research indicates that the CDI demonstrates adequate specificity and sensitivity for identifying youth with depressive disorders (Timbremont, Braet, & Dreessen, 2004). The current study utilized the CDI to assess for associations between WCST factor scores and self-reported symptoms of depression.

Multidimensional Anxiety Scale for Children. The Multidimensional Anxiety Scale for Children (MASC) is a 39-item (first edition) or 50-item (second edition) self-report questionnaire that assesses physical symptoms of anxiety, social anxiety, harm avoidance, and separation anxiety on a four-point scale (March, 2012; March, Parker, Sullivan, Stallings, & Conners, 1997). Independent research suggests the MASC demonstrates good internal consistency and divergent validity from depression measures, such as the CDI (Muris, Merckelbach, Ollendick, King, & Bogie, 2002). The current study utilized the MASC to assess for associations between WCST factor scores and self-reported symptoms of anxiety.

Trauma Symptom Checklist for Children. The Trauma Symptom Checklist for Children (TSCC) is a 54-item self-report measure that assesses trauma-related symptoms on a 4-point frequency scale (Briere, 1996). The test's manual reports favorable psychometric properties, such as good internal reliability and external validity (Briere, 1996). The current study utilized the TSCC to assess for associations between WCST factor scores and self-reported trauma-related symptoms.

Procedure

Neuropsychological evaluations are typically initiated after an initial psychiatric evaluation and are generally conducted over several sessions or days depending on the functioning of the child. A standard neuropsychological battery is administered by a neuropsychologist, psychometrician, and/or neuropsychology trainee (i.e., postdoctoral fellow, predoctoral intern, or practicum extern student).

Neuropsychological data on the WCST was gathered via medical chart review. Interpretive WCST-128 PDF reports that had been generated through the WCST-128 software were extracted from the hospital data files and used to create a database that was used for subsequent analyses. The research database included assigned participant numbers for tracking; demographic characteristics including (a) age at the time of evaluation, (b) sex, (c) race, (d) diagnosis, (e) medication status and medications, (f) insurance status; (g) and all WCST reported scores. The database also included key variables related to the aforementioned psychiatric and neuropsychological measures that were used as part of this study.

The WCST was computer administered and scored according to protocol and instructions in the revised manual (Heaton et al., 1993). Only scores that are described in the manual as recommended for clinical interpretation were included in the analysis (Heaton et al., 1993): Total Correct (TC); Perseverative Responses (PR); Perseverative Errors (PE); Nonperseverative Errors (NPE); Percent Conceptual Level Responses (%CLR); Categories Completed (CAT); and Failure-to-Maintain-Set (FMS). Only raw scores were used. Several scores were excluded. For example, the variable Total Trials was excluded because it is a linear combination of TC, PE, and NPE. Similarly, Total Errors was excluded because this score is a linear combination of PE and NPE. As such, these scores were excluded due to innate redundancy.

Analysis

The required sample size for a principal component analysis follows a necessary minimum of “at least 10-15 subjects per variable” (Field, 2000, p. 443), however, adequate sampling was determined by the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO-test; Cerny & Kaiser, 1977). Normality testing includes tests for skewness and kurtosis, which were used to determine the distribution of scores for each variable. Descriptive statistics regarding the sample were performed to illustrate the demographics and clinical characteristics of the study sample. A principal components analysis followed by varimax (orthogonal) rotation with Kaiser normalization was conducted on the seven selected WCST variables. Orthogonal rotation was chosen given the benefit it serves to eliminate issues of multicollinearity by reducing correlations between like variables. The number of factors to retain was based on the Guttman-Kaiser criterion (i.e., eigenvalues should approximate or exceed 1.00), in combination with the scree test and consideration of the proportion of variance accounted for by each factor. Age-corrected partial correlations were conducted to test for associations between WCST latent factors and neuropsychological and psychiatric variables, following the derivation of a latent WCST structure through principal components analysis.

Results

Data Screening

The required sample size for a principal components analysis follows a necessary minimum of “at least 10-15 subjects per variable” (Field, 2000, p. 443), however, adequate sampling was determined by the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO-test; where KMO > 0.5 is considered adequate), with a resultant KMO value of 0.69 suggesting that the sample size (*N* = 128) was sufficient and well-suited for subsequent principal component analysis (PCA).

There is no assumption of normality necessary for conducting principal component analysis, however, normality tests were performed to understand the general distribution of scores for this clinical sample. Normality testing revealed that the Perseverative Responses variable was not normally distributed, with skewness of 2.1 (*SE* = 0.214) and kurtosis of 6.99 (*SE* = 0.425). Similarly, the Perseverative Errors variable was not normally distributed, with kurtosis of 5.364 (*SE* = 0.425). No other WCST variables used for subsequent principal analysis differed significantly from normality, thereby the data for those variables were considered to be approximately normally distributed in terms of skewness and kurtosis.

Statistical Analyses

All analyses were conducted using IBM SPSS Statistics Software (Version 24). Descriptive analyses and frequency analyses were used to provide descriptive information about the sample with regard to age, gender, race, length of stay (LOS), handedness, diagnosis (see Table 1) and the frequency distribution of the seven standard WCST index scores used in the present study (see Table 2). The average age of the children in the sample at the time of their evaluation was 10.62 years (i.e., 10 years, 7 months, 13 days) with a standard deviation of 1.82 years (*n* = 128). Gender demographics of the sample show a generally even split between male and female participants, with 74 participants identifying as male (57.8%) and 54 participants identifying as female (42.2%). The racial demographics of the sample included 77 children who were identified as “White/Caucasian” (60.2%), 22 children who were identified as “Hispanic/Latino” (17.2%), 15 children who were identified as “African American” (11.7%), eight children who were identified as “Multiracial” (6.3%), and six children who were identified as “Other” (4.7%). The average length of hospital stay (LOS) was 18.54 days (SD = 19.8 days; *n* = 128). The majority of the sample was right-handed, with 106 participants identifying as right-hand dominant (82.8%), 18 participants identifying as left-hand dominant (14.1%), and 4 participants with unknown handedness (3.1%). Diagnoses for each participant were determined based on the diagnoses they carried at the time of their discharge from the hospital. Depressive disorders including Major Depressive Disorder, Dysthymic Disorder, or Depressive Disorder Not Otherwise Specified were diagnosed in 40.6% of the sample (*n* = 52). Other mood disorders including Mood Disorder Not Otherwise Specified or Disruptive Mood Dysregulation Disorder was diagnosed in 37.5% of the sample (*n* = 48). Anxiety Disorders including Generalized Anxiety Disorder, Anxiety Disorder Not Otherwise Specified, or Obsessive-Compulsive Disorder was diagnosed in 36.7% of the sample (*n* = 47). Attention-Deficit Hyperactive Disorder was diagnosed in 56.3% of the sample (*n* = 72). Additional diagnoses and their frequencies within the present sample are listed in Table 1, including Behavioral Disorders (*n* = 13; 10.2%), Adjustment Disorder (*n* = 11; 8.6%), Bipolar Disorders (*n* = 8; 6.3%), Psychotic Disorders (*n* = 6; 4.7%), Learning Disorders (*n* = 5; 3.9%), Attachment Disorder (*n* = 5; 3.9%), Pervasive Developmental Disorder and Autism Spectrum Disorders (PDD/ASD; *n* = 3; 2.3%), Cognitive Disorders (*n* = 3; 2.3%), and Tic Disorder (*n* = 1; 0.8%).

A principal components analysis of the seven selected indices of the WCST was conducted to determine the latent structure of the WCST test. Bartlett’s test of sphericity, which tests the overall significance of all the correlations within the correlation matrix, was significant ($\chi^2(21) = 1484.1$, $p < 0.001$), indicating that it was appropriate to use a factor analytic model on this set of data. The Kaiser-Meyer-Olkin measure of sampling adequacy indicated that the strength of the relationships among variables was high (KMO = 0.69), thus it was acceptable to proceed with the analysis. Communalities above 0.60 for all WCST variables were confirmed in order to further suggest that the sample size was well-suited for subsequent principal components analysis (MacCallum, Widaman, Preacher, & Hong, 2001). A series of factor analyses were conducted which indicated that three factors gave the most interpretable solution. An orthogonal rotation was performed since factors were expected to be independent, and in attempt to reverse any issues of collinearity. Given the different frequency distributions for each variable (see skew and kurtosis analyses above), factor loading cut-offs followed stringent guidelines (i.e., a factor cut-off of 0.63 is considered to be "very good") to preserve the significance of the resulting factor structure (Tabachnick & Fidell, 2007).

The three-factor solution is outlined in Table 3. The variables Total Correct, Non-Perseverative Errors, % Conceptual Level Responses, and Categories Completed loaded onto factor 1, which was named "Problem Solving." The variables Perseverative Responses and Perseverative Errors loaded onto factor 2, which was named "Flexibility." The variables Total Correct and Failure-to-Maintain Set loaded onto factor 3, which was named "Interference Control." The first factor had an eigenvalue of 2.97 and accounted for 42.5% of the variance in the data. Factor two had an eigenvalue of 2.33 and accounted for a further 33.2% of the variance. The third factor had an eigenvalue of 1.40 and accounted for a further 20% of the total variance. Overall, the three-factor solution accounted for 96% of the total variance. Most of the WCST indices loaded unequivocally on one of the three components, although Total Correct loaded on both Problem Solving and Interference Control factors, with slightly higher loading on the latter (see Table 3).

Following the development of a three-factor solution, factor scores were analyzed for their association to various psychiatric and neuropsychological variables. Raw scores for the

WCST variables of Non-Perseverative Errors (NPE), Perseverative Responses (PR), Perseverative Errors (PE), and Failure-to-Maintain Set (FMS) were inverted to their absolute negative values, so that raw score values were positively correlated with performance (e.g., a greater negative raw score value is synonymous with more impaired performance for that variable). Once selected WCST variables were appropriately inverted, z-transformations were conducted to convert raw scores into respective *z*-scores for all seven variables, utilizing the means and standard deviations of the present sample for each variable, respectively. Composite factor scores were then calculated by summing the respective WCST variable *z*-scores for all variables that loaded into each of the three factors, respectively (e.g., *z*-scores for TC, NPE, CLR, and CC were summed to create a composite score for Factor 1). Partial correlations with age corrections were then conducted for each of the composite scores against psychiatric variables of length of stay (LOS; in days), number of diagnoses, and self-reported symptoms (as measured by the CDI, MASC, and TSCC). Results of this correlational analysis revealed that Factor 1 was negatively correlated with the CDI (r = -.266; p = 0.048), MASC (r = -.331; p = 0.016), and TSCC (r = -.315; p < 0.033). Factor 2 was negatively correlated with the MASC (r = -.275; p < 0.048), and Factor 3 was also negatively correlated with the MASC (r = -.205; p < 0.046). Results of partial correlational analysis are illustrated in Table 4.

Given the statistically significant correlations between anxiety and depression diagnoses for all three factors, post-hoc one-way ANCOVAs were conducted to determine whether a statistically significant difference existed between individuals with anxiety diagnoses, depression diagnoses, or no such diagnoses on their performance across the three separate factors. One-way ANCOVAs revealed no significant effect of depression or anxiety diagnosis on any of the three composite factor scores. Partial correlations with age corrections were conducted for each of the composite scores against neuropsychological variables of full-scale intelligence estimates (FSIQ; as measured by the WASI), Controlled Oral Word Association Test – FAS (COWAT-FAS), Controlled Oral Word Association Test – Animals (COWAT-Animals), Rey-Osterreich Complex Figure – Copy Condition (RCFT-Copy), Trail-Making Test – Part B (TMT-B), and Stroop Test – Color-Word Condition (Stroop Color-Word). Results revealed that Factor 1 is positively correlated with FSIQ ($r = .44$; $p < 0.01$), COWAT-FAS ($r = .27$; $p < 0.01$), COWAT-Animals ($r = .25$, $p < 0.01$), and Stroop Color-Word ($r = .22$, $p < 0.05$). Factor 2 is positively correlated with FSIQ ($r = .39$, $p < 0.01$), COWAT-FAS ($r = .24$, $p <. 01$), COWAT-Animals ($r = .18$, $p<.05$), and RCFT-Copy ($r = .18$, $p <. 05$). Factor 3 is positively correlated with FSIQ ($r = .21$, $p < .05$). There were no other significant correlations.

Discussion

The present study addressed the question of whether the WCST has a multidimensional latent structure in psychiatrically hospitalized youth. Prior studies and clinical experience have suggested that the WCST is a complex task that taps cognitive abilities of problem solving, perseveration, and loss of set (Heaton et al., 1993). Performance on this task requires the integration of both cognitive and, more specifically, executive processes and, therefore, one would not expect the WCST to be represented by a unidimensional cognitive domain. At the same time, this project aimed to compare the results of the present study with findings from previous factor analytic studies of the WCST involving various adult and pediatric populations. As such, it is not only important to highlight and expand on the multidimensional structure of the WCST suggested by the above presented data, but also to compare these findings with similar factor analytic studies.

The results of the present study revealed a three-factor solution involving three distinct factors thought to be relatd to problem solving, flexibility, and interference control. This three-factor latent structure of the WCST accounted for 96% of the total variance. Overall, the factor solution was strong, with eigenvalues well over the minimum threshold of 1 for all three factors in this study's proposed model. Findings from previous studies have been inconsistent, and some have argued for one, two, and three factor solutions for the WCST. Variability in latent structure solutions have largely been considered the result of using different sample groups, different sets of WCST variables, and different factor analytic techniques (Kizilbash Donders 1999; Bowden et al., 1998). Some have argued that the sensitivity of the WCST to factor analytic procedures might also explain how variations in sample size and composition can alter outcomes. Confirmatory factor analytic techniques have been employed to better glean which factor solution exists as a best-fit model. Respective fit indices of confirmatory factor analyses for one, two, and three factor models suggest that none of the models fit closely enough to be considered a singular best-fit model across clinical and nonclinical adult populations (Greve et al., 2005).

Moreover, comparisons of factor solutions in adult and pediatric samples reveal differences in number of factors and their respective factor loadings. Although research has yet to define a singular best-fit factor model for the WCST, three-factor models have shown statistically significant improvement in fit over the one and two factor solutions (Greve et al., 2005). It is possible that the general inadequacy of one, two, and three factor models is the result of there being different best-fit models for different clinical subgroups, in which case, the most salient three-factor model may be the best-fit model for the purposes of the presently studied population of psychiatrically hospitalized youth. At the same time, it is somewhat difficult to suggest with full certainty that the factor structure findings in this present study provide a best-fit model given that the present factor structure has not been evaluated by methods of confirmatory factor analysis, specifically statistical tests of good model fit within a novel study sample.

One previous study compared resultant three-factor models from exploratory factor analyses in clinical populations against a normative, nonclinical sample and found that the three-factor model appeared to be closest in fit compared to one and two factor models, although not a “true” fit for the nonclinical sample group (Greve et al., 2005). This may be a result of the differences in sample demographics in that a three-factor model may be better suited for clinical rather than normative, nonclinical populations. As just one example, a factor analytic study of the WCST standardization sample revealed that in normal individuals the WCST is best described by a unitary factor, while in neurological patients with either focal or diffuse impairment, performance on the WCST was primarily explained on the basis of two factors then named Problem Solving/Perseveration and Loss of Set (Goldman et al., 1996). These unique population-specific factor structures highlight the inherent limitations of the WCST such that the internal structure of the test does not hold across nonclinical and clinical subgroups. Moreover, these structural differences highlight important distinctions in WCST performance across clinical samples such that the standardization sample may not be the most appropriate normative comparison group when evaluating psychiatrically hospitalized youth. Succinctly put, different best fit models for different clinical subgroups might threaten the tests generalizability, and interpretations of individual performance may not translate across clinical and nonclinical groups. Instead, factor models for distinct clinical subgroups are critical in accurately evaluating WCST performance and the specific cognitive and executive constructs that define its latent structure.

Two prior principal component analyses of the WCST in clinical psychiatric samples similarly revealed a three-factor solution (Cuesta, Peralta, Caro, & de Leon, 1995; Sullivan et al., 1993). In both studies, the three-factor solution shared great similarity with the three-factor solution of the present study, including a third factor related to interference control that was generally informed by the same two WCST scores as found in the present study: Total Correct and Failure-to-Maintain Set. At the same time, a significant difference between the present three-factor solution and those suggested by the two aforementioned studies is that scores related to perseverations mapped onto a singular factor—the *Flexibility* factor—in the present study, but were divided between factors one and two in the two previous studies. The difference in structure of the three-factor solutions between this study and those prior could be the result of differing sample sizes. Sullivan and colleagues (1993) conducted their analysis with a mixed sample of 58 adult participants while Cuesta and colleagues (1995) conducted their analysis with a sample of 38 adult schizophrenic or schizoaffective patients.

At the same time, there are significant methodological differences between the present study and those prior, including that the authors did not reduce the number of variables included in their analyses based on the inherent redundancies of the several WCST scores, whereas the present study reduced the number of variables to avoid collinearity. The sample size of the present study was significantly larger, and therefore more statistically sound given the more stringent criteria for sample size to variable ratio. Despite inherent limitations of previous studies, the consistency of a three-factor solution across all three clinical studies suggests some validity to the three-factor model as an appropriate structure model for the WCST in clinical populations.

A factor analysis of a large mixed patient sample revealed three stable factors including (a) general executive function, (b) nonperseverative errors, and (c) failure to maintain set (Greve et al., 1999). However, even in this model a primary factor related to general executive functioning reflects the overlap of variables known to be associated to separate and distinct executive processes. The present results demonstrate a more obvious distinction between variables related to problem solving (i.e., Factor 1; Total Correct, Percent Conceptual Level Responses, Nonperseverative Errors, and Categories Completed) and variables related to cognitive flexibility (i.e., Factor 2; Perseverative Errors and Perseverative Responses). Several previous studies have demonstrated the most salient factor as response inflexibility (i.e., perseverative tendencies which includes scores of Perseverative Errors and Perseverative Responses; Goldman, Axelrod, & Tompkins, 1992; Heaton et al., 1993; Sullivan et al., 1993); however, the present study results suggest that problem solving is most strongly associated with performance on the WCST for psychiatrically hospitalized youth. The factor structure presented in this current study is generally consistent with that of Paolo and colleagues who applied principal component analysis to two separate samples of 187 normal elderly individuals and 181 persons with Parkinson's disease (Paolo et al., 1995) and found a similar, though not identical, three-factor solution for both groups that was characterized by factors of Conceptualization/Problem Solving, Failure to Maintain Set, and Learning. Interestingly, perseveration did not emerge as a separate factor in the normative elderly sample, further highlighting performance variability between clinical and nonclinical populations.

Within the present study's factor model, there are three distinct dimensions that appear to underlie performance on the WCST: (a) Problem Solving, (b) Flexibility, and (c) Interference Control. The first factor represents a problem-solving dimension, with moderate to high positive loadings by the variables Total Correct, Nonperseverative Errors, Percent Conceptual Level Responses, and Categories Completed. To put these variables into the context of the respective problem-solving dimension, we have to consider what this might look like for someone who has a limited capacity for novel problem solving. A person who struggles to find novel solutions to problems is likely to make a greater number of ambiguous or unexplained errors (i.e., Nonperseverative Errors), and is therefore more likely to achieve fewer total correct responses over the course of the task (i.e., Total Correct). Moreover, this same individual will struggle to achieve a high ratio of successive correct responses that adhere to the proper sorting rule (i.e., Percent Conceptual Level Responses). As a result, this individual's errored performance will likely lead them to complete fewer categories over the course of the task administration (i.e., Categories Completed). As such, the first factor was aptly named after a problem-solving dimension, as the variables that loaded onto this factor were all most closely related to aspects of novel problem solving.

This conceptual construct is similar to factors involved in sustained attention, suggesting that children with limited sustained attention might have similar difficulties on this task as those mentioned above. The primary problem-solving dimension revealed in this present study is consistent with the test developers' definition of the WCST as "a measure of 'executive function', requiring the ability to develop and maintain an appropriate problem-solving strategy across changing stimulus conditions in order to achieve a future goal" (Heaton et al., 1993, p. 1), where problem solving is defined as a core component of the WCST.

The second factor represents a flexibility dimension, with high loadings by the variables Perseverative Responses and Perseverative Errors. The variables within this dimension highlight the independent impact of perseverative tendencies on WCST performance that can occur as a result of impaired or diminished cognitive flexibility. Put in context, someone who struggles to be flexible in their problem-solving approach is more likely to have trouble shifting to and solving for a new sorting category while likely continuing to solve for the previous correct sorting category, thereby perseverating on the initial solution rather than seeking a novel approach to a new sorting problem. When an examinee successfully completes a category, the correct sorting principle changes to a new category without informing the examinee, at which point initial feedback is provided to indicate that the previous sorting principle is no longer correct. The examinee must inhibit the tendency to persist or perseverate with the old principle and must use the provided feedback to determine the new, correct sorting principle. This second flexibility factor is considered a salient, distinct dimension of the WCST that is necessary for successful completion of the task.

The third factor represents an interference control dimension, with medium loading of the variable Total Correct and high loading of the variable Failure-to-Maintain Set. Interference control requires that a person prevent interference or inhibit interference due to competition of relevant or irrelevant stimuli. A failure to maintain set occurs when an examinee makes five or more consecutive correct responses and then makes an error before successfully completing a category (Heaton et al., 1993). This type of error highlights a possible distractibility component that underlies performance on the WCST. Even if participants demonstrate strong novel problem solving abilities by providing the correct conceptual level response and are able to maintain flexibility in their problem-solving approach while avoiding perseverative tendencies, they may still struggle to perform well on the task if they struggle to inhibit their response to interfering and irrelevant stimuli. Therefore, they may also struggle to maintain a correct set of responses to complete a set category. Given that this variable loaded onto a third factor that was separate from those more closely related to problem solving and cognitive flexibility, it appears that the third dimension is likely one that relates to interference control.

Correlational analyses were conducted to determine whether psychiatric or cognitive variables were associated with the latent factors that compose the structure model of the WCST in the presently studied psychiatric youth population. In keeping with the National Institute of Mental Health (NIMH) Research Domain Criteria (RDoC; Garvey, Avenevoli, & Anderson, 2016) these correlations were conducted to integrate information about cognitive, affective, and behavioral processes that underlie psychopathology and related symptoms. Number of diagnoses, length of hospital stay, and self-reported symptom measures (CDI, MASC, and TSCC) were used as constructs of psychodiagnostic severity, and subsequently analyzed to determine which variables, if any, could predict performance on the WCST. Results demonstrated that self-report symptom measures were correlated with performance on the WCST, while length of hospital stay and number of diagnoses were not. In keeping with the RDoC framework, self-report symptom measures are likely a better measure of perceived or experienced psychopathology than diagnoses or objective criteria such as length of hospitalization. Length of hospitalization is an observable variable that may predict severity of symptomatology under other circumstances, but was not a predictor of problem-solving ability, cognitive flexibility, or interference control on the basis of the latent structure model of the WCST proposed in this present study.

It is possible that seemingly objective measures of psychodiagnostic severity, such as length of hospitalization or number of diagnoses, may not be associated with WCST performance given that the study population is already defined by severe psychopathology (i.e., psychiatrically hospitalized) where within-group differences are limited. Instead, the WCST factor structure was significantly associated with more subjective measures of psychopathology as defined by scores on self-report symptom inventories. Specifically, problem solving (Factor 1) had a statistically significant small negative correlation to depression (CDI), anxiety (MASC), and trauma (TSCC) while flexibility (Factor 2) and interference control (Factor 3) had small negative correlations to anxiety (MASC) only. The correlation of all three factors to symptoms of anxiety suggests a possible effect of anxiety on WCST performance. This finding suggests that symptoms of anxiety such as tension, panic, restlessness, performance fears, and general stress may impact performance on the WCST such that children with increased anxiety symptoms may struggle with decision making, cognitive flexibility, interference control, and set-shifting (Eysenck, Derakshan, Santos, & Calvo, 2007; Snyder et al., 2014) and thus may perform lower than their non-anxious peers (Ansari, Derakshan, & Richards, 2008; Eysenck et al., 2007).

At the same time, anxiety can also play a role in limiting the initiation, engagement, and sustained attention for the WCST task (Bishop, 2009). Although these are not directly related to the executive processes underlying the WCST, it is possible that functional and cognitive symptoms of anxiety could inhibit executive processes that are involved in successful completion of the WCST. Severe psychopathology may also inhibit initiation and engagement in the WCST task, which might lend some explanation as to why all three self-report measures were correlated with the WCST's primary problem-solving factor. For example, symptoms related to depression such as low motivation, lethargy, limited effort, anhedonia, and diminished ability to think or concentrate may impact test performance on the WCST. The CDI is specifically designed to assess a variety of cognitive, behavioral, and neurovegatative symptoms related to depression, as well as assess emotional and functional problems associated with depression (Kovacs, 2010). As a result, experiencing lowered self-esteem and perceived ineffectiveness could impact one's problem-solving approach, thereby impacting one's performance on the task, particularly as measured by variables related to the primary problem-solving factor of the WCST in this study.

Further correlational analyses were conducted to determine whether the WCST latent factors were associated with other neuropsychological measures of general cognition and executive functioning. The results of these correlations revealed that all three factors demonstrated a weak to moderate significant correlation with general intellect (IQ) as measured by a brief intellectual screening measure. The correlation among all variables to IQ demonstrates validity of our resulting factor structure, such that IQ has been previously correlated to WCST performance and is upheld in the present study as well. Moreover, this finding confirms that there is a general cognitive component to the WCST task and that performance on the WCST is related to, at least in part, on having intact intellectual functioning. The underlying executive processes that the WCST taps into likely rely on a requisite cognitive baseline. Moreover, performance on phonemic and semantic verbal fluency tasks correlated to factors 1 and 2—problem solving and cognitive flexibility, respectively. It may be that the WCST latent factors are correlated to verbal fluency tasks as both tasks involve strategic planning, problem solving, and inhibitory control (e.g., the ability to not perseverate on a specific word group or sorting category) and flexibility in thinking (e.g., thinking of different words in sequence or thinking of different sorting strategies). Prior research indicates that verbal fluency tasks are a measure of high order executive functioning including, more specifically, set shifting and executive control processes (Alvarez & Emory, 2006, Jurado & Rosselli, 2007).

The Stroop Test Color-Word condition correlated with the latent problem solving factor (Factor 1) while the RCFT Copy condition correlated with the latent flexibility factor (Factor 2) suggesting that these two measures may be differentiated by separate underlying executive constructs. The RCFT Copy condition relies on strengths in planning and organization for successful completion. Moreover, an individual must be flexible in their approach while considering both the big picture as well as the smaller details in order to successfully reproduce the image. As such, it is unsurprising that planning and organization correlated with the flexibility factor (Factor 2). Interestingly, the Stoop Color-Word test condition is widely accepted as a test of inhibitory control, but did not correlate with the latent interference control factor in this present study. It is possible that age-related differences in executive control processes impact the executive strategies that are employed for successful performance on the Stoop test in children, and subsequently alter patterns of performance in children overall (e.g., Leon-Carrion, Garcia Orza, & Perez-Santamaria, 2004). Moreover, the differentiation between color naming and word reading is a developmental process, and performance on this task is likely implicated by lesser differentiation in latency aged children.

Clinical Implications

The clinical objective of this study was to provide psychologists and neuropsychologists with important information regarding the latent structure of the WCST in children suffering with severe psychopathology and those hospitalized for psychiatric reasons. The results of this study confirm that the latent structure of the WCST in the present sample is largely the same as the latent structure of the WCST determined in other clinical and nonclinical samples. This result alone provides a certain level of confidence for practitioners who work with child and adolescent psychiatric populations in knowing that the WCST measures the intended constructs of executive problem solving, cognitive flexibility, and inhibitory control. Moreover, the resulting factor structure in the present study provides critical information that can be used to inform the analysis and interpretation of WCST performance in children who struggle with severe psychopathology.

It is important for clinical neuropsychologists and psychologists to consider both the latent constructs of the WCST—problem solving, flexibility, and inhibitory control—as well as the WCST variables that are associated with each respective construct in order to provide accurate interpretations of WCST score reports.

The present results demonstrate that not all factors and their respective variables are associated with other measures of executive functioning, but that specific factors are associated with only a few specific executive functioning measures. As such, it is important for clinicians to interpret WCST performance separately from performance across other executive functioning measures. Moreover, the results highlight the critical importance of not substituting the WCST for other measures of executive functioning without carefully considering the specific executive demands of each measure. The present study also found that performance on the WCST is not directly influenced by psychiatric hospitalization itself nor by the length of hospital stay. Diagnosis alone is not a predictor of WCST performance either, suggesting that objective diagnostic criteria are likely not useful in determining or hypothesizing about a child's performance on the WCST and are unlikely to be predictors of overall executive ability.

It is true, however, that self-reported symptoms and self-perceptions about psychiatric symptomatology are associated with WCST performance in the present sample. This finding suggests that self-report symptom inventories and questionnaires can be useful in not only investigating children's perceptions of their mental illness(es), but may also be associated with having greater difficulties on the WCST and possibly other executive measures that measure similar constructs to the WCST. Most striking is the association between self-reported symptoms of anxiety and WCST performance, suggesting that anxious symptomatology may impact WCST performance in clinical psychiatric child and adolescent populations. A child who reports elevated symptoms of anxiety, for example, may struggle more on the WCST. However, it would be important to investigate this association further before drawing conclusions about such clinical implications. Overall, these results are part of an effort to build broadly useful and accessible information that investigators and practitioners will find useful in their search for more precise analysis and interpretation of WCST performance in psychiatric child populations.

The results of the present study are also clinically useful in that they propose a more dimensional and comprehensive approach to understanding child psychopathology. Broadly, the present study upholds the NIMH RDoC mission to assess the range of functioning of neurobiological, cognitive, and behavioral capacities along continua of greater or lesser degress of health or adaptation as related to psychopathology. The results of the present study focus on fundamental components of behavior and emotion (e.g., self-report symptom inventories) as well as cognitive functioning in terms of executive ability as estimated by WCST performance. At the same time, the results serve to support a more integrative and dimensional understanding of how behavioral, emotional, and cognitive functioning can constitute risk for multiple disorders, dysfunctions, or difficulties. More specifically, this study shows preliminary evidence of how self-report symptoms of anxiety, for example, can constitute risk for greater impairment on the WCST and, thus, could be implicated in executive skill deficits for children with severe psychopathology. Focusing on fundamental components of behavior and cognition rather than DSM diagnoses will allow for detection and monitoring of emerging symptoms that do not meet the DSM criteria for a disorder or diagnoses. The present results support this transition towards more dimensional approaches to psychopathology as diagnosis alone was not found to be a predictor of WCST performance.

Considering these results as just one small advance in a larger search for more integrative conceptual models that are capable of representing knowledge within and across neurobiological, behavioral, and cognitive levels aids in improving our understanding of the complexity of mental illness. Clinicians can utilize results such as those proposed in the present study to provide more dimensional illustrations of clinical presentations to better understanding levels of difficulty and dysfunction as well as to provide more accurate recommendations and accommodations that best serve patients and their needs.

Limitations

While technically the subject-to-variable ratios were adequate with an acceptable threshold of approximately 10:1 (Tabachnick & Fidell, 2007), this is considered to be a generally small sample size. Solutions derived from small sample sizes are less stable and reliable than those derived from larger samples, thus suggesting a potential limitation to the present study design. Another discrepancy in the current study involves the variable termination criteria for the WCST-128. When the WCST is administered in standard fashion, there are two termination criteria (i.e., the completion of six categories or the completion of all 128 cards, whichever is achieved first), which means that the number of trials completed by any given administration can vary from 70 to 128.

The two possible termination criteria present additional error to factor analytic studies of the test. Although the large amount of variance accounted for in the present principal components analysis does not suggest that there is error in the resulting factor structure introduced here, it is likely that using a single termination criterion would only strengthen the results of factor analytic studies on the WCST. Oppositely, in one study where subjects either completed the same number of trials (i.e., all 128 trials despite the number of categories completed) or standard WCST administration, factor analysis revealed a three-factor solution to be consistent across both samples (Greve et al., 2002). Thus, it is not unreasonable to imagine that the results of the present analysis could generalize to the sample's nonclinical counterparts. At the same time, the WCST test developers reported that failure-to-set was a relatively rare finding among both normal and clinical patients in their normative study, therefore, the finding of a third "Interference Control" factor represented almost solely by the Failure-to-Maintain set variable may be unique to this sample.

There are other potential limitations of the study design. The use of orthogonal rotation has generally been the rule for factor analytic studies of the WCST and was therefore considered appropriate for the present study. However, Greve and colleagues (2002) have argued that the variables of the WCST are not all independent, which creates an argument that oblique rotation may be more appropriate for factor analyses of the WCST. Another limitation to the present study is the lack of validity measures. Effort testing has not consistently been utilized as part of the neuropsychological battery administered at this location, thus allowing a potential for invalid data in the sample due to malingering or disinterest.

Future Directions

First and foremost, future factor analytic studies of the WCST should consider utilizing a larger sample size. Greve and colleagues (2005) suggest using sample sizes of about 1,000 participants, however, the present author acknowledges that there are obvious barriers and challenges to obtaining a clinical sample of that size. However, a larger sample size that includes a more heterogeneous clinical sample of psychiatrically hospitalized youth—such as children from various hospitals and regions—would lend greater credibility to the present findings by offering a more stable and reliable factor structure for inpatient psychiatrically hospitalized youth.

Findings from other studies have been inconsistent, which may be the result of using different sets of WCST variables, variations in sample size and composition, and different factor analytic techniques. Furthermore, the fact that a certain factor structure emerges in adult samples is no guarantee that a test measures the same latent constructs in a pediatric sample. Future study should consider conducting confirmatory factor analyses of this three-factor model against a separate clinical sample of psychiatrically hospitalized youth to determine whether this three-factor model is a true fit with this clinical population. Moreover, confirmatory factor analyses (CFA) of this three-factor model against nonclinical pediatric samples may provide further insight into whether there is a single multidimensional structure of the WCST that applies across clinical and nonclinical groups, or whether the factor model differs according to the target population. CFAs of the WCST that include indicators from other tests would also be important to consider. Similar exploratory factor analyses have supported the WCST as a measure of executive function (e.g., Paolo et al., 1995), however, the WCST factors have typically loaded independently of other neuropsychological measures. Test termination criteria could be another possible explanation for the variability in one-, two-, and three-factor models of the WCST that have been documented in the literature, which may be the result of error due to differences in test length. Future factor analytic studies of the WCST may wish to standardize the termination criteria so that only one discontinuation rule is applied. If a three-factor solution persists after correcting for variable termination criteria, then there can be more certainty that the three-factor solution is the best-fit solution for this psychiatric youth population.

Although the present study included a preliminary screen of the WCST factor structure against variables related to other neuropsychological measures, it would be important to examine the relationship of the WCST to other neuropsychological measures with greater scrutiny to gain further information about the test's construct validity in psychiatrically hospitalized youth. Preliminary findings in this present study suggest that certain executive tasks may be easier than others for this cohort. As such, future correlational analyses of various executive measures may be useful to consider, given that failure to successfully complete the WCST would not necessarily indicate failed performance on other measures of executive functions.

Conclusion

The present study holds significant clinical utility as it defines the structure of the WCST when used with psychiatrically hospitalized children. The results of the present study confirm that the WCST is a multidimensional test of executive functioning that specifically measures novel problem-solving ability, mental flexibility, and capacity for inhibitory control. The WCST factor structure is associated with many other tests of executive functioning (i.e., Verbal Fluency, RCFT, and Stroop Color-Words) but not with all executive functioning measures suggesting that the WCST is not a broad measure of executive functioning but a more highly specific executive task that taps into executive domains of problem solving, mental flexibility, and inhibitory control. Moreover, self-reported symptoms of psychopathology likely impact WCST performance, whereas objective criteria such as length of hospitalization and number of diagnoses do not appear to have a significant impact on WCST performance in already psychiatrically hospitalized youth. As such, it matters more how children perceive and experience their psychiatric symptomatology than how their illnesses manifest externally. It is important to consider these findings in clinical settings, to not only be aware of the executive demands of the WCST test but also to interpret children's performance on this test as a measure of their problem-solving capacity, their mental flexibility, and their level of inhibitory control. It is also important to consider these results when conceptualizing how severe psychopathology impacts cognitive functioning and vice versa. These findings are specifically relevant for the psychiatric child population, and the latent structure of the WCST proposed in this study should be considered when evaluating children in similar clinical settings.

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Table 1. Summary of Demographic Characteristics for the Research Sample

	Total N	Mean (SD)	% (n)
Age	128	10.62 (1.82)	--
% Male	128	--	57.8% (74)
% White	128	--	60.2% (77)
Length of Stay (LOS)	124	18.54 (19.8)	--
Handedness (% RHD)	120		82.8% (106)
Diagnoses			
Depression	124		40.6% (52)
Mood	124		37.5% (48)
Anxiety	124		36.7% (47)
Bipolar	124		6.3% (8)
Psychotic	124		4.7% (6)
Behavioral	124		10.2% (13)
PDD/ASD	124		2.3% (3)
ADHD	124		56.3% (72)
Learning	124		3.9% (5)
Tic Disorder	124		0.8% (1)
Cognitive	124		2.3% (3)
Adjustment	124		8.6% (11)
Attachment	124		3.9% (5)

Age is measured in years. Length of Stay (LOS) is measured by days of admission. RHD = "right-hand-dominant". Diagnoses are classified based on child's diagnoses upon discharge from unit.

Table 2. Descriptive Statistics for 7 Standard WCST Scores Among Psychiatrically Hospitalized Children

	N	Mean	SD	Min	Max
Total Correct	128	70.72	15.09	31	99
Perseverative Responses	128	21.13	15.36	3	101
Perseverative Errors	128	18.73	12.38	3	81
Non-Perseverative Errors	128	22.78	17.52	3	77
% Conceptual Level Responses	128	58.83	21.45	0	93
Categories Completed	128	4.36	2.04	0	6
Failure-to-Maintain-Set	128	1.08	1.16	0	5

Table 3. Factor Loadings from a Varimax Rotation Analysis of 7 Standard WCST Indices Among Psychiatrically Hospitalized Children

WCST index	Components		
	Problem Solving	Flexibility	Interference Control
Total Correct	**.646**	-.213	**.648**
Perseverative Responses	-.246	**.964**	-.084
Perseverative Errors	-.304	**.947**	-.079
Nonperseverative Errors	**-.967**	.115	-.016
% Conceptual Level Responses	**.840**	-.503	.108
Categories Completed	**.872**	-.432	.025
Failure-to-Maintain-Set	-.040	-.039	**.976**
Variance Explained	42.5%	33.2%	20%

Factor loadings larger than 0.63 are in boldface.

Table 4. Partial Correlations among Composite Factor Scores and Number of Diagnoses, Length of Stay (LOS), and Self-Reported Symptoms

	Factor 1	Factor 2	Factor 3
# of Diagnoses	-.086	-.090	-.130
Length of Stay (LOS)	.069	.099	-.085
CDI	-.266*	-.200	.004
MASC	-.331*	-.275*	-.205*
TSCC	-.315*	-.177	-.127

**p < 0.01; *p < 0.05

Table 5. Partial Correlations among Composite Factor Scores and Performance on Select Neuropsychological Assessment Measures

	Factor 1	Factor 2	Factor 3
FSIQ	.444**	.389**	.213*
Verbal Fluency (FAS)	.273**	.239**	.135
Verbal Fluency (Animals)	.250**	.178*	.100
RCFT (Copy Condition)	.134	.182*	.056
Trailmaking (Part B)	.063	.120	.134
Stroop (Color-Words)	.223*	.140	.147

**p < 0.01; *p < 0.05