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Personality traits and cognitive ability in individuals with schizophrenia, bipolar disorder, attention-deficit/hyperactivity disorder, and community participants.

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Personality traits and cognitive ability in individuals with schizophrenia, bipolar disorder, attention-deficit/hyperactivity disorder, and community participants.

A dissertation submitted in partial satisfaction of the

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by

Aleksey Zvinyatskovskiy

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ABSTRACT OF THE DISSERTAION

Personality traits and cognitive ability in individuals with schizophrenia, bipolar disorder, attention-deficit/hyperactivity disorder, and community participants.

by

Aleksey Zvinyatskovskiy

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2015

Professor Robert M. Bilder, Co-chair

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Cognitive ability and personality traits usefully characterize psychopathology across individuals presenting with schizophrenia, bipolar disorder, and ADHD as well as the general population. Working memory and executive functioning are two putative markers of neurobiological impairment associated with pathology in these disorders. Impulsivity and schizotypy are personality traits related to symptoms of mental illness. Although relationships between cognitive ability and personality have been examined in the past, it is unclear whether these relationships are similar in individuals with mental illness and the general population. The present study examined the relationship between cognitive ability and personality traits in individuals with mental illness and community participants. First, we carried out a hierarchical clustering and factor analysis procedures to aid in data reduction and confirm the factor structure of personality scales used in the study. Data were collected using measures of working memory, executive functioning, impulsivity, and schizotypy from individuals with mental illness (53 with schizophrenia, 47 with bipolar disorder, and 46 with attention-deficit/hyperactivity disorder) and 941 participants recruited from the community. Moderated regression analyses were carried out to examine whether the relationship between impulsivity and executive functioning was similar in individuals with bipolar disorder and ADHD compared to community participants; and whether the relationship between schizotypy and working memory was similar in individuals with schizophrenia and bipolar disorder compared to community participants. Our study found that despite being developed to assess different aspects of impulsivity, popular self-report impulsivity scales measure similar aspects of the impulsivity construct. We also found that the three schizotypy scales in our study measure three separate constructs, a result contrary to prior findings. Finally, almost all personality traits had a similar relationship with cognitive ability in individuals with mental illness and community participants. The exception was physical anhedonia, which showed a significantly stronger negative relationship with working memory in individuals with schizophrenia, but not in individuals with bipolar disorder, than in community participants. While additional evidence is necessary to understand the likely underlying mechanisms of this difference, this finding shows that the relationship between these traits is not equivalent between individuals with schizophrenia and community participants.

The dissertation of Aleksey Zvinyatskovskiy is approved.

Michael F. Green

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University of California, Los Angeles

2015

DEDICATION

To my parents, Svetlana and Roman, to my sister, Oksana, and to Clara:

without their belief in me and countless sacrifices, none of this would be possible.

To my advisors, teachers, and especially to Bob and Steve:

thank you for teaching me how to think well.

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Zvinyatskovskiy, A., Hennah, W., Tomppo, L., Lonnqvist, J., Kaprio, J., Huttunen, M., Cannon, T.D. (April 2011) *Epistatic interactions of DISC1 and its binding partners in relation to a Schizophrenia endophenotype.* Poster presented at the biannual meeting of the International Congress of Schizophrenia Research, Colorado Springs, Colorado.

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Introduction

There is a growing consensus that the major limitation for future identification of genetic and biological mechanisms of psychopathology is the lack of easily and cheaply quantifiable markers (Bilder et al., 2009; Freimer & Sabatti, 2003). Given the ongoing focus on biological bases of psychopathology, there is a growing need to identify such markers. Identified biomarkers are likely to span disorders and can be thought of as phenotypes falling between the level of the gene and the level of the disorder, or endophenotypes. As outlined by Gottesman and Gould (2003), endophenotypes are characterized by demonstrated impairment associated with the disorder; state independence (i.e., being unrelated to the phase of the disorder or treatment status); heritablity; and presence in unaffected relatives at a higher rate than in the general population. In recent years, several candidate endophenotypes have been identified as putative markers of neurobiological impairment associated with schizophrenia, bipolar disorder, and attention-deficit/hyperactivity disorder (ADHD). Poor performance on tests of cognitive ability, particularly declarative memory, working memory, and executive functioning, are traits shared across these disorders. Cognitive test scores are associated with genetic variation and severity of psychopathology, lending further support that they are markers of psychopathology more closely related to neurobiological functioning than symptoms used to diagnose mental illness (Bora, Yucel, & Pantelis, 2009; Ivleva et al., 2012; Nigg, 2010). In addition to cognitive endophenotypes, scores on personality scales measuring impulsivity and schizotypy are another example of traits continuous in the population and associated with these disorders (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001; Schürhoff, Laguerre, Szöke, Méary, & Leboyer, 2005). Individuals with schizophrenia, bipolar disorder, and ADHD show higher levels of impulsivity relative to the general population, while individuals with schizophrenia and bipolar disorder show elevated scores on measures of schizotypy. Finally, genetic studies identified common genetic variability across these three disorders (Cross-Disorder Group of the Psychiatric Genomics Consortium, 2013), further suggesting that schizophrenia, bipolar disorder, and ADHD likely share common neurobiological mechanisms.

In addition to an extensive literature documenting the relationship between scores on tests of cognitive ability and liability to psychopathology, as well as between personality scales and psychopathology, personality traits related to psychopathology are also associated with diminished cognitive ability (Gilvarry, Russell, Hemsley, & Murray, 2001; Keilp, Sackeim, & Mann, 2005). However, there are few studies examining the relationships between scores on measures of personality traits and tests of cognitive ability in individuals with mental illness compared to the general population. Individuals with schizophrenia, bipolar disorder and ADHD consistently show impairment on structural and functional measures of neurobiological functioning (Arnone et al., 2009; Aron & Poldrack, 2005; Ellison-Wright & Bullmore, 2010; Frodl & Skokauskas, 2012). Given the neurobiological differences between patient and healthy populations, one possibility is that neurobiological mechanisms involved in cognitive performance and personality traits in individuals with these disorders differ from those in the general population. Common impairments spanning neurobiological mechanisms responsible for cognitive functioning and personality traits may lead to significantly different correlations between personality traits and cognitive ability in individuals with mental illness relative to the general population. Alternately, mechanisms involved in these processes may be similar in individuals with mental illness and the general population, though with individuals with mental illness showing a greater degree of impairment than the general population. As a result, it may not be enough to establish that individuals with these disorders perform differently than the general population on tests of cognitive ability and measures of personality traits. Relationships between tests of cognitive ability and personality scales have to be compared in individuals with mental illness and the general population in order to ensure that similar relationships are preserved between commonly-used measures of personality and cognitive ability across all levels of functioning. Findings of a different relationship in individuals with mental illness would suggest a different nature of pathology than is currently proposed by models of continuous impairment spanning the general population and individuals with schizophrenia, bipolar disorder, and ADHD. They would suggest that the nature of impairment associated with these disorders results in unique relationships between traits found in the general population.

Cognitive Ability

Cognitive dysfunction has been seen as a promising marker of neurobiological impairment in psychopathology. Performance on tests of cognitive ability has been associated with specific neurological mechanisms (Lezak, 2012) and markers of functional impairment (Green, Kern, Braff, & Mintz, 2000). Cognitive impairment is also strongly associated with psychopathology, particularly in schizophrenia, bipolar disorder, and ADHD (Bora et al., 2009; Doyle et al., 2005; Fioravanti, Bianchi, & Cinti, 2012), suggesting that impairment found in these disorders may be at least partially a product of mechanisms similar to those involved in cognitive dysfunction. Given the close relationship between cognitive ability and neurobiological functioning, and the association between cognitive ability and mental illness, cognitive ability is seen as a likely candidate marker of neurobiological impairment associated with psychopathology.

Generalized Cognitive Impairment. Tests examining broader cognitive ability domains were found to be more successful in predicting functional outcome than tests looking at specific cognitive processes (Sheffield et al., 2014), suggesting that the clinical utility of neuropsychological tests may partially lie outside of their ability to measure specific neurobiological processes. However, while general cognitive impairment is consistently found in individuals with schizophrenia, bipolar disorder, and ADHD, impairment within discreet cognitive domains, such as memory and executive functioning, appears to be a more promising marker of psychopathology in these disorders.

Schizophrenia. Cognitive impairment has been associated with schizophrenia since it was first described at the turn of the 20th century (Bleuler, 1950; Kraepelin, 1919). Impairment across many cognitive domains has been documented since then, with the first meta-analysis being published by Heinrichs and Zakzanis (1998). The degree of impairment on measures of global cognitive abilities depends on the type of measure used to assess them. Greatest degree of impairment is observed on batteries that include a greater number of tests of fluid cognitive abilities, while tests measuring verbal functioning and other crystallized abilities show a lesser degree of impairment. Neuropsychological batteries developed to be sensitive to the kinds of fluid cognitive processes that are found to be impaired in individuals with schizophrenia show the most impairment, followed by batteries designed to estimate IQ, such as the Wechsler Adult Intelligence Tests (WAIS; Wechsler, 1997, 2008) which focuses on more verbal and crystallized intelligence variables and subsequently shows a lower degree of impairment. Tests such as the Wide Range Achievement Test (WRAT; Wilkinson, 1993; Wilkinson & Robertson, 2006), which measures reading, writing, and arithmetic, and the National Adult Reading Test (NART; Nelson, 1982), which focuses on word pronunciation, assess even more crystallized domains and therefore show the least degree of impairment in individuals with schizophrenia relative to healthy participants (Dickinson, Ragland, Calkins, Gold, & Gur, 2006; Heinrichs & Zakzanis, 1998; Laws, 1999; Abraham Reichenberg, 2010). Effect sizes for the overall difference in performance between individuals with schizophrenia and healthy participants fall in the large range (d =0.90 to d = 1.24), based on Cohen's (1988) criteria. Effect sizes from comprehensive neuropsychological batteries fall in the large range (d = 1.01 to d = 1.24), whereas scores from tests such as the WRAT or NART yield effect sizes in the moderate-large range (d = 0.59 to d = 0.63).

Cognitive impairment appears to be present throughout the lifespan of individuals who go on to show symptoms of schizophrenia in late adolescence/early adulthood, although the extent of the impairment varies according to the stage of the illness. There is evidence of subtle neurodevelopmental abnormalities being present at an early age in children who go on to develop schizophrenia (Rapoport, Addington, Frangou, & Psych, 2005). Impairment in general cognitive ability has been documented in children who later develop schizophrenia (Woodberry, Giuliano, & Seidman, 2008), with moderate effect sizes being observed (d = 0.54). Developmental course of impairment in childhood appears to differ within specific domains, however a general pattern of impairment on tasks measuring a variety of cognitive processes is consistently observed prior to onset of the disorder (Reichenberg et al., 2010). High risk subjects show an increase in impairment during the prodromal stage of the disorder (Fusar-Poli et al., 2012; Jahshan, Heaton, Golshan, & Cadenhead, 2010). During the first episode, individuals with schizophrenia show significant impairment across a large number of cognitive domains, with effect size for general cognitive ability in the large range (*d* = 0.91) and effect sizes in other domains generally falling between 0.50 and 1.51 (Mesholam-Gately, Giuliano, Goff, Faraone, & Seidman, 2009). The degree of this impairment is generally consistent with those observed in individuals with chronic schizophrenia, who consistently demonstrate impaired cognitive ability (Fioravanti et al., 2012; Heinrichs & Zakzanis, 1998).

Greater impairment on measures of general ability compared to tests of specific cognitive domains may suggest that impaired functioning in a specific cognitive domain occurs within a context of generalized dysfunction associated with schizophrenia (Dickinson et al., 2006; Reichenberg et al., 2008). While comparison of results across tests of different levels of difficulty and psychometric properties presents a number of challenges (see Chapman & Chapman, 1978; Strauss, 2001), there is little doubt that individuals with schizophrenia exhibit impairment across a range of cognitive domains relative to healthy participants.

Bipolar disorder. Since Kraepelin's description of different course of illness in dementia praecox (schizophrenia) and manic depressive illness (bipolar disorder), the two have been considered separate disorders (Kraepelin, 1919). More recent findings suggest they may be more closely related than previously thought (Craddock & Owen, 2005). In addition to mood symptoms that characterize bipolar disorder, approximately 20% to 50% of individuals with bipolar disorder endorse psychotic symptoms during periods of mania or depression (Pope & Lipinski, 1978), suggesting a commonality between bipolar disorder and schizophrenia. Other commonalities between the two disorders include cognitive impairment (Stefanopoulou et al., 2009) and common genetic factors (Lichtenstein et al., 2009; Moskvina et al., 2008). It appears likely that schizophrenia and bipolar disorder may share common etiological factors with cognitive impairment serving as a putative marker of common neurobiological mechanisms.

Earlier studies of bipolar disorder focused on comparisons between individuals with mental illness and healthy participants. Results of these studies showed that individuals with mental illness had little impairment relative to healthy participants on tests of general cognitive ability (Arts, Jabben, Krabbendam, & van Os, 2008; Bora et al., 2009; Robinson et al., 2006) with even smaller effect sizes observed on tests of premorbid intellectual functioning (See Table 2; Mann-Wrobel, Carreno, & Dickinson, 2011; Robinson et al., 2006; Torres, Boudreau, & Yatham, 2007). More recent studies have focused on comparing cognitive abilities in individuals with bipolar disorder based on severity of cognitive impairment. Results from these types of studies suggest that individuals with bipolar disorder who are the most impaired, characterized as falling 1 to 2 standard deviations (SDs) below healthy participants on global measures of cognitive ability, show impaired performance on measures of premorbid IQ, whereas individuals with mental illness demonstrating less severe impairment do not (Burdick et al., 2014). While the exact criteria for identifying subgroups of individuals with bipolar disorder are still being debated, it appears that the degree of impairment varies significantly across individuals with this disorder (Burdick et al., 2014; Martino et al., 2014). Bipolar disorder is an episodic condition, comprised of periods of mania, depression and euthymia. Impaired cognitive ability has been found in individuals with this condition during all three of these states, suggesting that cognitive impairment is a trait associated with bipolar disorder and not a state associated with severe episodes associated with the illness (Kurtz & Gerraty, 2009). While cognitive deficits in individuals with bipolar disorder are generally more limited than in individuals with schizophrenia, this may not be the case in patient subgroups exhibiting most severe levels of impairment.

ADHD. Although ADHD is not closely related to schizophrenia or bipolar disorder, there is evidence to suggest that common neurobiological mechanisms may play a role in these disorders. Recent genetic findings showed that common variants play a role across all three disorders (Cross-Disorder Group of the Psychiatric Genomics Consortium, 2013). Neuroimaging studies have demonstrated impairments in prefrontal regions in both schizophrenia (Minzenberg, Laird, Thelen, Carter, & Glahn, 2009) and ADHD (Aron & Poldrack, 2005), which are consistent with findings of impaired executive functioning and working memory in these individuals. Individuals with a genetic predisposition to schizophrenia show increased frequency of ADHD (Keshavan, Sujata, Mehra, Montrose, & Sweeney, 2003) and individuals with a diagnosis of ADHD in adolescence are at elevated risk for developing psychosis (Jandl, Steyer, & Kaschka, 2012). Similarly, higher rates of bipolar disorder are observed in individuals with ADHD and high rates of ADHD are observed in individuals with bipolar disorder (Klassen, Katzman, & Chokka, 2010). Relatives of individuals with bipolar disorder are more likely to have ADHD, and relatives of individuals with ADHD show higher prevalence rates of bipolar disorder than healthy participants (Faraone, Biederman, & Wozniak, 2012). All these findings suggest that common neurobiological mechanisms may play a role in the etiology of these disorders.

ADHD is a childhood disorder whose main features include difficulty paying attention, restlessness, and impulsivity (American Psychiatric Association, 2000, 2013). If childhood onset can be documented, it is possible to diagnose ADHD in adulthood. It has been estimated that up to 75% of children with ADHD continuing to exhibit symptoms in adulthood (Wilens, Biederman, & Spencer, 2002). Relative to healthy participants, adults with ADHD are impaired in terms of their overall intellectual functioning. Effect sizes on tests of general cognitive ability fall between $d = 0.27$ and $d = 0.67$ (See Table 3; Frazier, Demaree, & Youngstrom, 2004; Hervey, Epstein, & Curry, 2004). While general cognitive impairment appears to be present in individuals with ADHD, given the large role played by inattention and impulsivity in the disorder, as well as evidence of prefrontal lobe impairment, executive functioning is a more likely candidate marker of neurobiological impairment in this disorder.

Although general cognitive impairment is found in schizophrenia, bipolar disorder, and ADHD, there is evidence to suggest that performance within specific cognitive domains may serve as more robust markers of neurobiological dysfunction in these disorders. Impairment in domains of declarative and working memory as well as executive functioning appear to be better candidate markers of neurobiological impairment shared across all three disorders.

Memory Impairment. Memory impairment is found in schizophrenia, bipolar disorder, and ADHD (Bora et al., 2009; Fioravanti et al., 2012; Hervey et al., 2004). Although lesser degree of impairment is present in ADHD, memory impairment is a phenotype commonly found across individuals with schizophrenia and bipolar disorder, making it a putative marker of neurobiological impairment present in these conditions. Studies usually characterize memory impairment in terms of impaired declarative and working memory.

Declarative memory is a form of long term memory for information that can be consciously recalled, such as facts (Baddeley, 1998; Lezak, 2012). It is comprised of at least three stages: encoding, storage, and retrieval. Declarative memory can be divided into semantic and episodic domains. Semantic memory is responsible for factual information, while episodic memory is responsible for autobiographical information. Tasks measuring memory usually require individuals to learn (encode) and reproduce (recall) the learned information following a delay period.

Working memory is a mechanism for short-term storage and manipulation of verbal and visuospatial information (Baddeley, 1998, 2003). It is made up of components responsible for temporary storage of verbal and visuospatial information, called the phonetic loop and visuospatial sketchpad, and a mechanism responsible for updating and manipulating stored information, called the central executive. Tasks measuring working memory require subjects to hold the information in short-term storage while manipulating it, a process generally considered to be associated with executive functioning (Lezak, 2012; Strauss, Sherman, & Spreen, 2006).

Schizophrenia. Declarative memory is one of the domains consistently found to be impaired in individuals with schizophrenia (Aleman, Hijman, de Haan, & Kahn, 1999; Dickinson et al., 2006; Heinrichs & Zakzanis, 1998). individuals with mental illness are worse than controls at organizing information during memory encoding, making it more difficult to get information into storage and therefore less likely to retrieve it later (Reichenberg and Harvey, 2007; Cirillo and Seidman, 2003). Studies examining performance on tasks measuring storage or retrieval have produced mixed results. While studies show that some of the largest effect sizes between individuals with schizophrenia and healthy participants are found on tests of memory, suggesting that memory may be particularly affected in this population, the exact nature of the impairment remains unknown (Heinrichs & Zakzanis, 1998; Fioravanti, et al. 2012). Effect sizes generally fall between 0.78 and 1.53. Some of the largest effect sizes between individuals with schizophrenia and healthy participants were observed on tests of declarative memory, with episodic memory being more impaired than semantic memory, suggesting that episodic memory may be particularly affected in individuals with this disorder (Fioravanti et al., 2012; Heinrichs & Zakzanis, 1998).

Working memory is another domain in which individuals with schizophrenia consistently show impairment relative to the general population. There is evidence suggesting that working memory dysfunction is part of the general pattern of cognitive impairment seen in schizophrenia. Impairment has been found regardless of whether performance is assessed using established or experimental working memory tests within the verbal or visuospatial domains (Lee & Park, 2005; Piskulic, Olver, Norman, & Maruff, 2007). Association between working memory impairment and disordered activation in the dorsolateral prefrontal cortex (DLPFC; Potkin et al., 2009) suggests that working memory impairment may be related to impaired executive processes. In individuals with schizophrenia, effect sizes on tests of working memory fall between 0.45 and 1.18, the wide range of impairment likely being related to characteristics of the different tests used to measure working memory (Aleman et al., 1999; Dickinson et al., 2006; Fioravanti et al., 2012; Heinrichs & Zakzanis, 1998; Lee & Park, 2005; Piskulic et al., 2007).

Verbal declarative memory and working memory have particularly strong evidence of meeting endophenotype criteria in individuals with schizophrenia (Allen, Griss, Folley, Hawkins, & Pearlson, 2009; Gur et al., 2007). Lower scores on tests assessing these domains have been found to be associated with the disorder; be state independent; heritable; and present in unaffected relatives at a higher rate than in the general population (Gur et al., 2007).

Bipolar disorder. Impairment on tests of declarative memory is a common feature of bipolar disorder as well as schizophrenia. Individuals with both disorders show profound impairment in this domain of functioning. Older studies consistently found impaired declarative memory in individuals with bipolar disorder relative to healthy participants. Effect sizes on tests of declarative memory fall between 0.54 and 0.90. Effect sizes between 0.42 and 0.44 have been reported on recognition trials (Arts et al., 2008; Bora et al., 2009; Kurtz & Gerraty, 2009; Mann-Wrobel et al., 2011; Robinson et al., 2006; Torres et al., 2007). Studies comparing performance across groups of individuals with mental illness showing varying degrees of cognitive impairment, have found generally consistent results. Verbal memory was impaired in patient groups showing any degree of impairment relative to healthy participants, although a subset of individuals with bipolar disorder showed no cognitive impairment relative to healthy participants (Burdick et al., 2014; Martino et al., 2014). These findings suggest that declarative memory impairment may be a reliable marker of neurobiological dysfunction in individuals with bipolar disorder showing cognitive impairment.

Working memory is another cognitive domain showing impairment in individuals with bipolar disorder(Arts et al., 2008; Bora et al., 2009; Kurtz & Gerraty, 2009; Mann-Wrobel et al., 2011; Robinson et al., 2006; Torres et al., 2007). Effect sizes generally fall between 0.37 and 1.02, with larger effect sizes found on tests with greater executive involvement. When stratifying individuals with mental illness based on general impairment, most impaired individuals show significant working memory impairment as do moderately impaired individuals

(Burdick et al., 2014), suggesting that working memory may reliably characterize neurobiological dysfunction found in individuals with bipolar disorder.

Cognitive impairment has been found in euthymic individuals with bipolar disorder, as well as in individuals during manic and depressed episodes (Kurtz & Gerraty, 2009). During mania and depression, individuals show effect sizes ranging from 1.31 to 1.43 on measures of verbal learning and memory, suggesting that memory impairment is a consistent feature of bipolar disorder found in individuals at all stages of the illness. Impairment on tests of declarative and working memory is considered to be an endophenotype of bipolar disorder. It is associated with the disorder (Bora et al., 2009), is independent of disease state (Kurtz & Gerraty, 2009), is heritable and is usually found in first degree relatives of individuals with the disorder to a degree falling between individuals with the disorder and healthy participants (Arts et al., 2008; Glahn et al., 2010; Hasler, Drevets, Gould, Gottesman, & Manji, 2006). Both declarative memory and working memory impairment show strong evidence for being endophenotypes of bipolar disorder and schizophrenia, suggesting that common mechanisms may be responsible for neurobiological dysfunction associated with these disorders (Glahn et al., 2010; Heinrichs & Zakzanis, 1998; Lee & Park, 2005; Smith, Barch, & Csernansky, 2009; Stefanopoulou et al., 2009).

ADHD. On tests of declarative memory, individuals with ADHD also show impairment relative to healthy participants. Effect sizes on tests of verbal memory fall between $d = 0.59$ and $d = 0.91$, whereas effect sizes on tests of non-verbal memory fall between $d = <0.01$ and $d = 0.43$ (Frazier et al., 2004; Hervey et al., 2004; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). While the majority of these results are based on studies done in children, studies using adult participants also show impaired memory functioning relative to healthy participants (Schoechlin & Engel, 2005). In adults, effect sizes on measures of verbal memory are only slightly below those observed in children (*d* = 0.56). On tests of visuospatial memory, however, effect sizes from adult participants fall within the range observed in children (*d* = 0.18). While the results suggest that individuals with ADHD may be more impaired on measures of verbal than visuospatial memory, a result consistent with attention problems (Hervey et al., 2004), this finding has to be interpreted with caution as the difference in effect sizes may also be related to test characteristics rather than an underlying deficit. Although it is possible that the greater impairment in cognitive ability observed in children relative to adults may reflect a difference in the impact of the disorder in childhood versus adulthood demonstrated in the literature (Faraone, Biederman, & Mick, 2006), another possibility is that the difference in effect size is a result of less reliable effect size estimated in adults due to fewer studies being conducted in this population.

Given the overlap between working memory, attention, and executive processes, it is not surprising that individuals with ADHD show working memory impairment compared to healthy participants. Effect sizes vary between *d* = 0.31 and *d* = 0.82 on tests of verbal working memory in children participants (Frazier et al., 2004; Hervey et al., 2004). Effect sizes from adult samples fall at the lower end of this range (*d* = 0.44; Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005).

Although declarative and working memory impairment has been noted in individuals with ADHD (Frazier et al., 2004; Hervey et al., 2004; Schoechlin & Engel, 2005; Willcutt et al., 2005), several meta-analyses failed to find support for memory as being an endophenotype of the disorder (Doyle et al., 2005; Joel T. Nigg, Blaskey, Stawicki, & Sachek, 2004; Rommelse et al., 2008). This suggests that while impaired memory might reflect common mechanisms related to the etiology of schizophrenia and bipolar disorder, there is currently little evidence to support memory processes as being markers of underlying pathology related to ADHD.

Executive Functioning. Another cognitive domain that serves as a putative marker of neurobiological impairment in psychopathology is executive functioning. Executive functions monitor, control, and update other cognitive processes. Poor performance on tests of executive functioning is often associated with frontal lobe pathology (Laws, 1999). However, due to multiple connections between frontal lobes and cortical sensory areas, the limbic system, and other subcortical structures, impairment in executive functioning is possible without frontal lobe pathology (Johnson-Selfridge & Zalewski, 2001). As a result, executive functioning comprises a broad range of abilities. Although many definitions of executive functioning exist, they are generally agreed to be comprised of working memory, response inhibition, set shifting, abstract reasoning, planning, organization, fluency, and aspects of attention (Lyon & Krasnegor, 1996). Tests designed to measure executive functioning often focus on a number of abilities that fit into this broad construct. For example, the Wisconsin Card Sorting Test (WCST; Heaton, 1981) measures abstract reasoning as well as the ability to shift cognitive sets; fluency tests assess speeded information processing (Lezak, 2012); and the Trail Making Test, Part B (TMT-B) assesses mental flexibility, a construct related to response inhibition, as well as visual scanning, visual-motor coordination, and speeded information processing. Part A of the Trail Making Test is mostly related to speeded information processing and psychomotor skills (Strauss, Sherman, & Spreen, 2006). The variability across constructs measured by these tests is representative of the broad nature of executive functioning. While these tests measure a number of different constructs, there is also significant overlap between these constructs. Speeded information processing, attention, and mental flexibility play important roles across a number of tests, with the extent to which individual tests depends on these processes varying across tests. Impairment on a number of tests of executive functioning is commonly found in schizophrenia, bipolar disorder and ADHD. Most frequently, WCST, TMT, and fluency measures are used to assess executive functioning because these tests are among the most validated measures of constructs making up the executive functioning domain. Impairment on established and experimental tests of executive functioning is regularly found in individuals with schizophrenia, bipolar disorder and ADHD, as well as their first degree relatives, suggesting that impaired executive functioning may be an endophenotype of these disorders (Allen et al., 2009; Arts et al., 2008; Nigg, 2010).

Schizophrenia. Individuals with schizophrenia show executive impairment based on performance on a variety of tests. Effect sizes generally fall between 0.53 and 1.45 (Dickinson et al., 2006; Heinrichs & Zakzanis, 1998; Johnson-Selfridge & Zalewski, 2001; Laws, 1999). Most commonly impaired functioning is observed on tests such as the WCST, TMT, and a variety of fluency tests, in addition to other tests measuring more specific executive processes (Dickinson et al., 2006; Fioravanti et al., 2012; Heinrichs & Zakzanis, 1998; Johnson-Selfridge & Zalewski, 2001). Executive impairment is regarded as an endophenotype of schizophrenia (Allen et al., 2009; Gur et al., 2007). Lower scores on tests of executive functioning are associated with the disorder, state independent, heritable, and present in unaffected relatives at a higher rate than in the general population (Gur et al., 2007).

Bipolar disorder. Individuals with bipolar disorder also show executive impairment (Arts et al., 2008; Bora et al., 2009; Kurtz & Gerraty, 2009; Mann-Wrobel et al., 2011; Robinson et al., 2006; Torres et al., 2007). Effect sizes between 0.52 and 0.99 are regularly observed on tests of this domain as measured by WCST, TMT, Stroop and fluency tests, suggesting that, along with impaired memory performance, executive impairment is a major characteristic of the disorder (See Table 2). Findings from groups formed according to the degree of overall impairment severity largely show consistent results. Individuals with bipolar disorder with severe and moderate degrees of impairment show significantly lower performance on tests of executive functioning relative to healthy participants (Burdick et al., 2014; Martino et al., 2014), with only individuals without any cognitive impairment showing no executive dysfunction. Individuals with bipolar disorder show greater impairment on tests of visual scanning during mania relative to euthymic individuals, while depressed individuals are more impaired on fluency measures. However, impairment on a broad range of executive measures has been found in euthymic individuals with bipolar disorder, suggesting that cognitive impairment is a trait associated with this disorder and not a product of clinical state (Kurtz & Gerraty, 2009). Executive impairment is considered to be an endophenotype of bipolar disorder. It is associated with the disorder (Bora et al., 2009), is independent of disease state (Kurtz & Gerraty, 2009), is heritable and is usually found in first degree relatives of individuals with bipolar disorder to a degree falling between individuals with the disorder and healthy participants (Arts et al., 2008; Glahn et al., 2010; Hasler et al., 2006).

ADHD. Individuals with ADHD consistently show impairment in executive functioning as well as in other cognitive domains with high executive involvement. Impairment on dedicated tests of executive functioning is found in individuals with mental illness relative to healthy participants. The degree of impairment generally falls between d = 0.02 and d = 0.68, with the majority of effect sizes falling between 0.45 and 0.65 (Frazier et al., 2004; Hervey et al., 2004; Willcutt et al., 2005). Effect sizes were generally calculated based on scores from tests such as WCST, Stroop Color-Word Score (Strauss et al., 2006), and TMT-B measured in children. In a meta-analysis of results based on studies of cognitive ability in adults, effect sizes ranged between 0.21 and 0.89, which generally fell within the same range as the majority of effect sizes observed in children with ADHD (Boonstra et al., 2005; Schoechlin & Engel, 2005). The similarity in the magnitude of effect sizes between children and adults with ADHD suggests a similar degree of impairment in executive functioning during childhood and adulthood, an observation inconsistent with prior findings of a decline in symptom severity observed in follow-up studies (Faraone et al., 2006). However there are fewer studies examining cognitive ability in adults with ADHD compared to studies looking at impairment in children and any findings from these studies have to be interpreted with caution.

Overall, effect sizes seen in individuals with ADHD are lower than those observed in individuals with schizophrenia and bipolar disorder, suggesting that a lesser degree of cognitive impairment may be present in this population. Still, executive impairment is considered to be a promising endophenotype of ADHD (Kebir, Tabbane, Sengupta, & Joober, 2009). There is evidence to suggest that executive impairment in ADHD is heritable and runs in families along with risk for the disorder (Doyle et al., 2005). While some doubt remains whether impairment in other domains meets endophenotype criteria, there is a general consensus that findings of impaired executive functioning in individuals with ADHD and their relatives are robust enough and show large enough effect sizes to be a useful phenotype (Doyle et al., 2005; Nigg et al., 2004; Rommelse et al., 2008).

Individuals with ADHD share phenotypes with bipolar disorder, with impaired executive functioning being a promising endophenotype of both conditions. In addition to similarities in performance on tests of cognitive ability, higher rates of bipolar disorder are observed in individuals with ADHD and high rates of ADHD are observed in individuals with bipolar disorder (Klassen et al., 2010). Relatives of individuals with bipolar disorder are also more likely to have ADHD, and relatives of individuals with ADHD show higher prevalence rates of bipolar disorder than healthy participants (Faraone et al., 2012). This evidence points to commonalities across disorders that may suggest common underlying pathology.

Executive impairment is also one of the putative endophenotypes of schizophrenia (Allen et al., 2009; Gur et al., 2007). There is evidence that executive impairment is an endophenotype shared between bipolar disorder and schizophrenia that is likely to represent common underlying mechanisms shared across the two disorders (A. Reichenberg et al., 2008; Smith et al., 2009). Impairment on tests of executive functioning has also been documented in both individuals with schizophrenia (Dickinson et al., 2006) and ADHD (Frazier et al., 2004; Hervey et al., 2004). However, while there are studies that suggest a relationship between schizophrenia and ADHD (Jandl et al., 2012), additional evidence is needed before it is possible to say whether neurocognitive impairment in schizophrenia and ADHD represents common etiological pathways.

Summary. Cognitive impairment is found in individuals with schizophrenia, bipolar disorder, and ADHD. While domains showing impairment vary according to disorder, individuals with schizophrenia, bipolar disorder, and ADHD show impaired memory and executive functioning. Memory impairment is commonly observed in individuals with schizophrenia and bipolar disorder (Fioravanti et al., 2012; Kurtz & Gerraty, 2009) and is considered to be an endophenotype of these disorders, suggesting that memory impairment is related to underlying neurobiological impairment in these disorders (Allen et al., 2009; Bora et al., 2009). Executive impairment is consistently found in schizophrenia, bipolar disorder, and ADHD and is considered to be a putative endophenotype of these disorders (Bora et al., 2009; Fioravanti et al., 2012; Willcutt et al., 2005). While executive impairment is shared across these three disorders and the majority of the evidence points to executive functioning potentially being a shared marker of neurobiological impairment between bipolar disorder and ADHD (Dickinson et al., 2006; Frazier et al., 2004), there is less evidence to suggest that executive functioning serves as a marker of neurobiological pathways shared between schizophrenia and ADHD (Jandl et al., 2012). Thus, in the present study, memory impairment will be used as a measure of shared impairment in schizophrenia and bipolar disorder, whereas executive impairment will be used in individuals with bipolar disorder and ADHD.

Personality Traits

In addition to cognitive ability, commonalities across psychiatric disorders can also be characterized using personality traits. While there is less evidence linking personality traits to neurobiological dysfunction than cognitive functioning, personality traits span diagnostic categories suggesting that they may be related to traits shared across disorders. Impulsivity is a personality trait commonly found in individuals with bipolar disorder, ADHD, and, less frequently, schizophrenia, whereas schizotypy is a personality trait closely related to schizophrenia but also found in individuals with bipolar disorder.

Impulsivity. Impulsivity is a multidimensional construct generally considered to be "a predisposition toward rapid unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions" (Moeller et al., 2001). It is associated with decreased sensitivity to negative consequences of behavior, engaging in behavior without prior planning, and showing low regard for long-term consequences of actions (Moeller et al., 2001). The majority of theories take into account both positive and negative aspects of the construct. For example, Dickman (1990) described positive, or functional, impulsivity as being related to traits such as enthusiasm, adventurousness, and activity; and negative, or dysfunctional, impulsivity as being related to disorderliness and avoidance of facts in decision-making. Patton, Stanford, and Barratt (1995) separated impulsivity into three components: motor impulsiveness, thought of as acting without forethought; attentional impulsiveness, associated with concentration difficulty; and non-planning impulsiveness, associated with acting prior to thinking through your actions. Eysenck and Eysenck (1978) proposed that impulsivity is divided into impulsiveness, doing things without planning ahead, and venturesomeness, engaging is risky, thrill-seeking behavior.

Constructs related to impulsivity can be measured using both self-report and behavioral measures (Ouzir, 2013). However, there appears to be a difference between the two approaches to measuring the construct. For example, the study by Reddy et al. (2014) found a dissociation between self-report and experimental measures of impulsivity. While individuals with bipolar disorder reported being more impulsive than healthy participants on self-report measures, they did not significantly differ from controls on behavioral measures of risk-taking. Individuals with schizophrenia, on the other hand, scored comparably to healthy participants on self-report measures of impulsivity, but were significantly more risk-averse than healthy participants or individuals with bipolar disorder on behavioral measures of risk-taking. The dissociation between self-report and behavioral measures of impulsivity may indicate that the two approaches measure different constructs related to impulsivity, providing further evidence of the multidimensional nature of the construct.

Schizophrenia. Impulsivity is a less prominent feature of schizophrenia, but one that has been demonstrated with some consistency. Studies using self-report measures have reliably found greater levels of impulsivity in individuals with the disorder relative to healthy participants (Nolan, D'Angelo, & Hoptman, 2011; Ouzir, 2013; Reddy et al., 2014). However, evidence of impulsivity being a part of the disorder using behavioral tasks has been mixed, with some studies finding individuals with schizophrenia to be more impulsive than controls (Enticott, Ogloff, & Bradshaw, 2008; Kaladjian, Jeanningros, Azorin, Anton, & Mazzola-Pomietto, 2011) while others not finding this to be the case (Nolan et al., 2011). The fact that impulsivity is inversely related to executive functioning and that executive functioning is consistently found impaired in individuals with schizophrenia (Johnson-Selfridge & Zalewski, 2001) suggests that impulsivity may be related to cognitive impairment associated with schizophrenia.

While little research has been done in this area, there is evidence to suggest that impulsivity is transmitted along with genetic loading for schizophrenia. In a study by Torgersen et al. (2002), individuals diagnosed with schizotypal personality disorder (SPD) who had first-degree relatives with schizophrenia scored higher on self-report measures of impulsivity than individuals with SPD without first-degree relatives diagnosed with schizophrenia. Greater genetic loading for schizophrenia was found to be associated with higher degree of impulsivity in non-schizophrenia individuals. It is possible that mechanisms underlying impulsivity are related to the genetic risk of psychosis.

Bipolar disorder. Impulsivity is present in bipolar disorder, a condition with diagnostic criteria that include a number of impulsivity symptoms (American Psychiatric Association, 2013). Impulsivity can be thought of as being both a state and a trait (Moeller et al., 2001). State impulsivity is time limited and, in bipolar disorder, most often present during manic episodes. Trait impulsivity is present for extended periods of time, which may or may not include periods of mania. In addition to exhibiting state impulsivity during manic episodes, individuals with bipolar disorder show elevated scores on measures of trait impulsivity during euthymia (Moeller et al., 2001; Swann, 2010). Relatives of individuals with bipolar disorder who do not meet diagnostic criteria for the disorder show elevated scores on self-report measures of impulsivity relative to controls (Henna et al., 2013). This suggest that impulsivity may be a marker of a heritable neurobiological dysfunction associated with bipolar disorder, rather than a measure of particular phase of illness or a trait limited only to individuals with the disorder (Saddichha & Schuetz, 2014).

ADHD. The diagnostic criteria for ADHD explicitly include negative aspects of impulsivity in the hyperactivity/impulsivity symptom cluster (American Psychiatric Association, 2000, 2013; Urcelay & Dalley, 2012). These symptoms include behaviors related to difficulty keeping still (e.g. “[acting] as though driven by a motor”) or signs of difficulty controlling one's thought patterns (i.e. “talking excessively,” “blurting out answers,” “[not] waiting [for your] turn to speak," and "interrupting others"). First-degree relatives of individuals with ADHD show impaired scores on impulsivity measures, suggesting that impulsivity runs in families (Epstein et al., 2000), with genetic factors account for 70 – 80% of the variance (Ruf et al., 2008).

While there is only some evidence to support elevated levels of impulsivity being present in individuals with schizophrenia, it is closely related to bipolar disorder and ADHD. Individuals with both disorders not only show elevated levels of impulsivity, impulsive traits are part of the diagnostic criteria for these disorders. This suggests that impulsivity may be related to shared impairment across these disorders. Greater levels of impulsivity in relatives of individuals with bipolar disorder and ADHD suggest that greater impulsivity may be inherited along with genetic risk for these disorders.

Factor structure of impulsivity scales. Although impulsivity can serve as a useful marker for impairment shared between bipolar disorder and ADHD, additional work is needed to understand the nature of the impulsivity construct as assessed by personality scales. Recent findings suggest that factor structures of commonly used impulsivity scales, such as the Barratt Impulsiveness Scale (BIS; Patton et al., 1995) differ from those originally proposed by their authors. A number of studies failed to replicate the original model proposed by Patton et al. (1995) which divided impulsivity into three constructs: motor impulsiveness, attentional impulsiveness, and non-planning impulsiveness (Vasconcelos, Malloy-Diniz, & Correa, 2012). Instead, a two-factor model has been found to be a better fit for scores on the BIS, representing non-planning and motor impulsivity. These results have been replicated in the general population (Morean et al., 2014; Reise, Moore, Sabb, Brown, & London, 2013) as well as a forensic sample (Haden & Shiva, 2009).

Inclusion of multiple similarly-worded items poses a challenge in interpreting the factor structure of assessment scales. While this approach results in higher scores on measures of internal consistency, it often complicates the interpretation of factor or correlation analyses by making it difficult to separate common from unique item variance (Reise et al., 2013). One possible solution for this problem involves construction of homogeneous parcels based on correlations between items (Schalet, Durbin, & Revelle, 2011). Identification of homogeneous parcels allows for easier interpretation of factor loadings as parcel scores are based on variance shared between items. This approach has been applied only to a limited extent in prior studies of impulsivity factor structure, with the Reise et al. (2013) paper being one of the few available examples.

Dickman's Impulsivity Inventory, which encompasses positive and negative aspects of impulsivity (Dickman, 1990) , appears to suffer from the same problem by relying on similarly worded items to maximize reliability (Steinberg, Sharp, Stanford, & Tharp, 2013). Re-evaluation of the dysfunctional impulsivity component of the Dickman scale revealed three items with weak loadings (Di Milia, 2013) that have also been identified as weak in other studies (Adan, Natale, Caci, & Prat, 2010; Caci, Nadalet, Baylé, Robert, & Boyer, 2003). Removal of these items from factor analyses by Di Milia (2013) yielded better-fitting and more easily interpretable solutions, suggesting that original scale include too many redundant items.

Unlike the BIS and Dickman Impulsiveness Scale, other measures of impulsivity appear to show more consistent factor analytic findings across studies. The Eysenck Impulsiveness – Venturesomeness – Empathy (IVE) Questionnaire consists of two impulsivity-related components: impulsiveness and venturesomeness, (S. Eysenck, Pearson, Easting, & Allsopp, 1985). Their factor structure has been replicated in subsequent studies (Aluja & Blanch, 2007; Luengo, Carrillo-De-La-Peña, & Otero, 1991). The third factor, empathy, generally shows less robust loadings and is not as closely tied to the impulsivity construct (Aluja & Blanch, 2007; Caci et al., 2003). The Control scale from the Multidimensional Personality Questionnaire (MPQ) has been originally devised of a unidimensional measure of control/impulsiveness that is a part of a larger measure of personality traits (Tellegen & Waller, 2008). It has generally shown to have a robust structure. However a study examining loadings of individual items within the control scale found a two-factor structure, with the factors being cautious/spontaneous and methodical/disorganized (Parker, Michael Bagby, & Webster, 1993). While some of the commonly-used impulsivity scales have relatively robust factor structures, re-examination of factor structure of impulsivity scales is warranted in order to examine the extent to which they include redundant items. Removal of these items may result in better-fitting models with more easily interpretable factor loadings on the Barratt and Dickman scales, clarifying what constructs they measure. It may also lead to more easily interpretable results of factor analysis across all impulsivity scales aimed at determining the extent to which they measure common constructs.

Relationship between impulsivity scales. Measurement of the impulsivity construct is challenging not only due to the need of creating a psychometrically robust scale, but also due to the multidimensional nature of the construct. Availability of multiple scales measuring differing aspects of the construct creates a challenge in terms of understanding the overall construct. It is essential to understand how the different constructs measured by these scales are related to one another. A study by Miller, Joseph and Tudway (2004) examined relationships between subscales of the Dickman, Eysenck, and Barratt impulsivity scales. Principal component analysis showed that Dickman's dysfunctional impulsivity, Eysenck's Impulsiveness, and the three Barratt subscales loaded onto a single non-planning and dysfunctional impulsivity factor. Eysenck's Venturesomeness, Dickman's functional impulsivity, and Barratt's motor impulsivity loaded onto a sensation-seeking/venturesomeness factor. This solution appears consistent with prior literature, although cross-loadings of Barratt's motor impulsivity subscale are suggestive of the redundancy problems with the BIS cited above and limits the interpretation of the resultant domain-wide factors. Nevertheless, these findings point to large commonalities between impulsivity constructs as measured by these scales, suggesting that when measuring impulsivity, generally similar constructs are being assessed regardless of the scale used.

Impulsivity and cognitive ability. In addition to being related to psychopathology, higher levels of impulsivity are also associated with impaired cognitive ability. Elevated scores on impulsivity measures are inversely correlated with verbal fluency, memory, and executive functioning (Keilp et al., 2005). Low to moderate correlations were observed between measures within these domains and the three subscales of the Barratt Impulsiveness Scale. Given the relationship between impulsivity, cognitive functioning and psychopathology, this suggests that the relationship between impulsivity and impaired cognitive ability may be a marker of common underlying processes associated with psychopathology.

Higher impulsivity is a trait commonly found in individuals with bipolar disorder and ADHD. Based on family studies, it is likely that it is related to neurobiological processes involved in the etiology of these disorders. Impulsivity is a multifaceted construct and a number of scales are available stemming from different theories of impulsivity and purporting to measure different aspects of the disorder. However, there is commonality across these scales and they appear to measure highly related constructs. Impulsivity is related to cognitive ability, another construct used to characterize impairment across disorders. Greater impulsivity is related to impaired cognitive ability, particularly in domains of verbal fluency, memory, and executive functioning, domains found to be impaired in individuals with bipolar disorder and ADHD. Both of these constructs, cognitive functioning and impulsivity, likely reflect processes related to psychopathology that span diagnostic categories.

Schizotypy. In addition to impulsivity, schizotypy is another construct that spans diagnostic categories and is thought to be related to underlying neurobiological impairment. The concept of schizotypy was introduced by Paul Meehl in a seminal paper proposing a pathogenic model of schizophrenia (Meehl, 1962). This model organized prior clinical observations of schizophrenia-like thought disorder and interpersonal abnormalities found in relatives of individuals with schizophrenia that fell short of a full diagnosis of schizophrenia and joined them with observations and formulations of Sandor Rado into a psychobiological model of schizotypy (Lenzenweger, 2006). According to Meehl's model, schizotypy is a quasi-dimensional construct, representing a personality organization that is necessary but not sufficient for developing schizophrenia (Nelson, Seal, Pantelis, & Phillips, 2013). This model can be described as quasi-dimensional because it characterizes individuals with schizotypy as comprising a unique taxon, though one that falls along levels of progression from healthy participants to those diagnosed with schizophrenia. Meehl postulated that approximately 10% of the population have this personality organization, which is a product of genetic predisposition that leads to neurological impairment (Meehl, 1962). He termed this neurobiological predisposition *schizotaxia*, a “genetically determined integrative defect, predisposing to schizophrenia and a sine qua non for that disorder” (Meehl, 1962). According to the model, development of diagnosable schizophrenia results from complex interactions between schizotaxia, environmentally mediated social learning experiences, and polygenic potentiators (Lenzenweger, 2006; Meehl, 1962, 1990).

There is a large literature that supports the taxonic structure of schizotypy (Beauchaine, Lenzenweger, & Waller, 2008) and the model generated a tremendous amount of research into the nature of schizotypy since its introduction (Lenzenweger, 2006). However the model has recently been criticized for using small or unrepresentative samples, focusing on a single aspect of schizotypy, using only a single taxometric method, and possibly being confounded by a positive skew of sample distributions (Rawlings, Williams, Haslam, & Claridge, 2008). Taxonic nature of schizotypy is also brought into question by studies demonstrating that abnormal perceptual experiences are much more prevalent in the general population than the 10% figure suggested by Meehl (Nelson et al., 2013). In fact, there is a new and growing literature that suggests that schizotypy may be a dimensional construct lies along the continuum of all “natural nervous system variations” that spans normal functioning on one end and psychosis on the other, with schizotypy falling in the middle (Rowlings, et al., 2008; Nelson et al., 2013; van Os et al., 2009).

Schizophrenia. A dimensional relationship between schizotypy and schizophrenia presupposes that both constructs share etiological factors, and that they extend into the healthy population. There is evidence of a continuous relationship between schizophrenia and schizotypy based on genetic findings (Nelson et al., 2013). Studies comparing family members of individuals with schizophrenia report elevated positive schizotypal traits (Kremen, Faraone, Toomey, Seidman, & Tsuang, 1998; Mata et al., 2003; Yaralian et al., 2000) and higher levels of social anhedonia (Kendler, Thacker, & Walsh, 1996). Positive symptoms of schizotypy are ones that mimic positive symptoms of schizophrenia, such as delusions and hallucinations, but of lesser severity. In individuals with schizotypy, these symptoms may include odd beliefs and abnormal physical sensations or perceptions. Alternately, negative schizotypy traits are related to negative symptoms of schizophrenia, such as lack of motivation, affective flattening, and thought disorder, but also of lesser severity. In schizotypy, these symptoms may include social and physical anhedonia, or disorganized thinking. A review by Fanous and Kendler (2004) of family, twin, and molecular genetic studies of schizophrenia and schizotypy shows that both disorders are heritable and run together in families. Positive symptoms of psychosis predict positive schizotypal traits in relatives of individuals with schizophrenia and negative psychotic symptoms predict negative schizotypal traits.

However, greater support for a dimensional relationship between schizophrenia and schizotypy comes from neurocognitive findings (Nelson et al., 2013). Like schizophrenia, shizotypy is associated with impairment in cognitive ability. Healthy participants with elevated scores on schizotypy scales show impaired performance on measures of verbal IQ (Noguchi, Hori, & Kunugi, 2008), attention (Chen et al., 1997), and working memory (Park & McTigue, 1997; Schmidt-Hansen & Honey, 2009). Similarly to individuals with psychosis, cognitive impairment is associated with negative and disorganized schizotypy traits, rather than positive traits (Chen et al., 1997; Park & McTigue, 1997). Smaller degree of impairment is observed in individuals with elevations on schizotypy scales compared to those with a diagnosis of schizophrenia (Chen et al., 1997; Noguchi et al., 2008). This difference in magnitude of effect sizes is consistent with the notion that schizotypy is a phenotype that falls in the middle of the schizophrenia continuum, between normal functioning and psychosis.

***Bipolar disorder*.** Relatives of individuals with affective psychosis and schizophrenia show higher levels of Cluster A personality disorder traits, which include Paranoid, Schizoid, and Schizotypal Personality Disorders, compared to individuals with non-psychotic bipolar disorder and healthy participants (Gilvarry, et al., 2001). Relatives with higher scores on measures of Cluster A traits also showed greater cognitive impairment relative to healthy participants on measures of verbal fluency, executive functioning, and general cognitive ability. Schizophrenia and affective psychosis share a number of similarities based on family, genetic, and neuropsychological studies (Berrettini, 2000; Kichtenstein et al., 2009; Stefanopoulou et al., 2009), suggesting that common neurobiological processes may play a role in these disorders. Elevated scores on measures of personality traits related to schizotypy and impaired cognitive functioning may serve as psychosis risk factors, regardless of the context in which they occur.

Schizotypy is a construct closely related to risk for psychosis. While not all individuals with bipolar disorder experience psychotic symptoms, a large percentage do (Pope & Lipinski, 1978), suggesting that mechanisms related to psychosis may include traits spanning the continuum between schizophrenia and bipolar disorder. Schizotypy can therefore be a useful marker of predisposition to these disorders.

Factor structure of schizotypy. While schizotypy may be an important marker of predisposition to severe psychopathology, it is necessary to ensure the instruments designed to measure this construct have strong psychometric features. The Chapman Scales are a commonly used measure of schizotypy and are comprised of the Social Anhedonia, Physical Anhedonia, and Perceptual Aberration scales (Chapman, Chapman, & Raulin, 1976, 1978). Scores on these scales have been shown to load onto positive and negative symptoms of schizotypy. Perceptual Aberration scale loads onto the positive symptom domain, Physical Anhedonia loads onto the negative symptom domain, and Social Anhedonia loads onto both the positive and negative domains simultaneously (Brown, Silvia, Myin–Germeys, Lewandowski, & Kwapil, 2008; Chapman, Chapman, & Miller, 1982; Kwapil, Barrantes-Vidal, & Silvia, 2007).

The Chapman scales include a number of similarly-worded items designed to measure highly related constructs. As a result, these scales show high levels of internal consistency. However, as discussed above, such an approach causes problems of differentiating common from unique variance on factor loadings of highly-related scale items. Although studies by Brown et al. (2008) and Kwapil et al. (2007) used parceling of scale items improve model fit, as recommended by Browne and Cudeck (1992), these studies randomly assign items from each of the scales into one of three parcels without regard to their content. Unlike the method proposed by Schalet et al. (2011) and used in the Reise et al. (2011) analysis of the Barratt Impulsiveness Scale, this approach does not address the issue of differentiating between common and unique item variance. Investigations of factor structure of individual Chapman Scales have not accounted for common item variance in prior studies, making interpretation of individual item loadings difficult. Although the scales have shown high reliability and predictive validity (Chapman, Chapman, Kwapil, Eckblad, & et al, 1994), internal validity of the scales has not been sufficiently assessed.

A lack of information regarding individual item loadings on the Chapman Scales also limits the conclusions that can be drawn regarding the validity of the constructs they assess. Studies examining relationships between the scales by Brown et al. (2008) and Kwapil, Barrantes-Vidal and Silvia (2007) described above found cross-loadings of social anhedonia onto positive and negative schizotypy domains. Because it is unclear which items load onto which of the two domains, it is difficult to understand the reasons behind the cross-loading of the scale. In order to identify constructs that are being measured by the Chapman scales, it is first important to understand whether all of the items within the Chapman scales measure similar constructs. Understanding constructs measured by the Chapman scales will help answer the main question of this study: whether personality scales and tests of cognitive ability have similar relationships with one another in individuals with mental illness and healthy participants.

Relationship between schizotypy scales and cognitive test scores. Schizotypy is a construct associated with psychosis proneness and therefore related to schizophrenia and bipolar disorder. Currently, there is only a limited number of studies available that examine the quantitative relationships between measures of personality and cognitive ability. Elevated levels of schizotypy have been found to be related to impairment in the working memory domain (Chen, Hsiao, & Lin, 1997; Gilvarry et al., 2001). However, it is unclear whether this relationship is consistent across individuals with mental illness and the general population. Impairment associated with psychopathology may result in different relationships between personality and cognition in individuals with mental illness relative to the general population. If there are shared pathological processes underlying both cognitive and personality impairments, then the correlation should be significantly different among affected individuals. Similar correlations in individuals with mental illness and healthy participants would suggest that cognitive ability and personality traits are resultant from separate underlying processes.

Summary. Impulsivity and schizotypy are personality traits commonly associated with psychopathology. Elevated impulsivity levels are found in individuals with schizophrenia, bipolar disorder, and ADHD, although there is stronger evidence for elevated impulsivity levels in bipolar disorder and ADHD than in schizophrenia. Schizotypy is a personality trait related to psychosis proneness, and as such, it is likely related to mechanisms shared across schizophrenia and bipolar disorder. Both impulsivity and schizotypy have been associated with impairment in cognitive ability. Individuals with impulsivity show executive impairment whereas individuals with schizotypy show memory impairments. This suggests that common mechanisms may be responsible for personality traits and cognitive performance, with dysfunction in these mechanisms leading to higher levels of impulsivity and schizotypy as well as cognitive impairment.

Recent studies found inconsistencies between factor structures of impulsivity scales proposed by their authors and results from factor analyses conducted by other groups. There is also little information available regarding the factor structure of the Chapman scales. Prior to examining relationships between personality traits and cognitive ability it is important to understand psychometric properties of personality scales.

Present Study

As discussed above, prior studies have demonstrated that cognitive ability and personality traits usefully characterize performance across individuals presenting with psychopathology and healthy participants (Allen et al., 2009; Bora et al., 2009; Doyle et al., 2005; Moeller et al., 2001; Yaralian et al., 2000). Cognitive impairment has been found to span diagnostic categories, suggesting that common mechanisms of psychopathology related to cognitive ability may play a role across disorders (Stefanopoulou et al., 2009). It has also been found that scores on personality traits can be used to characterize pathology more effectively than categorical constructs, given the evidence that psychopathology lies along a continuum (Clark, 2007; Miller et al., 2010). Finally, higher levels of schizotypy are related to lower scores on tests of working memory (Leach, Hurd, & Crespi, 2013) and higher scores on measures of impulsivity are related to lower scores on measures of executive functioning (Keilp et al., 2005), suggesting that personality traits and cognitive ability may be governed by common underlying processes.

Both personality scales and scores on tests of cognitive ability are used to assess performance across the spectrum spanning healthy participants and individuals with different types of psychopathology. Given the large literature that shows neurobiological differences between individuals with schizophrenia, bipolar disorder, ADHD and the general population (Arnone et al., 2009; Aron & Poldrack, 2005; Ellison-Wright & Bullmore, 2010; Frodl & Skokauskas, 2012), disruption of neurobiological processes associated with psychopathology likely spans cognitive domains and personality traits. Presence of such disruptions across different domains of functioning may change the relationship between domains in individuals with mental illness relative to community participants. This would suggest that impairment associated with psychopathology does not only lead to poorer performance on tests of cognitive ability and elevated scores on some personality measures, but that the nature of the impairment is such that it results in a differential relationship between performance on tests of cognitive ability and personality scales in individuals with mental illness compared to community participants. Demonstration of such a differential relationship, while making no assumptions about likely mechanisms responsible for it, would show that pathology in schizophrenia, bipolar disorder and ADHD is associated with change in functioning that is more profound than impairment across a number of domains. An important aspect of test validity involves verifying that a given test of a construct is related in expected ways to other tests of similar constructs (John & Soto, 2007). Examination of possible differential relationships between personality scale performance and scores on tests of cognitive ability is a necessary first step to understanding whether they have similar relationships across the entire span of functioning. To our knowledge, there have been no published studies examining whether the relationship between personality scale scores and cognitive test scores is different in individuals with mental illness relative to the general population.

Mental illness grouping. While individuals with schizophrenia, bipolar disorder, and ADHD show impaired memory functioning, only studies of individuals with schizophrenia and bipolar disorder suggest that memory impairment is an endophenotype of these disorders (Bora et al., 2009; Gur et al., 2007). Studies of individuals with ADHD suggest that executive functioning is a more promising marker of neurobiological dysfunction in this disorder than memory (Boonstra et al., 2005; Doyle et al., 2005). Individuals with bipolar disorder also demonstrate significant impairment in executive functioning (Bora et al., 2009). A study of children with bipolar disorder and ADHD suggests that response inhibition construct that is a part of executive functioning is particularly affected in individuals with these disorders (Passarotti, Sweeney, & Pavuluri, 2010). While studies of response inhibition in individuals with schizophrenia show response inhibition to be impaired relative to healthy participants (Enticott et al., 2008), working memory remains one of the most commonly-used and generally agreed-upon endophenotypes in schizophrenia (Gur et al., 2007). There is also little evidence to support executive functioning serving as a marker of a neurobiological pathway shared between schizophrenia and ADHD (Jandl et al., 2012). As a result, executive impairment appears to be an endophenotype shared between bipolar disorder and ADHD, but not with schizophrenia. Because the goal of our study was to study continuous traits that can be used to characterize psychopathology outside of commonly-used diagnostic categories, our study combined patient groups based on neurocognitive impairments commonly observed within these patient populations. Schizophrenia and bipolar disorder samples were combined, due to working memory being a common endophenotype found in individuals with these disorders. Similarly, bipolar disorder and ADHD samples were combined due to executive functioning, and particularly response inhibition, being a common endophenotype in these two groups of individuals.

In addition to measures of working memory and executive functioning, assignment of patient samples into groups was carried out based on personality traits common across the three disorders included in our sample. While elevated impulsivity levels are found in individuals with all three disorders, impulsivity plays a central role in bipolar disorder and

ADHD. Elevated levels of impulsivity are a part of the diagnostic categories of these two disorders (American Psychiatric Association, 2013). Despite the episodic nature of bipolar disorder, individuals with this condition continue to show elevated levels of impulsivity based on self-report measures even during periods of euthymia (Moeller et al., 2001; Swann, 2010). Elevated levels of impulsivity are also a persistent feature of ADHD (Urcelay & Dalley, 2012). Although found in individuals with schizophrenia, elevated levels of impulsivity are not considered to be a central aspect of the disorder (Ouzir, 2013). Thus, the decision to group individuals with bipolar disorder and ADHD was made not only based on shared impairment in executive functioning, but also based on impulsivity being a common trait shared by individuals with these two disorders.

Grouping together of individuals with schizophrenia and bipolar disorder was supported by psychosis being a key feature of schizophrenia and frequently found in individuals with bipolar disorder (American Psychiatric Association, 2013; Pope & Lipinski, 1978). Schizotypy is a trait closely related to schizophrenia and psychosis proneness (Lenzenweger, 2006; van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). Although there is some debate over the precise nature of the relationship between schizotypy and psychosis, there is evidence to suggest that schizotypy lies along a continuum that spans normal functioning on one end and psychotic symptoms on the other (Nelson et al., 2013; Rawlings et al., 2008; van Os et al., 2009). As a result, elevated traits on measures of schizotypy can serve as markers of neurobiological dysfunction associated with bipolar disorder and schizophrenia, but not ADHD. Grouping of individuals with schizophrenia and bipolar disorder together was carried out partially based on the fact that schizotypy is a personality trait likely to be a marker of neurobiological dysfunction in these disorders, and also due to working memory being a common endophenotype shared across these two conditions.

Item parceling. Two major barriers to examining the nature of relationships between cognitive ability and personality traits in individuals with mental illness and community participants is that 1) the number of items created by combining multiple personality scales is too large to be examined within even fairly large participant samples, and 2) there is uncertainty surrounding the psychometric properties of many self-report measures of personality. Combining items from four impulsivity and three schizotypy scales included in our study creates a dataset of approximately 200 items to be analyzed using data from approximately 1000 participants. Factor analyzing such a database would create unstable solutions, since this sample size provides insufficient statistical power to factor analyze 200 scale items. Interpreting the findings of a factor analysis using 200 scale items would also be very difficult and may hinder formulation of a coherent set of findings. Data reduction is a common approach used to maximize statistical power and simplify interpretation of study findings.

Using index scores from personality scales is one possible approach to data reduction. However, a number of studies have shown that psychometric properties of some scales differ from those originally proposed by their authors (Di Milia, 2013; E. Miller, Joseph, & Tudway, 2004; Parker et al., 1993; Reise et al., 2013). Inclusion of multiple similarly-worded items poses a challenge in interpreting the factor structure of assessment scales, often making it difficult to separate common from unique item variance when interpreting loading of items onto factors (Reise et al., 2013). Construction of homogeneous parcels based on correlations between items helps solve this problem by accounting for common variance between groups of similarly-worded items (Schalet et al., 2011). Therefore, as a means of data reduction, we created parcels from items showing strong correlations and similar content prior to verifying the factor structure of scales used in the study. We used parceling methods described by Schalet, Durbin, and Revelle (2011) and used in the Reise et al. (2013) study of the Barratt Impulsiveness Scale to increase homogeneity of scale items and find more reliable, replicable and unambiguous factor solutions for measures of impulsivity and schizotypy included in our study. We then created scores based on the derived factor structure in order to further reduce the number of items being analyzed. Verifying constructs measured by personality scales in our study helped us to not only reduce the number of items in our analysis, but also ensured that when testing our main hypothesis, we tested relationships between constructs that showed robust, replicable, and easily interpretable factor solutions.

Study Questions. This study focused on exploring three general questions: whether creating homogeneous parcels will result in robust and unambiguous factor structures across scales within a single domain that are consistent with prior findings; whether sum scores from impulsivity factors will have correlations with scores on tests of executive functioning that are significantly different in individuals with bipolar disorder and ADHD than in the general population; and whether sum scores from schizotypy factors will have correlations with scores on tests of working memory and declarative memory that are significantly different in individuals with schizophrenia and bipolar disorder than in the general population.

Strong loadings are expected from parcels reflecting constructs highly relevant to impulsivity and schizotypy as measured by individual scales within these domains. Factor structure of multi-factor scales, such as the Barratt Impulsiveness Scale, is expected to be simplified into the two-factor structure found in the study by Reise et al. (2013). Scales with simpler factor structures are expected to remain the same, but show stronger loadings of remaining parcels onto each factor and eliminate item cross-loading.

Factor analysis of parcels across impulsivity scales is expected to yield a more parsimonious solution, demonstrating that most impulsivity scales measure similar underlying constructs. It is expected that all impulsivity scales will assess only factors related to impulsivity/non-planning and sensation seeking, similar to results of Miller, Joseph and Tudway (2004). This analysis is expected to produce stronger loadings from individual parcels onto the two factors and few cross-loading of parcels are expected between the factors. Factor analysis results from using parcels from all three schizotypy scales is expected to yield a two-factor solution comprised of positive and negative impulsivity factors found in prior studies. Creating homogeneous parcels within the two scales is predicted to result in social anhedonia loading onto the negative schizotypy factor.

Finally, tests of personality and cognitive ability are expected to show significantly different correlations in individuals with mental illness compared to community participants. Correlations between standardized weighted sum scores on impulsivity/non-planning factor and scores on tests of executive functioning are expected to differ between individuals with bipolar disorder and ADHD compared to correlations found in community participants. Correlations between standardized weighted sum scores from the negative schizotypy factor and scores on tests of working memory are expected to be significantly different in individuals with schizophrenia and bipolar disorder compared to community participants.

These results would suggest that measures of personality traits and cognitive ability have different relationships in individuals with mental illness compared to community participants.

Methods

Participants

The study consisted of 53 participants diagnosed with schizophrenia or schizoaffective disorder, 47 participants diagnosed with bipolar I disorder, 46 participants diagnosed with ADHD, and 941 community members. Individuals with mental illness were recruited as part of the LA5C sample and community participants were recruited as part of the LA2K sample through the Center for Neuropsychiatric Phenomics. Age range for all groups was 21 to 50 years old. The age was chosen to limit phenotypic variability, since younger adults are still undergoing neurodevelopment and older individuals are beginning to show signs of cognitive decline. The schizophrenia, bipolar, and ADHD samples were 66%, 62%, and 56% male, respectively. The healthy sample was 51% male.

Selection criteria for participants in the clinical samples included European ancestry, fluency in English, and at least an eighth grade education. They had to be free from medical conditions that may impact neuropsychological performance. Individuals in the schizophrenia/schizoaffective disorder group were excluded if they had a lifetime diagnosis of bipolar I disorder, and individuals in the bipolar group were excluded if a lifetime diagnosis of schizophrenia or schizoaffective disorder could be established. Participants in either one of the groups could be diagnosed with ADHD in the past or currently. Participants in the ADHD sample could not carry any of the other two diagnoses. Individuals with mental illness were excluded if they were diagnosed with bipolar II disorder. Clinical group participants were also excluded for meeting DSM-IV-TR criteria for substance dependence in the past 6 months, current substance abuse criteria, not passing a toxicology urine screen, currently meeting criteria for any other Axis I disorder, or being actively suicidal. Individuals with mental illness taking psychoactive medications had to be stabilized on the medications. Individuals with mental illness were also excluded if they underwent neurocognitive testing in the past six months.

Community participants in this study were included if they were of either European or Hispanic ancestry. The healthy sample was designed to be representative of the general population of the larger Los Angeles area. Participants had to be fluent in English and have at least an eighth grade education. In the parent study, participants that were bilingual (English/Spanish) took fluency exams in both languages and were tested in the language showing better fluency; for this dissertation project only those people who were tested in English were included. They had to be free from medical conditions that may impact neuropsychological performance. Participants in the healthy group were excluded if they met diagnostic criteria for psychosis, schizophrenia, bipolar I or II disorder, and ADHD at any point in their life. Current diagnosis of mood or anxiety disorder, or suicidality were also reasons for exclusion, as well as the use of psychoactive medication at the time of the study. Lifetime prevalence of psychiatric disorders other than psychosis, schizophrenia, bipolar disorder, or ADHD, did not exclude individuals from participating.

Procedures

Participants were recruited from the local community using advertisements on Craigslist, local papers, the "Clinical Connection" website, or by word of mouth. Initial telephone screening was done to establish basic eligibility criteria. Participants were informed of study procedures and consented to participate in the study. They were given an hour-long screening interview and a urine drug screen to establish further eligibility for the study. If excluded following consent, they were paid for the time they spent participating in the study. Following the initial screening, participants were administered clinical and neuropsychological assessment measures as part of a larger assessment battery. Neuropsychological assessment took approximately 115 minutes. All procedures were approved by the institutional review board at UCLA.

Personality Measures

Impulsivity. Four commonly-used impulsivity scales were used in this study. The Barratt Impulsiveness Scale is a 30-item scale designed to measure three maladaptive aspects of impulsivity: motor impulsiveness, attentional impulsiveness, and non-planning impulsiveness (Patton et al., 1995). Motor impulsiveness is concerned with acting without forethought. Attentional impulsiveness is associated with concentration difficulty. Non-planning impulsiveness is associated with acting prior to thinking through your actions. A number of recent factor analytic studies of the BIS showed that a two-factor solution, comprised of non-planning and motor impulsivity factors, is a better representation of constructs measured by the scale (Haden & Shiva, 2009; Morean et al., 2014; Reise et al., 2013).

The Dickman Impulsiveness Inventory is a 23-item scale that divides impulsivity into two components: functional and dysfunctional (Dickman, 1990). Functional impuslvity is related to traits such as enthusiasm, adventurousness, and activity. Dysfunctional impulsivity is related to disorderliness and avoidance of facts in decision-making. Results of subsequent factor analyses have largely confirmed the original factor structure proposed by the scale author (Adan et al., 2010; Caci et al., 2003; Di Milia, 2013). However, these studies improved model fit by removing items identified as having weak loadings on their respective factors.

The Impulsiveness-Venturesomeness-Empathy (IVE) Scale is a 54-item questionnaire developed to test personality traits of impulsiveness, venturesomeness, and empathy (S. B. G. Eysenck & Eysenck, 1978) . Impulsiveness means doing things without planning ahead, and Venturesomeness means engaging is risky, thrill-seeking behavior with full awareness. Both of these constructs are related to impulsivity, with venturesomeness being seen as a more adaptive trait than impulsiveness. The structure of these scales has been consistently replicated by other studies (Aluja & Blanch, 2007; Luengo et al., 1991). The third scale, empathy, is not closely related to the impulsivity constructs and has not been shown to be as robust as the other two scales in the IVE Questionnaire (Aluja & Blanch, 2007; Caci et al., 2003).

The Control Scale from the Multidimensional Personality Inventory is a 24-item questionnaire designed to measure control, a construct often considered to be the opposite of impulsivity. The scale has shown strong psychometric qualities (Tellegen & Waller, 2008). Factor analytic studies revealed that scale items generally load onto two factors: cautious/spontaneous and methodical/disorganized (Parker et al., 1993).

Schizotypy. Schizotypy was measured using the 61-item Physical Anhedonia scale, the 40-item Social Anhedonia scale, and the 35-item Perceptual Aberration scale developed by Chapman and Chapman (Chapman et al., 1982, 1976). The Chapman scales have been developed as measures of traits related to schizotypy and have shown high reliability and predictive validity in identifying individuals at risk for transitioning to schizophrenia (Chapman et al., 1994). In prior factor analytic studies, Perceptual Aberration scale has been shown to load onto a factor representing positive symptoms of psychosis. The Physical Anhedonia scale loaded onto the negative symptoms of psychosis factor and the Social Anhedonia scale loaded onto both positive and negative symptom factors (Brown et al., 2008; Chapman et al., 1982; Kwapil et al., 2007).

Neuropsychological Measures

Working memory was assessed using subtests from the Wechsler Adult Intelligence Scale, 4th Edition (WAIS-IV; Wechsler, 2008), including Digit Span and Letter-Number Sequencing. The Digit Span test asks participants to recite back numbers in a given order, and Letter-Number Sequencing asks them to recite back groups of letters and numbers in a pre-determined order. These tests show high estimates of internal consistency using coefficient alpha, r = 0.90, 0.94, 0.93, and 0.88, respectively (Wechsler, 2008). They are considered to be estimates of short-term and working memory. The Forward portion of the Digit Span test is a measure more closely related to short-term memory rather than working memory because it requires the participant to simply repeat back the information presented to them. During the Backward and Sequencing portions of the Digit Span test and the Letter-Number Sequencing test, participants not only remember but also manipulate information according to the rules provided by the examiner. While all of these tests rely on some manipulation of information, the degree of manipulation necessary during the Digit Span Sequencing and Letter-Number Sequencing is larger than during the Digit Span Backward test. Manipulation of information while maintaining it in short-term memory is considered to be a key feature of working memory (Baddeley, 2003). To ensure that cognitive variables in our study represented working memory, we used the portion of variance on Digit Span Backward subtest scores related to manipulation by creating residual scores after regressing Digit Span Forward on Digit Span Backward. This residual score, capturing the manipulation component of working memory, was combined with scores from Digit Span Sequencing and Letter-Number Sequencing tests to produce a working memory score.

The Color Trails Test was used as a measure of executive functioning (D'Elia, Satz, Uchiyama, & White, 1996). It is a measure similar to the Trail Making Test (Reitan, 1979), but uses colors instead of letters on portion B that allows its use with different language groups. Part A of the Color Trails Test asks participants to connect circles with numbers drawn inside them in a sequential order, thus measuring constructs related to attention and speeded information processing. Part B of the test asks participants to alternate between connecting circles with numbers in a sequential order and connecting circles with colors. The participant is supposed to alternate between the two response sets, drawing a line from a number circle, to a color circle, to a number circle, to a color circle, and so on. As a result, Part B of the test relies more on processes related to set-shifting and response inhibition by asking the participant to switch between two alternating sets of response patterns. The test-retest reliability coefficient for parts A and B are 0.64 and 0.79, respectively. In order to ensure that we are measuring the executive component of the test related to task switching and response inhibition, a residual score of Part B was calculated given the scores on Part A of the Color Trails Test. This residual score was used as a measure of executive functioning within subsequent analyses.

Analysis Plan

Hierarchical clustering. Items on all personality scales were reverse coded so that higher scores on all items indicated greater degree of the construct being measures. Factor analyses were performed using the R statistical software package version 3.1.2 (R Core Team, 2014) *psych* library (Revelle, 2015). Correlation matrices were computed for items within each scale, with tetrachoric correlations being used on scales with dichotomous item responses using the *polycor* library (Fox, 2010). A hierarchical clustering algorithm was run using the *iclust* command within the *psych* library (Revelle, 2015). Items that correlated with one another were individually examined to determine whether they measured similar constructs. Items with similar content were identified as comprising a single parcel. Scores on items within a parcel were then averaged to produce a single parcel score.

Factor analysis in controls. Exploratory factor analysis was carried out on parcels derived from the impulsivity scales in community participants using minres extraction and promax rotation that are part of the *psych* library. The factor analyses were performed on parcels comprising each of the scales independently to verify that the factor structure identified in our dataset was consistent with factor structure described in the literature. After evaluating the factor structure of individual measures, subsequent factor analysis analyzed data across all measures within the impulsivity domain using only those parcels showing loadings above 0.45 during factor analysis of individual scales. The cutoff of 0.45 was selected in order to strike a balance between including too many spurious parcels into the factor and including too few parcels to be a meaningful representation of scale content. This overall analysis was performed in order to identify constructs measured by all of the measures across the entire domain of impulsivity.

An identical analysis using same extraction and rotation approaches was carried out on parcels from each of the Chapman scales included in this sample (Social Anhedonia, Physical Anhedonia, and Perceptual Aberrations). The highest loading parcels (> 0.45) from factor analysis of individual scales were selected for an overall factor analysis. A factor analysis of the highest loading parcels (> 0.45) from all scales was carried out in order to identify constructs measured by these three measures across the entire domain of schizotypy.

In order to assess how well the factor model fits the data, we looked at the significance of the chi-square test of the overall model fit as well as three common fit indices, the Root-Mean-Square Residual (RMR) Index, Tucker-Lewis Index (Tucker & Lewis, 1973), and the Root Mean Square Error of Approximation (RMSEA). Cutoffs were selected based on recommendations by Hu and Bentler (1999; Schumacker & Lomax, 2010). The cutoff for the RMR was <0.05, the cutoff for the TLI was >0.95, and the cutoff for the RMSEA was <0.06.

Standardized weighted sum scores were calculated for individuals with mental illness and controls using parcel structure and factor loadings from the control sample. The procedures used were those outlined by DiStefano, Zhu and Mindrila (2009) for calculating standardized weighted sum scores. Factor structure from the healthy sample was applied to patient samples to increase weighted sum score consistency and reliability. Since the healthy group had a much larger sample size (N = 941) than the clinical samples, results of hierarchical clustering and factor analysis results derived from the healthy group had greater reliability and generalizability. Prior to calculating sum scores, parcel scores were standardized to control for any differences in variance that might impact the resultant sum scores. Standardized weighed sum scores were created by selecting parcels with the highest loadings from the domain-wide factor analyses of impulsivity and schizotypy personality scales. This was done to ensure that only parcels that were most representative of a given factor were included in the final sum score. In order to strike a balance between including too many and too few parcels in the final sum score, only parcels with loadings above 0.40 on the domain-wide factors were used. Scores on parcels with loadings above 0.40 were standardized to ensure they all had identical distributions. Standardized parcel scores were then weighted using factor loadings and then added together to produce a single standardized weighted sum score for each of the factors derived in the overall factor analysis.

Moderated multiple regression. Moderated multiple regression analysis was carried out using SPSS statistical package version 16.0 (SPSS Inc., 2007) in order to determine whether there is a strong moderation effect of patient status in the relationship between personality traits and domains of cognitive ability. Interaction terms representing weighted sum scores on personality traits and binary patient status variables were calculated. The interaction term was included into a regression model which also included weighted sum scores on the personality domain of interest and patient status. These models were regressed onto composite scores representing performance on a cognitive domain of interest, either executive functioning or working memory.

To ensure that diagnostic groups could be combined based on performance on tests of cognitive ability and personality traits commonly found across disorders, moderated regression analyses within individual diagnostic categories were carried out. Moderation effect of patient status on the relationship between schizotypy and working memory was examined in individuals with schizophrenia. In individuals with bipolar disorder, the effect of patient status was examined on the relationship between schizotypy and working memory, and on the relationship between impulsivity and executive functioning. In individuals with ADHD, moderation effect of patient status on the relationship between impulsivity and executive functioning were examined.

Subsequent analysis examined moderation effects of patient status on the relationship between executive functioning and impulsivity in a group comprised of individuals with bipolar disorder and ADHD. Moderation effect of patient status on the relationship between working memory and schizotypy in a group comprised of schizophrenia and bipolar disorder individuals was also examined.

Additional moderated multiple regression analyses were carried out to examine the nature of significant findings. Individuals within clinical samples showing significant patient status by personality scale score interaction term were divided into low scorers, those who scored below the median, and high scorers, those who scored above the median, based on scores from personality scales and tests of cognitive ability. Separate moderated multiple regression analyses were carried out in both the low- and high-scoring samples to examine whether a subset of individuals in the clinical sample were driving the significant findings.

Results

Hierarchical Clustering

Hierarchical clustering analysis of correlations between personality scale items in the healthy sample revealed multiple, multi-item parcels, suggesting some item redundancy in the original scales (for summary of parcel structure, see Tables 4 - 10). After carrying out the *iclust* command, resultant item groupings were evaluated by hand and assigned to individual clusters based on qualitative judgment of similarity in item content. The clustering procedure reduced the number of items in most scales by half or more. The 30-item Barratt Impulsiveness Scale was reduced to 11 parcels. The Dickman Impulsiveness Inventory was reduced from 23 items to 8 parcels. After removing the Empathy scale from the Eysenck Scale because it measures a construct unrelated to impulsivity, the resultant 35 items loaded onto 15 parcels. Finally, the 24-item MPQ Control Scale was reduced to 10 parcels. Schizotypy scales were reduced in a similar fashion, with the 61-item Chapman Physical Anhedonia scale reduced to 25 parcels. The Chapman Social Anhedonia scale was reduced from 40 items to 20 parcels. And, the Perceptual Aberration scale was reduced from 35 items to 18 parcels.

Factor Analysis of Individual Scales

Factor analysis results of parcels from individual personality scales revealed solutions consistent with prior literature (See Tables 11 – 19). A two-factor solution was found in the

Barratt Impulsiveness Scale. Parcels related to not planning and thinking things through carefully loaded strongly on the first factor, with four parcels showing strong loadings (> 0.45; See Table 11). The second factor showed strong loadings from parcels related to acting on the spur of the moment, restlessness, and having racing thoughts, with three parcels showing strong loadings onto this factor. The fit statistics for this solution revealed a generally strong fit. RMR = 0.05, TLI = 0.73, and RMSEA = 0.089. Despite the TLI and RMSEA being below and above the cutoffs, respectively, the solution was consistent with prior findings that the two-factor solution fits the data better than the originally proposed three-factor solution (Reise et al., 2013; Vasconcelos et al., 2012). The correlation between the two factors was 0.25.

The best-fitting solution for the Dickman Impulsiveness Inventory parcels was a two-factor solution (See Table 12). The first factor showed strong loadings from parcels related to not planning or thinking through one's actions with three of the four parcels showing loadings above 0.45. Parcels loading onto the second factor were related to acting or thinking quickly, without having the time to think things through. All parcels had strong loadings onto this factor. The RMR Index for this solution was 0.04, the TLI was 0.857, and the RMSEA Index was 0.089. Based on generally-accepted cutoff criteria (Hu & Bentler, 1999; Schumacker & Lomax, 2010), this factor solution fit the data well. Despite the TLI and RMSEA being below and above the cutoffs, respectively, the solution was consistent with multiple prior findings (Di Milia, 2013). The correlation between the two factors was 0.13.

Factor analysis of parcels comprised of items from the venturesomeness and impulsivity indices of the Eysenck IVE scale revealed a two-factor solution consistent with the scale structure proposed by the authors (Eysenck & Eysenck, 1978; See Table 13). Parcels related to impulsivity loaded onto the first factor. Strongest loadings (> 0.45) were observed from parcels related to lack of planning, acting on impulse, not having self-control, and not checking one's actions. Parcels loading strongly onto the second factor were related to engaging in extreme activities such as parachute jumping, pot-holing and scuba diving, as well as being drawn to frightening and potentially dangerous activities. Thus, these results largely replicated the two indices proposed by the original authors of the scale: impulsivity and venturesomeness. Fit statistics showed very strong fit (RMR = 0.04, TLI = 0.90, RMSEA = 0.051). The correlation between the factors was 0.33.

Results from analysis of the MPQ Control Scale showed strong loadings (above 0.45) from all parcels onto a single factor (See Table 14). Given that all items in the analysis were reverse-coded, this suggests a single factor related to lack of control over one's actions. Factors with loadings above 0.60 were the ones related to a lack of spontaneity, carelessness, and not planning things in advance. This solution also fit the data well (RMR = 0.05, TLI = 0.86, RMSEA = 0.08).

Schizotypy scales revealed good model fit of the data. Chapman Physical Anhedonia scale, despite being the longest scale in the dataset with 61 items and 25 resultant parcels showed factor loadings above 0.45 from only six parcels (See Table 15). These were related to experiencing walking, petting, feeling cozy, dancing, leisure activities, and beautiful scenery. Examination of fit statistics reveled good overall fit, although the TLI fell well below the generally accepted cutoff: RMR = 0.05, TLI = 0.76, RMSEA = 0.05.

The Chapman Social Anhedonia Scale showed the best fit from a one-factor model with multiple parcels showing strong loadings (See Table 16). Parcels with the strongest loadings (>

0.45) were related to being alone, needing to have friends, people's expectations, not feeling connected to others, avoiding relationships, negative emotional responses to others, and having few close friendships. The fit statistics revealed generally good model fit with the TLI falling below the cutoff, RMR = 0.06, TLI = 0.75, RMSEA = 0.06.

Finally, the Chapman Perceptual Aberration scale showed a one factor solution with loadings above 0.45 observed on the majority of parcels (See Table 17). Parcels with the highest loadings were those related to physical changes in the body, feelings of not existing, and decay. Fit statistics for the Perceptual Aberration scale were RMR = 0.05, TLI = 0.84, RMSEA = 0.062.

Factor Analysis Across Measures Within a Single Domain

Following factor analysis of individual personality scales in the healthy sample, parcels with high loadings (> 0.45) were selected. Examination of the scree plot based on the dataset comprised of high-loading parcels from impulsivity scales showed that two- and three-factor solutions had eigenvalues above 1. The three-factor solution was uninterpretable with one parcel showing a factor loading above 1. The two-factor solution was thus selected as it provided interpretable factor loadings and a generally good model fit, RMR = 0.07, TLI = 0.69, RMSEA = 0.08. Parcels from all four impulsivity scales included in this study loaded highly onto the first factor. Highest loadings were observed from parcels generally related to acting on impulse without considering the consequences (See Table 18). The second factor had high loadings from parcels related to Venturesomeness, or engaging in thrill-seeking behavior. These parcels came from the Eysenck scale. Also, parcels related to thinking and acting quickly on the Dickman Impulsiveness Inventory loaded onto the Venturesomeness factor. Highest loadings were observed from parcels related to various thrill-seeking activities from the Eysenck questionnaire. The correlation between the factors was r = 0.30, suggesting a moderate degree of relationship.

Analysis of the scree plot derived from highest loading parcels from the three Chapman schizotypy scales included in the study revealed a two-factor solution with eigenvalues above 1. However, the three-factor solution revealed factor loadings that were more readily interpretable than those from the two-factor solution. The two-factor solution produced factors with loadings from perceptual aberration and social anhedonia scales while no parcels from the physical anhedonia scale loaded on either of the factors. The three-factor solution represented all three scales with parcels from each of the scales loading onto a separate factor (See Table 19). The three-factor solution showed a very strong fit, RMR = 0.03, TLI = 0.88, RMSE = 0.05. The majority of parcels exhibited strong loadings (> 0 .40) onto their respective factors. Only one parcel showed lower loading on each, the Perceptual Aberration and Social Anhedonia factors. Two parcels showed lower loadings on the Physical Anhedonia factor. The correlation between Perceptual Aberration and Social Anhedonia parcels was 0.43. The correlation between Perceptual Aberration and Physical Anhedonia was 0.00. The correlation between Social Anhedonia and Physical Anhedonia was 0.31.

Moderated Multiple Regression Analyses

Analysis across diagnostic groups. Regression analyses using weighed sum scores derived from impulsivity measures did not show any significant differences when regressing interaction terms between venturesomeness, impulsivity, and patient status on scores from measures of executive functioning. The venturesomeness by patient status interaction term was unrelated to measures of attention, b = -0.075, t(1033) = -1.768, p = 0.077 (See Table 24). This suggests, that the relationship between venturesomeness sum scores and scores on measures of attention was not significantly different in individuals with bipolar disorder and ADHD compared to community participants. The impulsivity by patient status interaction term was also unrelated to measures of attention, b = -0.000, t(1033) = -0.026, p = 0.979 (See Table 25). Thus, the relationship between impulsivity weighted sum scores and scores on measures of attention was also not significantly different in individuals with bipolar disorder and ADHD compared to community participants.

Regression analyses using weighed sum scores derived from physical anhedonia factor showed a significant difference between individuals with mental illness and community participants, while perceptual aberration and social anhedonia measures did not show any significant differences between individuals with mental illness and community participants. The physical anhedonia by patient status interaction term was significantly related to working memory, b = -0.296, t(1040) = -2.775, p = 0.006 (See Table 26). The relationship between physical anhedonia weighed sum score and scores on measures of working memory was significantly different in individuals with schizophrenia and bipolar disorder than in community participants (See Figure 1). The social anhedonia by patient status interaction term was unrelated to working memory, b = -0.010, t(1040) = -0.150, p = 0.880 (See Table 27). The relationship between social anhedonia sum scores and scores on measures of working memory was not significantly different in individuals with schizophrenia and bipolar disorder compared to community participants. The perceptual aberrations by patient status interaction term was also unrelated to working memory, *b* = -0.023, *t*(1040) = -0.784, *p* = 0.433 (See Table 28). The relationship between perceptual aberration sum scores and scores on measures of working memory was not significantly different in individuals with schizophrenia and bipolar disorder compared to community participants.

Analysis within single diagnostic groups. Moderated regression analysis using the bipolar patient group did not show any significant differences when regressing interaction terms between weighed sum scores on measures of venturesomeness and impulsivity, and patient status, on scores from measures of executive functioning. The venturesomeness by patient status interaction term was not significantly related to executive functioning, *b* = -0.062, *t*(987) = -1.077, *p* = 0.282. The relationship between venturesomeness weighed sum score and executive functioning was not significantly different in individuals with bipolar disorder than in community participants. The impulsivity by patient status interaction term was not significantly related to executive functioning, *b* = -0.003, *t*(987) = -0.170, *p* = 0.865. The relationship between impulsivity weighed sum score and executive functioning was not significantly different in individuals with bipolar disorder than in community participants.

Results from the ADHD patient group also did not show any significant differences when regressing interaction terms between weighed sum scores on measures of venturesomeness and impulsivity, and patient status, on scores from measures of executive functioning. The venturesomeness by patient status interaction term was not significantly related to executive functioning, *b* = -0.064, *t*(986) = -1.007, *p* = 0.314. The relationship between venturesomeness weighed sum score and executive functioning was not significantly different in individuals with ADHD than in community participants. The impulsivity by patient status interaction term was not significantly related to executive functioning, b = -0.001, t(986) = -0.055, p = 0.956. The relationship between impulsivity weighed sum score and executive functioning was not significantly different in individuals with ADHD than in community participants.

Moderated regression analysis within the schizophrenia patient group showed a significant difference between individuals with mental illness and community participants on weighed sum scores related to physical anhedonia, but not on scores related to perceptual aberration or social anhedonia. The physical anhedonia by patient status interaction term was significantly related to working memory, b = -0.335, t(993) = -2.4335, p = 0.015. The relationship between physical anhedonia weighed sum score and scores on measures of working memory was significantly different in individuals with mental illness than in community participants. The perceptual aberration by patient status interaction term was unrelated to working memory, b = 0.002, t(993) = 0.068, p = 0.946. The relationship between perceptual aberration weighed sum score and scores on measures of working memory was not significantly different in individuals with mental illness than in community participants. The social anhedonia by patient status interaction term was also unrelated to working memory, b = -0.133, t(993) = -1.454, p = 0.146. The relationship between social anhedonia weighed sum score and scores on measures of working memory was not significantly different in individuals with mental illness than in community participants.

In individuals with bipolar disorder, moderated multiple regression analysis did not show any significant differences when regressing interaction terms between weighed sum scores on measures of physical anhedonia, perceptual aberration, and social anhedonia and patient status on scores from measures of working memory. The physical anhedonia by patient status interaction term was not significantly related to working memory, *b* = -0.131, *t*(987) = -0.817, *p* = 0.414. The relationship between physical anhedonia weighed sum score and scores on tests of working memory was not significantly different in individuals with mental illness than in community participants. The perceptual aberration by patient status interaction term was not significantly related to working memory, *b* = 0.025, *t*(987) = 0.417, *p* = 0.667. The relationship between perceptual aberration weighed sum score and scores on tests of working memory was not significantly different in individuals with mental illness than in community participants. The social anhedonia by patient status interaction term was not significantly related to working memory, *b* = 0.007, *t*(987) = 0.084, *p* = 0.933. The relationship between social anhedonia weighed sum score and scores on tests of working memory was not significantly different in individuals with mental illness than in community participants.

Post-hoc analysis. Mean, median and standard deviation statistics were examined in the patient and schizophrenia groups to determine whether the patient group has a greater positive skew on physical anhedonia standardized weighed sum scores and working memory test scores, or greater range of scores. On the measure of physical anhedonia, the healthy group had a mean of -0.08, a median of -0.47, and a standard deviation of 1.67. The minimum score was -1.80 and the maximum score was 7.34. The schizophrenia group had a mean of 0.97, a median of 0.60, and a standard deviation of 1.73. The minimum score was -1.36 and the maximum score was 5.21. On measures of working memory, the healthy group had a mean of 10.17, a median of 10.08, and a standard deviation of 1.68. The minimum score was 3.57 and the maximum score was 14.97. The schizophrenia group had a mean of 8.07, a median of 8.11, and a standard deviation of 1.66. The minimum score was 3.48 and the maximum score was

11.30. As a result, on both measures of physical anhedonia and working memory, the schizophrenia group did not have more extreme scores than the healthy group. Although there appeared to be a greater skew of standardized weighed sum scores on measures of physical anhedonia than on measures of working memory in both schizophrenia and healthy samples, the degree of skew did not appear to differ significantly across the healthy and schizophrenia patient groups.

Within the schizophrenia patient group, individuals with mental illness who scored below the median on the Physical Anhedonia Scale did not show a significant difference in the relationship between physical anhedonia weighed sum scores and working memory scores compared to community participants. In this group, the physical anhedonia by patient status interaction term was not significantly related to working memory, $b = -0.740$, $t(967) = -1.368$, $p = 0.172$. There also was no significant difference in the relationship between physical anhedonia weighed sum scores and working memory scores in individuals with schizophrenia who scores above the median on the Physical Anhedonia Scale compared to community participants. The physical anhedonia by patient status interaction term was also not significantly related to working memory, $b = -0.214$, $t(966) = -0.777$, $p = 0.437$. The relationship between physical anhedonia and working memory was not significantly different in individuals with mental illness with low scores or high scores on a measure of physical anhedonia compared to community participants.

Individuals with mental illness who scored below the median on tests of working memory did not show a significant difference in the relationship between physical anhedonia weighed sum scores and working memory scores compared to community participants. In this group, the physical anhedonia by patient status interaction term was not significantly related to working memory, *b* = -0.057, *t*(966) = -0.303, *p* = 0.762. There also was no significant difference in the relationship between physical anhedonia weighed sum scores and working memory scores in individuals with schizophrenia who scored above the median on tests of working memory compared to community participants. The physical anhedonia by patient status interaction term was not significantly related to working memory, *b* = -0.115, *t*(967) = -0.493, *p* = 0.622. The relationship between physical anhedonia and working memory was not significantly different in individuals with mental illness with low scores or high scores on tests of working memory compared to community participants.

Discussion

This study verified psychometric properties of common measures of impulsivity and schizotypy and examined whether common measures of personality and cognitive ability have similar relationships in individuals with mental illness as they do in community participants. The results showed that after accounting for item heterogeneity, factor structure of common measures of impulsivity and schizotypy were largely consistent with those from earlier studies. Factor analysis of all impulsivity scales revealed that after accounting for item heterogeneity and selecting only the strongest-loading parcels, all impulsivity scales measured similar constructs whereas the three schizotypy measures included in this study measured distinct constructs. Examination of relationships between scores on tests of personality traits and scores on measures of cognitive ability showed that with the exception of the significantly stronger relationship between schizotypy and working memory found in individuals with mental illness with schizophrenia relative to community participants, all of the personality scales have similar relationships with scores on tests of executive functioning and working memory in individuals with mental illness as they do in community participants.

Individual Scale Analysis

In terms of examining psychometric properties of personality scales included in this study, hierarchical clustering analysis revealed that multiple items within personality scales included in this study were highly related to one another. Creation of more homogeneous clusters greatly reduced the number of items within each scale. Assigning items to more homogeneous clusters saw the length of the scales reduced by approximately half, suggesting that both impulsivity and schizotypy scales include a number of items measuring highly related constructs.

Factor analysis of the resultant clusters within each scale showed results that were largely consistent with prior literature. Factor analysis of the Barratt Impulsiveness Scale revealed a two-factor structure comprised of non-planning and acting on the spur of the moment factors that was consistent with prior findings (Morean et al., 2014; Reise et al., 2013; Vasconcelos et al., 2012). Results from factor analysis of the Dickman Impulsiveness Inventory also produced a two-factor solution with one factor generally loading onto a negative aspect of impulsivity (not thinking through one's actions) and the second factor loading on a more positive aspect of impulsivity (thinking quickly or not having time to think). This solution was consistent with the original scale design (Dickman, 1990) and produced results largely similar to results from later factor analytic studies (Adan et al., 2010; Caci et al., 2003; Di Milia, 2013).

Results from factor analysis of parcels from the Eysenck Impulsiveness and Venturesomeness scales produced a two-factor solution that clearly replicated these two scales. These results also supported findings from prior studies (Aluja & Blanch, 2007; Luengo et al., 1991). While the MPQ Control scale has been developed as a unidimensional measure (Tellegen & Waller, 2008), a factor analytic study by Parker, Bagby, and Webster (1993) showed that the scale might best fit a two-factor solution. Results of this factor analysis were consistent with the original one-dimensional structure proposed by the scale authors presenting the control construct.

Strong loadings from the majority of the parcels on the Barratt, Dickman, Eysenck and MPQ Control scales and a lack of cross loadings between factors demonstrates that after controlling for item heterogeneity, these scales are robust measures of underlying constructs impulsivity constructs. The results are consistent with findings from prior studies. The two-factor solution found on the Barratt Impulsiveness Scale is consistent with the study by Reise et al. (2013), which also controlled for item heterogeneity. This suggests that the presence of similarly worded items likely impacted the originally proposed factor structure of the Barratt scale.

The Dickman Impulsiveness Inventory and the Eysenck Impulsiveness and Venturesomeness scales included in this sample showed factor loadings that were consistent with solutions published in prior studies. Despite showing substantial reduction in length after assigning scale items to individual parcels, the fact that this factor analysis produced similar results to those found in prior studies suggests that these scales may be less impacted by similarly worded items. As a result, the use of the parceling approach did not change the overall factor structure of the scale.

Factor analysis of the MPQ Control scale revealed a one-factor solution that was consistent with the design proposed by the scale authors. These findings were different from results from the Parker, Bagby, and Webster (1993) findings of a two-factor structure. While it is impossible to tell which of these results may have been more impacted by item heterogeneity, results of this study suggest that reducing item heterogeneity leads to a one-factor solution of the MPQ Control scale that is consistent with the intention of the scale authors.

Factor analysis of three Chapman Scales included in this study revealed that each of the scales has a one-factor solution. These results are consistent with prior studies and suggest that each of the scales measures a single construct. The majority of parcels from the Perceptual Aberration scale showed strong loadings (> 0.45), indicating that all of the parcels within the scale measure important aspects of the overall construct related to perceptual aberration. While factor analysis of the Social Anhedonia and Physical Anhedonia scales also revealed a one-factor solution, they did not show loadings that were as consistently strong as they were in the Perceptual Aberration scale. This suggests that only a subset of parcels best captures the construct of social anhedonia as measured by the Chapman Social Anhedonia scale. Similarly out of a total 25 parcels, only six showed strong loadings on the Physical Anhedonia scale. This means that only a subset of items is strongly related to the physical andhedonia construct measured by the Physical Anhedonia Scale. While the Chapman scales have been well-validated in the past and shown strong reliability (Chapman et al., 1982) and predictive validity (Chapman et al., 1994), their internal structure has not been widely researched in the past. These results show that while the Chapman scales are reliable and valid measures of the schizotypy construct, out of the Perceptual Aberration, Social Anhedonia, and Physical Anhedonia scale, only the Perceptual Aberration scale measures the underlying construct consistently. A large portion of items in the Social and Physical Anhedonia scales appears to be weakly related to the underlying constructs measured by these scales.

Factor Analysis Across Scales

Including all of the parcels from this analysis which showed strong loadings onto their respective scales (>0.45) into a factor analysis of parcels across scales within a single domain (e.g. impulsivity or schizotypy) showed which constructs are measured by all of the scales within a single personality domain.

Impulsivity scales. The results showed that parcels comprising impulsivity scales included in this study measure two general constructs. The first is a general impulsiveness construct representing lack of planning or organization and acting on impulse without examining the consequences of one's actions. The second factor represents thrill-seeking behavior and appears closely related to the Venturesomeness aspect of the Eysenck IVE scale (Eysenck & Eysenck, 1978). Indeed, the majority of the parcels loading onto this second factor were part of the Eysenck scale and loaded onto the Venturesomeness factor in the factor analysis of this scale. Parcels from the Dickman Impulsiveness Inventory also loaded onto this factor suggesting that the venturesomeness construct is partially represented by parcels in this scale as well.

Impulsivity is generally considered to be a multifaceted construct (Ouzir, 2013). Each of the impulsivity scales included in this analysis is considered to measure a slightly different aspect of this construct (Dickman, 1990; S. B. G. Eysenck & Eysenck, 1978; Patton et al., 1995; Tellegen & Waller, 2008). While some of the scales purport to measure both positive and negative aspects of impulsivity (Dickman, 1990), others measure different aspects of dysfunctional impulsivity (Reise et al., 2013) or thrill-seeking behavior in addition to impulsivity (Eysenck & Eysenck, 1978). However, our results show that after accounting for the heterogeneity of individual scale items, the majority of the scales measure relatively similar underlying constructs. Factor analysis of the highest-loading parcels from individual scales revealed that the majority of the parcels related to acting without thinking, not planning one's actions, and not taking the consequences of one's action into consideration loaded onto a single factor. A second factor related to thrill-seeking behavior and acting quickly on one's impulses was also found.

Notably, our findings did not show a separate factor related to the positive aspects of impulsivity described by Dickman (1990). Parcels forming the positive impulsivity factor in the analysis of the Dickman Impulsiveness Inventory loaded onto the venturesomeness factor in the overall analysis. Instead of being a separate aspect of the impulsivity construct, Dickman's definition of positive impulsivity may be more closely related to the kind of openness to new experiences that is captured by Eysenck's Venturesomeness Scale.

Schizotypy scales. Factor analysis of parcels with strong loadings within the three Chapman schizotypy scales included in this study revealed that individual parcels generally loaded onto their respective scales. This suggests that each of the three Chapman scales measures a unique construct related to schizotypy. Unlike prior findings of the three Chapman scales loading onto two factors, corresponding to positive and negative symptoms of schizophrenia (Brown et al., 2008; Chapman et al., 1982; Kwapil et al., 2007), our solution produced somewhat different results. In the three-factor solution, each of the scales loaded onto a separate factor implying that the scales measures three unique constructs. However, correlations between the three factors implied a moderate association between Social Anhedonia and both Perceptual Aberration as well as Physical Anhedonia, while no relationship was found between Perceptual Aberration and Physical Anhedonia.

Based on the eigenvalue plot alone, a two-factor solution was a better fit than the three-factor solution. However, the two-factor solution was also inconsistent with prior findings. In the two-factor solution, Perceptual Aberration and Social Anhedonia scales loaded on individual factors with the Physical Anhedonia scale showing no significant loadings (> 0.45) on either of the factors. Both the three-factor and two-factor solutions are different from prior findings which showed Perceptual Aberration and Physical Anhedonia scales loading onto two different factors and Social Anhedonia scale loading onto both factors. However, the three-factor solution is the most readily interpretable, given that it shows significant loadings from all three scales. Also, the associations between factors are consistent with factor loadings from prior findings which show that the Social Anhedonia scale is related to the other two scales, which load onto separate factors.

It is possible that accounting for item heterogeneity in the Chapman scales leads to a solution that emphasizes the differences between the three scales. It appears that there are significant differences in the constructs being measured by the Perceptual Aberration, Social Anhedonia, and Physical Anhedonia scales. However, the finding that Social Anhedonia factor is related to both Perceptual Aberration and Physical Anhedonia factors, but Perceptual

Aberration and Physical Anhedonia factors are unrelated to one another, is consistent with prior literature. Perceptual Aberration and Physical Anhedonia factors appear to measure significantly different constructs, such as positive and negative symptoms of schizophrenia, and the Social Anhedonia factor is related to both of these constructs.

Moderated Multiple Regression

Analyses across diagnostic groups. Relationships between personality scale sum scores and scores on tests of cognitive ability were similar in individuals with mental illness relative to community participants. All measures of impulsivity included in this sample show this pattern. Barratt, Dickman, Eysenck, and MPQ scales measuring impulsivity had similar relationships to measures of attention in individuals with mental illness as they did in community participants. This suggests that there is a similar relationship between impulsivity scales and scores on measures of cognitive ability despite observed differences in neurobiological functioning between individuals with bipolar disorder and ADHD, and community participants (Aron & Poldrack, 2005; Ellison-Wright & Bullmore, 2010; Frodl & Skokauskas, 2012). The results suggest that the relationship between personality traits and cognitive ability remains unimpacted despite the differences in personality traits and cognitive ability found between individuals with mental illness and healthy participants.

Scores on measures of social anhedonia and perceptual aberration also had similar relationships with scores on tests of working memory in individuals with schizophrenia and bipolar disorder as they did in community participants. This also suggests that despite differences in neurobiological functioning between individuals with schizophrenia and community participants, relationships between scores on measures of perceptual aberration and social anhedonia, and tests of cognitive ability remain the same across the entire range of functioning. However, scores on the physical anhedonia scale had a significantly different relationship with scores on measures of working memory in individuals with mental illness than they did in community participants. The fact that, unlike relationships between other measures in this study, the relationship between scores on the physical anhedonia scale and tests of working memory is different in individuals with mental illness relative to community participants may suggest that this set of measures captures different processes than other scales included in this study.

Differences in neurobiological functioning found in individuals with schizophrenia and bipolar disorder relative to healthy participants (Arnone et al., 2009) may affect common neurobiological processes that span mechanisms underlying physical anhedonia and working memory, resulting in a stronger association between measures of these constructs being observed in individuals with mental illness relative to community participants. The fact that other domains of personality and cognitive ability did not show a difference in association between individuals with mental illness and community participants may suggest that mechanisms underlying physical anhedonia and working memory may be uniquely affected by neurobiological mechanisms implicated in pathology found in individuals with schizophrenia and bipolar disorder. Disturbance within these mechanisms may lead to a pattern of impairment that is unique to individuals with schizophrenia and bipolar disorder and is not shared across the rest of the population. This finding is contrary to current theories of continuous impairment that spans individuals with mental illness and the general population.

In order to ensure that these findings accurately capture the relationship between impulsivity and executive functioning and between schizotypy and working memory, we also examined relationships between personality traits and cognitive ability within specific diagnostic categories. We also wanted to examine whether the unique relationship between physical anhedonia and working memory found in individuals with schizophrenia and bipolar disorder is a feature shared across these mental disorders, or unique feature of one of these psychiatric conditions.

Analyses within diagnostic groups. Examination of whether patient status moderates the relationship between scores on personality scales and tests of cognitive ability within individual diagnostic categories did not produce significant results when comparing individuals with bipolar disorder or ADHD to community participants. In individuals with bipolar disorder, no significant differences in the relationship between impulsivity or venturesomeness and scores on measures of executive functioning were observed in individuals with mental illness relative to community participants. Also, no significant differences were found in the relationship between physical anhedonia, perceptual aberration, and social anhedonia, and working memory in individuals with bipolar disorder compared to community participants. Similarly, no significantly different relationships between impulsivity and venturesomeness, and executive functioning were found across individuals with ADHD and community participants.

When examining relationships between schizotypy and working memory in individuals with schizophrenia compared to community participants, a significant moderation effect of patient status was found in the relationship between physical anhedonia and working memory. No moderation effects were found in the relationships between perceptual aberration and working memory, or between social anhedonia and working memory across individuals with mental illness and community participants. Taken together with a lack of similar findings when examining moderation effects in individuals with bipolar disorder relative to healthy participant, these results suggest that the difference in the relationship between physical anhedonia and working memory found in the combined schizophrenia and bipolar disorder group was likely driven by the difference in the relationship found in individuals with schizophrenia relative to community participants.

There was also a lack of a significant difference in the relationship between physical anhedonia and working memory in individuals with schizophrenia with low levels of physical anhedonia compared to community participants, and a lack of a significant difference in the relationship between physical anhedonia and working memory in individuals with schizophrenia with high levels of physical anhedonia compared to community participants. This suggests that the stronger relationship between physical anhedonia and working memory found in individuals with schizophrenia as a whole compared to community participants likely does not reflect an effect found in a subset of individuals with schizophrenia with low or high scores on measures of physical anhedonia. Similarly, there was a lack of significant difference in the relationship between physical anhedonia and working memory in individuals with schizophrenia who performed below the schizophrenia group median on measures of working memory, compared to community participants. There was also a lack of significant difference in the relationship between physical anhedonia and working memory in individuals with schizophrniea who performed above the schizophrenia group median on measures of working memory compared to community participants. This suggests that the stronger relationship between physical anhedonia and working memory found in individuals with schizophrenia as a whole compared to community participants likely does not reflect an effect found in a subset of individuals with schizophrenia with low or high scores on measures of working memory. The lack of a difference in the mean, median, and range of scores on measures of physical anhedonia and working memory in individuals with mental illness compared to community participants and a lack of significantly different associations between physical anhedonia and working memory found in a subset of individuals with schizophrenia suggests that the stronger relationship between physical anhedonia and working memory found in the schizophrenia group as a whole is likely a product of neurobiological impairment associated with schizophrenia, rather than an artifact associated with a more discrete patient subgroup or a trait shared across psychiatric disorders.

The difference in the relationship between physical anhedonia and working memory in individuals with schizophrenia relative to community participants suggests that impairment associated with this disorder may result in a different relationship between physical anhedonia and working memory. The relationship between physical anhedonia and working memory may capture aspects of neurobiological functioning that are not continuous across individuals with schizophrenia and the general population, a finding that is contrary to continuous models of impairment in psychopathology. Within the context of our other findings, which show similar relationships between personality traits and cognitive ability in individuals with mental illness and community participants across most measures and diagnostic groups, the unique relationship between physical anhedonia and working memory found in individuals with schizophrenia suggests that while the majority of traits related to psychopathology may be continuous across the population, some traits may have exhibit unique characteristics in individuals with schizophrenia relative to the rest of the population.

While the results of our study do not allow any specific hypotheses to be made regarding the nature of the impairment responsible for the difference in the relationship found in individuals with schizophrenia, it may be possible that neurobiological impairment spanning mechanisms responsible for performance on social anhedonia scales and working memory leads to a closer association between these two constructs in this patient group. Physical anhedonia and working memory scales may be measuring different constructs in individuals with schizophrenia compared to community participants. However, additional studies are necessary to examine the likely mechanisms responsible for this difference in the relationship between these constructs, which are assumed to be continuous in the population.

Limitations

Given the current view that impairment associated with psychopathology occurs along a continuum in the population, the use of a dichotomous patient status variable in this study is inconsistent with this view. A dichotomous patient status variable limits the variance associated with impairment along the continuum of performance spanning community participants and those with psychopathology. It is likely that this partitioning of variance limited the statistical power of our study to identify relationships between personality traits and cognitive ability at different levels of the population continuum. Future studies should attempt to include measures that can be used as continuous estimates of psychopathology in the general population as well as individuals diagnosed with psychiatric disorders.

Impulsivity can be measured using both self-report and performance-based measures. Although originally considered to measure similar constructs, recent evidence suggests that self-report and performance-based measures may assess different constructs related to impulsivity (Reddy et al., 2014). Significant differences were found in this study between levels of impulsivity found on self-report and performance-based measures in individuals with bipolar disorder and schizophrenia. These findings were consistent with prior reports of low correlations between self-report and performance-based measures of impulsivity (Enticott et al., 2008; Ouzir, 2013). Different performance-based measures of impulsivity also assess different aspects of this multifaceted construct. Given that only self-report measures of personality were used in this study our findings can only be generalized to those aspects of impulsivity assessed by self-report measures. It is possible that disturbance of neurobiological processes associated with bipolar disorder and ADHD affects constructs assessed by performance-based impulsivity measures to a greater extent than it does constructs assessed by self-report measures. Assessing impulsivity using performance-based measures may result in a finding of a different relationship between impulsivity and executive functioning in individuals with mental illness relative to community participants.

The use of diagnostic categories in our study also did not allow for differentiation between subtypes of individuals with bipolar disorder and ADHD. Given the evidence of varying degrees of cognitive impairment found in individuals with bipolar disorder (Burdick et al., 2014; Martino et al., 2014), evaluation of relationships between cognitive ability and personality traits based on subtypes may have yielded a more detailed account of possible mechanisms affected in this disorder. It is possible that individuals with mental illness showing greater cognitive impairment would have demonstrated relationships between personality traits and cognitive ability that were unexplored due to the small size of our patient sample. By focusing on individuals with bipolar disorder who demonstrate greater cognitive impairment, additional relationships between schizotypy and working memory could have been identified. Inclusion of individuals with bipolar disorder with mild or no cognitive impairment may have limited our ability to identify possible relationships. Trend-level relationships between perceptual aberration and working memory suggest that an underlying relationship may be present in this domain, and may have been significant with more statistical power in our sample.

Similarly, relationships between impulsivity and cognitive ability are likely different in individuals with ADHD presenting with the hyperactive/impulsive versus the inattentive symptom subtypes, as well as bipolar patient subgroup with greater degree of cognitive impairment. Examination of relationships between impulsivity and cognitive ability separately in individuals with these subtypes may have yielded significantly stronger relationships between impulsivity and executive functioning in individuals with mental illness relative to community participants.

Finally, while this study suggests that the relationships between personality traits and cognitive ability are consistent in individuals with mental illness and community participants, the mechanisms behind these relationships remain unknown. One path to understanding the likely mechanisms involves invariance testing, such as differential item functioning (DIF) analysis. This approach would clarify whether relationships between scores on personality measures and cognitive tests are a result of similar underlying processes being measured by scales of impulsivity and schizotypy, as well as tests of working memory and processing speed.

Unfortunately, the small sample size of the patient group used in this study prevented invariance testing from being carried out. While the consistency of results from prior studies in different patient populations using measures of impulsivity, schizotypy, working memory and processing speed suggests that they all measure similar constructs in individuals with mental illness as they do in community participants, a DIF analysis of these scales would serve to strengthen this point.

Conclusions

Factor analysis of individual impulsivity and schizotypy scales was generally consistent with prior findings. Examination of factor structure across all measures of impulsivity revealed consistency across measures of impulsivity designed to assess different aspects of the constructs. Factor analysis of the Chapman Scales revealed that they measure different aspects of schizotypy. Assignment of items into homogeneous parcels using hierarchical clustering showed that all scales in this study rely on a great number of similarly worded items. The use of more homogeneous items led to findings of greater consistency across constructs measured by impulsivity scales, but not across schizotypy scales. Factor analysis of parcels from all personality within a single domain revealed that impulsivity scales included in this study measured two common factors, impulsiveness and venturesomness. Within the schizotypy domain, factor analysis revealed a three-factor solution, with each of the Chapman Scales loading onto a separate factor. This solution differed from two-factor solutions found in the literature, where the two factors were found to represent positive and negative symptoms of schizotypy.

The majority of the findings in this study support the notion of similar relationships between personality traits and cognitive ability in individuals with mental illness and the general population. A similar relationship between impulsivity and executive functioning was observed in individuals with bipolar disorder and ADHD relative to community participants. The relationship between perceptual aberration and social anhedonia with working memory did not differ across individuals with schizophrenia and bipolar disorder, and community participants. However, the relationship between physical anhedonia and working memory was significantly different in the combined schizophrenia and bipolar disorder group relative to community participants. Analysis of relationships between personality and cognitive traits showed that this difference was only found in individuals with schizophrenia, but not in individuals with bipolar disorder. These findings suggest that while the majority of personality traits have similar relationships with cognitive ability in individuals with mental illness as they do in the general population, the relationship between physical anhedonia and working memory is different in individuals with schizophrenia. While additional evidence is necessary to understand the likely underlying mechanisms of this difference, this finding suggests that individuals with schizophrenia differ from other groups in terms of the relationship between physical anhedonia and working memory. The relationship between these traits is not continuous between individuals with schizophrenia and community participants.

TABLES AND FIGURES

Table 1.

Effect sizes comparing individuals with schizophrenia and healthy participants on tests of cognitive ability by cognitive domain

	Lee and Park, 2005	Fioravanti et al., 2012	Piskulic et al., 2007	Dickenson et al., 2007	Aleman et al., 1999	Heinrichs and Zakzanis, 1998	Laws, 1999	Johnson-Selfridge and Zalewski, 2001
	(Rosenthal's r)		(Cohen's d)	(Hedges' g)	(Cohen's d)	(Cohen's d)	(Cohen's d)	(Glass' Δ)
General Cog. Ability								
WAIS Verbal IQ						0.98		
WAIS Performance IQ						1.46		
WAIS FSIQ				1.19		1.24	1.23	
Other IQ Est.				0.59		0.63		
Declarative Memory								
Verbal Immediate		1.05		1.25	1.22	1.53*		
Verbal Delayed		1.14		1.09	1.20	1.11**		
Nonverbal Immediate		1.22		0.82	1.00	1.42		
Nonverbal Delayed				0.78	1.09			
Working Memory								
Verbal	0.45							
Visuospatial	0.46		1.00***					
Letter Number Seq.				0.85				
Digit Span Forward				0.73	0.71			
Digit Span Backward				0.86	0.82			
Digit Span Total		0.67		0.71		0.62		
Arythmetic				1.18				
Executive Functioning								
Stroop C-W				0.99				1.45
TMT B				0.92		1.17		
WCST Per				0.81		0.95	0.53	
WCST Cat				1.00			0.53	
Verbal Ability								
WAIS Vocabulary		0.99		0.90		0.69		
Letter Fluency				0.83		1.39		
Animal Fluency				1.14				
Attention								
TMT A		0.99*		0.88		0.95		
Stroop W				0.97		1.22		
AX CPT				1.13		1.18		
Connors CPT				1.02				

Notes. FSIQ = Full Scale IQ; Other IQ Est. = IQ estimated using tests such as the Wide Range Achievement Test (WRAT) and the National Adult Reading Test (NART); Verbal Immediate = Immediate recall trials from California Verbal Learning Test (CVLT), Rey Auditory Verbal Learning Test (RAVLT), and Hopkins Verbal Learning Test (HVLT); Verbal Delayed = delayed recall trials from the CLVT, RAVLT, and HVLT; Nonverbal Immediate = immediate recall from tests such as Visual Reproduction and Figure Recall; Nonverbal delayed = delayed trials from nonverbal memory tests; Stroop C-W = Stroop color word trial; TMT B = Trail Making Test, Part B; WCST Per = WCST Perseverative Responses; WCST Cat = WCST Categories Completed; TMT A = Trail Making Test, Part A; Stroop W = Stroop word reading trial; CPT = Continuous Performance Test* Includes additional tests Wechsler Memory Scale (WMS) logical memory, WMS-R verbal memory index, Portland Paragraph immediate, Luria Nebraska Neuropsychological Battery memory index, and Selective Reminding Test** Includes verbal learning test process scores*** Includes a number of experimental measures of individual working memory processes

Table 2.

Effect sizes comparing individuals with bipolar disorder and healthy participants on tests of cognitive ability by cognitive domain

	Arts et al., 2008	Bora et al., 2009	Kurtz & Gerraty, 2009	Mann-Wrobel et al., 2011	Robinson et al., 2006	Torres et al., 2007
	(Cohen's d)	(Cohen's d)	(Cohen's d)	(Hedges' g)	(Hedges' g)	(Hedges' g)
General Cog. Ability						
WAIS FSIQ	0.16	0.40			0.19	
Other IQ Est.		0.17		0.14		0.04
Declarative Memory						
Learning Trials		0.85	0.81	0.61	0.90	0.81
Verbal Short Delay	0.82	0.73		0.64	0.73	0.74
Verbal Long Delay	0.85	0.77	0.78		0.71	0.72
Verbal Recognition		0.44		0.42		0.43
Nonverbal Immediate	0.62	0.54	0.72	0.67		
Nonverbal Delayed			0.80			
Working Memory						
Digit Span Forward	0.37	0.37	0.41	0.40	0.47	
Digit Span Backward	1.02	0.75	0.65	0.81	0.98	0.59
Digit Span Total				0.64		
DSST	0.84	0.75		0.76	0.59	0.69
Executive Functioning						
Stroop C-W	0.65	0.76		0.71	0.63	
TMT B	0.99	0.86	0.73	0.80	0.78	0.56
WCST Per	0.88	0.70	0.61	0.66	0.76	
WCST Cat	0.52	0.66	0.54	0.56	0.62	0.69
Verbal Ability						
WAIS Vocabulary				0.09		0.08
Letter Fluency	0.59	0.60	0.51	0.55	0.34	0.47
Animal Fluency	0.87		0.75	0.58		
Attention						
TMT A	0.71	0.69	0.65	0.64	0.52	0.60
Stroop W	0.73			0.74		0.71
CPT	0.58	0.83	0.69		0.60	0.62

Notes. FSIQ = Full Scale IQ; Other IQ Est. = IQ estimated using reading tests such as the Wide Range Achievement Test (WRAT) and the National Adult Reading Test (NART); Verbal memory = Trials from California Verbal Learning Test (CVLT), Rey Auditory Verbal Learning Test (RAVLT), and Hopkins Verbal Learning Test (HVLT); Nonverbal memory = trials from tests such as Visual Reproduction and Figure Recall; DSST = Digit Symbol Substitution Task; Stroop C-W = Stroop color word trial; TMT B = Trail Making Test, Part B; WCST Per = WCST Perseverative Responses; WCST Cat = WCST Categories Completed; TMT A = Trail Making Test, Part A; Stroop W = Stroop word reading trial; CPT = Continuous Performance Test

Table 3.

Effect sizes comparing adults with ADHD and healthy participants on tests of cognitive ability by cognitive domain

<table>
<tr><th></th><th>Willcutt et al., 2005</th><th>Hervey et al., 2004</th><th>Frazier et al., 2004</th><th>Schoechlin et al., 2005</th><th>Boonstra et al., 2005</th></tr>
<tr><td></td><td>(Cohen's d)</td><td>(Cohen's d)</td><td>(Cohen's d)</td><td>(Cohen's d)</td><td>(Cohen's d)</td></tr>
<tr><td>Global Cog. Ability</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>WAIS FSIQ</td><td></td><td>0.39</td><td>0.61</td><td></td><td></td></tr>
<tr><td>VIQ</td><td></td><td></td><td>0.67</td><td>0.27</td><td></td></tr>
<tr><td>PIQ</td><td></td><td></td><td>0.58</td><td></td><td></td></tr>
<tr><td>WRAT</td><td></td><td></td><td>0.64</td><td></td><td></td></tr>
<tr><td>Declarative Memory</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Learning Trials</td><td></td><td>0.91</td><td></td><td rowspan="3">0.56</td><td></td></tr>
<tr><td>Verbal Short Delay</td><td></td><td>0.59</td><td></td><td></td></tr>
<tr><td>Verbal Long Delay</td><td></td><td>0.60</td><td></td><td></td></tr>
<tr><td>Verbal Recognition</td><td></td><td>0.90</td><td></td><td></td><td></td></tr>
<tr><td>Nonverbal Immediate</td><td>0.43</td><td><0.01</td><td>0.24</td><td rowspan="2">0.18</td><td></td></tr>
<tr><td>Nonverbal Delayed</td><td></td><td>0.12</td><td>0.26</td><td></td></tr>
<tr><td>Working Memory</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Digit Span Backward</td><td></td><td></td><td></td><td></td><td>0.44</td></tr>
<tr><td>Digit Span Total</td><td></td><td>0.31</td><td>0.64</td><td></td><td></td></tr>
<tr><td>DSST</td><td></td><td></td><td>0.82</td><td></td><td></td></tr>
<tr><td>Executive Functioning</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Stroop C-W</td><td></td><td>0.47</td><td>0.56</td><td rowspan="4">0.21</td><td>0.89</td></tr>
<tr><td>TMT B</td><td>0.55</td><td>0.68</td><td>0.59</td><td>0.65</td></tr>
<tr><td>WCST Per</td><td>0.46</td><td>0.12</td><td>0.35</td><td></td></tr>
<tr><td>WCST Cat</td><td></td><td>0.02</td><td>0.29</td><td></td></tr>
<tr><td>Verbal Ability</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>WAIS Vocabulary</td><td></td><td></td><td></td><td rowspan="3">0.52</td><td></td></tr>
<tr><td>Letter Fluency</td><td></td><td>0.60</td><td>0.46</td><td rowspan="2">0.62</td></tr>
<tr><td>Animal Fluency</td><td></td><td></td><td>0.41</td></tr>
<tr><td>Attention</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TMT A</td><td></td><td>0.53</td><td>0.40</td><td>0.38</td><td></td></tr>
<tr><td>Stroop W</td><td></td><td>0.23</td><td></td><td></td><td></td></tr>
<tr><td>CPT Comm.</td><td>0.51</td><td>0.76*/0.51**</td><td>0.55</td><td rowspan="2">0.52</td><td>0.64</td></tr>
<tr><td>CPT Omiss.</td><td>0.64</td><td>0.26*/0.65**</td><td>0.66</td><td></td></tr>
</table>

FSIQ = Full Scale IQ; VIQ = Verbal IQ; PIQ = Performance IQ; WRAT = Wide Range Achievement Test; Verbal memory = Trials from California Verbal Learning Test (CVLT), Rey Auditory Verbal Learning Test (RAVLT), and Hopkins Verbal Learning Test (HVLT); Nonverbal memory = trials from tests such as Visual Reproduction and Figure Recall; DSST = Digit Symbol Substitution Task; Stroop C-W = Stroop color word trial; TMT B = Trail Making Test, Part B; WCST Per = WCST Perseverative Responses; WCST Cat = WCST Categories Completed; TMT A = Trail Making Test, Part A; Stroop W = Stroop word reading trial; CPT = Continous Performance Test
*Traditional CPT
**Conners CPT

Table 4

Cluster Structure of the Barratt Impulsiveness Scale - 11

Cluster Name	Item	Item Content
BARGoWithFlow	V4	I am happy-go-lucky.
	V3	I make up my mind quickly.
BARProblemSolving	V23	I can only think about one problem at a time.
	V18	I get easily bored when solving thought problems.
	V15	I like to think about complex problems.
	V29	I like puzzles.
BARChange	V24	I change hobbies.
	V21	I change where I live.
	V16	I change jobs.
BARRestless	V28	I am restless at lectures or talks.
	V11	I "squirm" at plays or lectures.
BARThoughts	V26	I have outside thoughts when thinking.
	V6	I have "racing" thoughts.
BARImpulse	V19	I act on the spur of the moment.
	V17	I act "on impulse".
	V14	I say things without thinking.
	V2	I do things without thinking.
BARThinkCarefully	V20	I am a steady thinker.
	V12	I am a careful thinker.
BARConcentrate	V9	I concentrate easily.
	V8	I am self-controlled.
	V5	I don't "pay attention".
BARPlanning	V1	I plan tasks carefully.
	V7	I plan trips well ahead of time.
BARPlanning2	V30	I plan for the future.
	V13	I plan for job security.
	V10	I save regularly.
	V27	I am more interested in the present than the future.
BARSpending	V25	I spend or charge more than I earn.
	V22	I buy things on impulse.

Table 5

Cluster Structure of the Dickman Impulsivity Scale

Cluster Name	Item	Item Content
DCKDeliberation	V14	I'm good at careful reasoning
	V4	I enjoy working out problems slowly and carefully
	V22	Before making any important decision, I carefully weigh the pros and cons
	V23	I rarely get involved in projects without first considering the potential problems
DCKThinkQuickly	V20	People have admired me because I can think quickly
	V6	I would enjoy working at a job that required me to make a lot of split-second decisions
	V15	I like to take part in really fast-paced conversations, where you don't have much time to think before you speak
DCKActQuickly	V5	I am good at taking advantage of unexpected opportunities, where you have to do something immediately or lose your chance
	V19	Most of the time, I can put my thoughts into words very rapidly.
DCKActQuickly2	V2	I try to avoid activities where you have to act without much time to think first.
	V16	I like sports and games in which you have to choose your next move very quickly
DCKThinkSlowly	V8	I have often missed out on opportunities because I couldn't make up my mind fast enough
	V12	I don't like to do things quickly, even when I am doing something that is not very difficult
	V11	I am uncomfortable when I have to make up my mind rapidly
	V3	I don't like to make decisions quickly, even simple decisions, such as choosing what to wear, or what to have for dinner
DCKNotPlanning	V13	I frequently buy things without thinking about whether or not I can really afford them
	V17	Many times the plans I make don't work out because I haven't gone over them carefully enough in advance
	V10	I frequently make appointments without thinking about whether I will be able to keep them
DCKNonDeliberate	V7	I often make up my mind without taking the time to consider the situation from all angles.
	V1	Often, I don't spend enough time thinking over a situation before I act
DCKNoConsequences	V21	I will often say whatever comes into my head without thinking first
	V18	I often get into trouble because I don't think before I act
	V9	I often say and do things without considering the consequences

Table 6

Cluster Structure of the Eysenck Impulsiveness and Venturesomeness Items

Cluster Name	Item	Item Content
EYSMakeUpMind	V35	Do you usually make up your mind quickly?
	V33	Do you prefer to 'sleep on it' before making decisions?
EYSThinkCarefully	V30	Before making up your mind, do you consider all the advantages and disadvantages?
	V12	Do you usually think carefully before doing anything?
EYSShoutBack	V34	When people shout at you, do you shout back?
EYSNotPlanning	V25	Do you think an evening out is more successful if it is unplanned or arranged at the last moment?
	V17	Do you get so 'carried away' by new and exciting ideas, that you never think of possible snags?
EYSImpulse	V14	Do you often do things on the spur of the moment
	V10	Are you an impulsive person?
	V5	Do you often buy things on impulse?
EYSChangeMind	V29	Do you often change your interests?
EYSSelf-Check	V28	Do you usually work quickly, without bothering to check?
	V20	Do you need to use a lot of self-control to keep out of trouble?
	V23	Are you often surprised at people's reactions to what you do or say?
	V21	Would you agree that almost everything enjoyable is illegal or immoral?
	V16	Do you often get involved in things you later wish you could get out of?
EYSNotThinking	V15	Do you mostly speak without thinking things out?
	V6	Do you generally do and say things without stopping to think?
	V7	Do you often get into a jam because you do things without thinking?
EYSBrandLoyalty	V2	Usually do you prefer to stick to brands you know are reliable, to trying new ones on the chance of finding something better?
EYSDanger	V32	Would you be put off a job involving quite a bit of danger?
	V27	Would you enjoy fast driving?
	V13	Would you like to learn to fly an aeroplane?
EYSActivities1	V24	Would you enjoy the sensation of skiing very fast down a high mountain slope?
	V9	Do you like diving off the highboard?
	V4	Would you enjoy parachute jumping?
	V1	Would you enjoy water skiing?
EYSActivities2	V31	Would you like to go pot-holing?
	V26	Would you like to go scuba diving?
EYSDangerAvoid	V18	Do you find it hard to understand people who risk their necks climbing mountains?
	V8	Do you think hitch-hiking is too dangerous a way to travel?
EYSFrightening	V19	Do you sometimes like doing things that are a bit frightening?
	V3	Do you quite enjoy taking risks?
	V11	Do you welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional?
EYSWater	V22	Generally do you prefer to enter cold sea water gradually, to diving or jumping straight in?

Table 7

Cluster Structure of the MPQ Control Scale

Cluster Name	Item	Item Content
MPQOranization	V10	People say that I am well organized (that I do things in a systematic manner).
	V9	I plan and organize my work in detail.
MPQPredictable	V13	Before I get into a new situation I like to find out what to expect from it.
	V12	Whenever I go out to have fun I like to have a pretty good idea of what I'm going to do.
	V4	I don't like to start a project until I know exactly how to do it.
MPQSpontaneous	V24	I often like to do the first thing that comes to my mind.
	V23	People consider me a rather freewheeling and spontaneous person.
	V19	I often act on the spur of the moment.
	V15	I often act without thinking.
MPQCareless	V20	I am often not as cautious as I should be.
	V17	I am more likely to do things quickly and carelessly rather than slowly and carefully.
MPQCautious	V6	I almost never do anything reckless.
	V11	I am a cautious person.
MPQMoney	V18	When I need to buy something, I usually go get it without thinking what more I may soon need from the same store.
	V1	I keep close track of where my money goes.
MPQNoPlan	V22	I generally do not like to have detailed plans.
	V16	I often prefer to play things by ear rather than to plan ahead.
MPQProjects	V14	I often stop one thing before completing it and start another.
	V21	I often start projects with little idea of what the end result will be.
MPQThink	V8	I usually think very carefully before I make up my mind.
	V2	When I have to make a decision, I usually take time to consider and weigh all possibilities.
	V3	I like to stop and think things over before I do them.
MPQRational	V7	I tend to value and take a rational, sensible approach to things.
	V5	I am very levelheaded, usually have both feet on the ground.

Table 8

Cluster Structure of the Chapman Physical Anhedonia Scale

Cluster Name	Item	Item Content
PhASex	V53	Sex is the most intensely enjoyable thing in life.
	V40	Sex is okay, but not as much fun as most people claim it is.
	V1	I have usually found lovemaking to be intensely pleasurable.
PhAOrgan	V37	The sound of organ music has often thrilled me.
	V6	I have always found organ music dull and unexciting.
PhASeldom	V10	On hearing a good song, I have seldom wanted to sing along with it.
	V9	I have seldom enjoyed any kind of sexual experience.
PhASinging	V58	When I'm feeling a little sad, singing has often made me feel happier.
	V42	I have seldom cared to sing in the shower.
PhAWalking	V60	A brisk walk has sometimes made me feel good all over.
	V45	After a busy day, a slow walk has often felt relaxing.
	V34	I have often found walks to be relaxing and enjoyable.
PhAMassage	V57	It has often felt good to massage my muscles when they are tired or sore.
	V18	I have always loved having my back massaged.
PhABarefoot	V44	On seeing a soft, thick carpet, I have sometimes had the impulse to take off my shoes and walk barefoot on it.
	V27	I never have the desire to take off my shoes and walk through a puddle barefoot.
PhASmellFlowers	V52	When I pass by flowers, I have often stopped to smell them.
PhAPetting	V36	I like playing with and petting soft little kittens or puppies.
	V3	I have often enjoyed the feel of silk, velvet, or fur.
PhACozy	V61	I have been fascinated with the dancing of flames in a fireplace.
	V35	The sound of the rain falling on the roof has made me feel snug and secure.
PhAStrength	V4	I have sometimes enjoyed feeling the strength in my muscles.
PhASeeFeel	V23	When I have seen a statue, I have had the urge to feel it.
PhADelayGrat	V2	When eating a favorite food, I have often tried to eat slowly to make it last longer.
PhABodySensation	V30	I have often enjoyed receiving a strong, warm handshake.
	V59	A good soap lather when I'm bathing has sometimes soothed and refreshed me.
PhADancing	V41	I have sometimes danced by myself just to feel my body move with the music.
	V5	Dancing, or the idea of it, has always seemed dull to me.
PhALeisure	V56	The sounds of a parade have never excited me.
	V13	The sound of rustling leaves has never much pleased me.
	V21	The warmth of an open fireplace hasn't especially soothed and calmed me.
	V49	I have usually found soft music boring rather than relaxing.
	V54	I think that flying a kite is silly.
	V47	The beauty of sunsets is greatly overrated.

PhABeauty	V38	Beautiful scenery has been a great delight to me.
	V22	Poets always exaggerate the beauty and joys of nature.
	V17	Flowers aren't as beautiful as many people claim.
PhAActivities	V25	I don't understand why people enjoy looking at the stars at night.
	V8	I have had very little fun from physical activities like walking, swimming, or sports.
	V32	I have never found a thunderstorm exhilarating.
	V11	I have always hated the feeling of exhaustion that comes from vigorous activity.
	V50	I have usually finished my bath or shower as quickly as possible just to get it over with.
	V15	There just are not many things that I have ever really enjoyed doing.
	V16	I don't know why some people are so interested in music.
PhAViews	V46	The bright lights of a city are exciting to look at.
	V33	Standing on a high place and looking out over the view is very exciting.
	V39	The first winter snowfall has often looked pretty to me.
PhARides	V19	I never wanted to go on any of the rides at an amusement park.
PhASmell	V51	The smell of dinner cooking has hardly ever aroused my appetite.
	V29	When I have walked by a bakery, the smell of fresh bread has often made me hungry.
PhAFood	V28	I've never cared much about the texture of food.
	V24	I have always had a number of favorite foods.
	V7	The taste of food has always been important to me.
	V43	One food tastes as good as another to me.
	V12	The color that things are painted has seldom mattered to me.
PhATouch	V31	I have often felt uncomfortable when my friends touch me.
	V48	It has always made me feel good when someone I care about reaches out to touch me.
PhANewFood	V26	I have had very little desire to try new kinds of foods.
	V20	Trying new foods is something I have always enjoyed.
PhASunbathe	V55	I've never cared to sunbathe; it just makes me hot.
	V14	Sunbathing isn't really more fun than lying down indoors.

Table 9

Cluster Structure of the Chapman Social Anhedonia Scale

Cluster Name	Item	Item Content
SoAPrivacy	V33	There are things that are more important to me than privacy.
SoAIntenseRel	V39	My relationships with other people never get very intense.
	V9	I sometimes become deeply attached to people I spend a lot of time with.
SoAOthers	V30	It made me sad to see all my high school friends go their separate ways when high school was over.
	V12	When someone close to me is depressed, it brings me down also.
SoAPets	V40	In many ways, I prefer the company of pets to the company of people
SoAAlone	V35	I could be happy living all alone in a cabin in the woods or mountains.
	V27	I am usually content to just sit alone, thinking and daydreaming.
SoABeWithOthers	V36	If given the choice, I would much rather be with others than be alone.
	V8	Although there are things that I enjoy doing by myself, I usually seem to have more fun when I do things with other people.
	V4	A car ride is much more enjoyable if someone is with me.
SoATalkToFriend	V31	I have often found it hard to resist talking to a good friend, even when I have other things to do.
SoAFriends	V20	When I move to a new city, I feel a strong need to make new friends.
	V19	Knowing that I have friends who care about me gives me a sense of security.
	V15	Just being with friends can make me feel really good.
	V7	I have always enjoyed looking at photographs of friends.
SoATalktoOthers	V16	When things are bothering me, I like to talk to other people about it.
	V5	I like to make long distance phone calls to friends and relatives.
SoAEmpathy	V25	When others try to tell me about their problems and hang-ups, I usually listen with interest and attention.
	V11	When things are going really good for my close friends, it makes me feel good too.
	V24	I feel pleased and gratified as I learn more and more about the emotional life of my friends.
SoASing	V18	It's fun to sing with other people.
SoAKnocking	V14	When I am alone, I often resent people telephoning me or knocking on my door.
SoAExpectation	V37	I find that people too often assume that their daily activities and opinions will be interesting to me.
	V23	People often expect me to spend more time talking with them than I would like.
SoANoConnection	V22	Although I know I should have affection for certain people, I don't really feel it.
	V10	People sometimes think that I am shy when I really just want to be left alone.
SoAAlone2	V38	I don't really feel very close to my friends.
	V17	I prefer hobbies and leisure activities that do not involve other people.
	V32	Making new friends isn't worth the energy it takes.
	V3	I prefer watching television to going out with other people.
SoAAvoidRelationships	V34	People who try to get to know me better usually give up after awhile.

	V28	I'm much too independent to really get involved with other people.
	V26	I never had really close friends in high school.
SoAEmotions	V21	People are usually better off if they stay aloof from emotional involvements with most others.
	V13	My emotional responses seem very different from those of other people.
SoACloseFriends	V2	I attach very little importance to having close friends.
	V1	Having close friends is not as important as many people say.
SoAChildren	V6	Playing with children is a real chore.
SoADiscussions	V29	There are few things more tiring than to have a long, personal discussion with someone.

Table 10

Cluster Structure of the Chapman Perceptual Aberration Scale

Cluster Name	Item	Item Content
PeABoundaries	V25	The boundaries of my body always seem clear.
PeAChangeSizeVisual	V24	I have never felt that my arms or legs have momentarily grown in size.
	V13	I have never had the passing feeling that my arms or legs have become longer than usual.
	V6	My hands or feet have never seemed far away.
PeAChangeShape	V19	Occasionally it has seemed as if my body had taken on the appearance of another person's body.
	V29	I have had the momentary feeling that my body has become misshapen.
PeAChangeVision	V3	Sometimes people whom I know well begin to look like strangers.
	V20	Ordinary colors sometimes seem much too bright to me.
PeAChangePhysical	V28	I can remember when it seemed as though one of my limbs took on an unusual shape.
	V27	Sometimes I have had the feeling that a part of my body is larger than it usually is.
	V17	Sometimes part of my body has seemed smaller than it usually is.
	V12	Now and then, when I look in the mirror, my face seems quite different than usual.
PeABodyIntegrity	V33	Parts of my body occasionally seem dead or unreal.
	V16	I have felt as though my head or limbs were somehow not my own.
	V22	I have sometimes had the feeling that one of my arms or legs is disconnected from the rest of my body.
	V1	I sometimes have had the feeling that some parts of my body are not attached to the same person.
PeAUniteWithOther	V26	Sometimes I have had feelings that I am united with an object near me.
	V9	I have felt that my body and another person's body were one and the same.
PeAAttached	V30	I have had the momentary feeling that the things I touch remain attached to my body.
PeAOutsideInside	V10	I have felt that something outside my body was a part of my body.
PeAStrangeVisual	V15	Sometimes when I look at things like tables and chairs, they seem strange.
PeANotExist	V2	Occasionally I have felt as though my body did not exist.
	V32	I sometimes have to touch myself to make sure I'm still there.
PeABodyOfOther	V34	At times I have wondered if my body was really my own.
	V8	Sometimes I have felt that I could not distinguish my body from other objects around me.
PeABodyNotOwn	V14	I have sometimes felt that some part of my body no longer belongs to me.
	V7	I have sometimes felt confused as to whether my body was really my own.
PeAMelting	V23	It has seemed at times as if my body was melting into my surroundings.
PeAPerception	V35	For several days at a time I have had such a heightened awareness of sights and sounds that I cannot shut them out.
	V31	Sometimes I feel like everything around me is tilting.
PeAAbnormal	V11	I sometimes have had the feeling that my body is abnormal.

PeADecay	V21	Sometimes I have had a passing thought that some part of my body was rotting away.
	V18	I have sometimes had the feeling that my body is decaying inside.
PeAAcuteSenses	V5	Often I have a day when indoor lights seem so bright that they bother my eyes.
	V4	My hearing is sometimes so sensitive that ordinary sounds become uncomfortable.

Table 11

Exploratory Factor Analysis of Barratt Impulsiveness Scale Parcels

	1	2
BARGoWithFlow		
BARProblemSolving	0.33	0.36
BARChange		0.42
BARRestless		**0.47**
BARThoughts		**0.64**
BARImpulse	-0.21	**0.58**
BARThinkCarefully	**0.63**	
BARConcentrate	**0.52**	
BARPlanning	**0.57**	
BARPlanning2	**0.58**	
BARSpending	-0.22	0.33

Table 12

Exploratory Factor Analysis of Dickman Impulsiveness Inventory Parcels

	1	2
DCKDeliberation	0.42	
DCKThinkQuickly		**0.58**
DCKActQuickly		**0.49**
DCKActQuickly2		**0.55**
DCKThinkSlowly		**0.62**
DCKNotPlanning	**0.61**	
DCKNonDeliberate	**0.77**	
DCKNoConsequences	**0.76**	

Table 13

Exploratory Factor Analysis Of Eysenck Impulsiveness and Venturesomeness Item Parcels

	1	2
EYSMakeUpMind		0.24
EYSThinkCarefully		0.41
EYSShoutBack		0.28
EYSNotPlanning		**0.48**
EYSImpulse		**0.66**
EYSChangeMind		0.44
EYSSelf-Check		**0.64**
EYSNotThinking		**0.65**
EYSBrandLoyalty		
EYSDanger	**0.68**	
EYSActivities1	**0.78**	
EYSActivities2	**0.66**	
EYSDangerAvoid	**0.49**	
EYSFrightening	**0.60**	
EYSWater	0.38	

Table 14

Exploratory Factor Analysis of MPQ Control Scale Parcels

	1
MPQOranization	**<u>0.52</u>**
MPQPredictable	**<u>0.45</u>**
MPQSpontaneous	**<u>0.69</u>**
MPQCareless	**<u>0.62</u>**
MPQCautious	**<u>0.57</u>**
MPQMoney	**<u>0.49</u>**
MPQNoPlan	**<u>0.60</u>**
MPQProjects	**<u>0.47</u>**
MPQThink	**<u>0.58</u>**
MPQRational	**<u>0.45</u>**

Table 15

Exploratory Factor Analysis of Chapman Physical Anhedonia Scale Parcels

	1
PhASex	
PhAOrgan	0.26
PhASeldom	0.22
PhASinging	0.38
PhAWalking	**0.47**
PhAMassage	0.32
PhABarefoot	
PhASmellFlowers	0.38
PhAPetting	**0.47**
PhACozy	**0.53**
PhAStrength	0.30
PhASeeFeel	0.27
PhADelayGrat	0.38
PhABodySensation	0.43
PhADancing	**0.47**
PhALeisure	**0.52**
PhABeauty	**0.45**
PhAActivities	0.37
PhAViews	0.44
PhARides	
PhASmell	0.33
PhAFood	0.42
PhATouch	0.32
PhANewFood	0.29
PhASunbathe	0.24

Table 16

Exploratory Factor Analysis of Chapman Social Anhedonia Scale Parcels

	1
SoAPrivacy	0.21
SoAIntenseRel	0.28
SoAOthers	
SoAPets	0.34
SoAAlone	0.36
SoABeWithOthers	0.44
SoATalkToFriend	0.22
SoAFriends	**<u>0.45</u>**
SoATalktoOthers	0.42
SoAEmpathy	0.41
SoASing	0.29
SoAKnocking	0.41
SoAExpectation	**<u>0.50</u>**
SoANoConnection	**<u>0.55</u>**
SoAAlone2	**<u>0.71</u>**
SoAAvoidRelationships	**<u>0.57</u>**
SoAEmotions	**<u>0.54</u>**
SoACloseFriends	**<u>0.57</u>**
SoAChildren	0.27
SoADiscussions	0.30

Table 17

Exploratory Factor Analysis of Chapman Perceptual Aberration Scale Parcels

	1
PeABoundaries	0.24
PeAChangeSizeVisual	
PeAChangeShape	0.35
PeAChangeVision	**0.48**
PeAChangePhysical	**0.60**
PeABodyIntegrity	**0.57**
PeAUniteWithOther	**0.47**
PeAAttached	0.42
PeAOutsideInside	**0.49**
PeAStrangeVisual	**0.50**
PeANotExist	**0.65**
PeABodyOfOther	**0.55**
PeABodyNotOwn	**0.54**
PeAMelting	**0.48**
PeAPerception	**0.55**
PeAAbnormal	0.43
PeADecay	**0.61**
PeAAcuteSenses	0.39

Table 18

Exploratory Factor Analysis of High-Loading Impulsivity Parcels

	1	2
BARThinkCarefully	**-0.49**	
BARConcentrate	-0.33	
BARPlanning	**-0.42**	
BARPlanning2	-0.35	
BARRestless	0.26	
BARThoughts	0.32	
BARImpulse	**0.68**	
DCKNotPlanning	**0.64**	
DCKNonDeliberate	**0.70**	
DCKNoConsequence	**0.77**	
DCKThinkQuickly		**0.46**
DCKActQuickly		0.35
DCKActQuickly2		**0.53**
DKCThinkSlowly		0.39
EYSDanger		**0.62**
EYSActivities1		**0.63**
EYSActivities2		**0.56**
EYSDangerAvoid		**0.48**
EYSFrightening		**0.65**
EYSNotPlanning	**0.47**	
EYSImpulse	**0.65**	
EYSSelfCheck	**0.62**	
EYSNotThinking	**0.72**	
MPQOrganization	**0.43**	
MPQPredictable	0.21	0.30
MPQSpontaneous	**0.64**	0.29
MPQCareless	**0.63**	
MPQCautious	0.34	0.39
MPQMoney	**0.48**	
MPQNoPlan	**0.47**	
MPQProjects	**0.47**	
MPQThink	**0.50**	
MPQRational	**0.42**	

Table 19

Exploratory Factor Analysis of High-Loading Schizotypy Parcels

	1	2	3
PEAChangeVision	0.32	0.31	
PEAChangePhysical	**0.45**	0.25	
PEABodyIntegrity	**0.61**		
PEAUniteWithOther	**0.47**		
PEAOutside	**0.59**		
PEAStrangeVisual	**0.50**		
PEANotExist	**0.68**		
PEABodyOfOther	**0.61**		
PEABodyNotOwn	**0.58**		
PEAMelting	**0.48**		
PEAPerception	**0.50**		
PEADecay	**0.54**		
PHAWalking			**0.49**
PHAPetting			**0.45**
PHACozy		-0.20	**0.57**
PHADancing			**0.42**
PHALeisure			**0.48**
PHABeauty		0.20	**0.42**
SOAFriends		0.33	0.27
SOAExpectation		**0.56**	
SOANoConnection		**0.60**	
SOAAlone		**0.69**	
SOAAvoidRelationships		**0.61**	
SOAEmotions		**0.56**	
SOACloseFriends		**0.55**	

Table 20

Multiple Regression of Impulsivity Standardized Weighed Sum Score on Executive Functioning Moderated by Patient Status

Model	B	Std. Error	β	t	p-value
Constant	0.139	0.029		4.721	0.000
Pt. Status	-1.545	0.133	-0.442	-11.649	0.000
Impulsivity	-0.001	0.005	-0.007	-0.201	0.840
Pt. Status * Impulsivity	0.000	0.013	-0.001	-0.026	0.979

Notes. R Squared = 0.199 (p = 0.000)

Table 21

Multiple Regression of Venturesomeness Standardized Weighed Sum Score on Executive Functioning Moderated by Patient Status

Model	B	Std. Error	β	t	p-value
Constant	0.141	0.029		4.837	0.000
Pt. Status	-1.546	0.098	-0.443	-15.837	0.000
Venturesomeness	0.032	0.013	0.070	2.395	0.017
Pt. Status * Venturesomeness	-0.075	0.043	-0.052	-1.768	0.077

Notes. R Squared = 0.204 (p < 0.001)

Table 22

Multiple Regression of Physical Anhedonia Standardized Weighed Sum Score on Working Memory Moderated by Patient Status

Model	B	Std. Error	β	t	p-value
Constant	10.167	0.055		185.645	0.000
Pt. Status	-1.083	0.194	-0.183	-5.579	0.000
Physical Anhedonia	-0.078	0.033	-0.076	-2.390	0.017
Pt. Status * Physical Anhedonia	-0.296	0.107	-0.096	-2.775	0.006

Notes. R Squared = 0.072 (p < 0.001)

Table 23

Multiple Regression of Social Anhedonia Standardized Weighed Sum Score on Working Memory Moderated by Patient Status

Model	B	Std. Error	β	t	p-value
Constant	10.159	0.055		183.387	0.000
Pt. Status	-1.215	0.232	-0.206	-5.232	0.000
Social Anhedonia	-0.054	0.024	-0.077	-2.251	0.025
Pt. Status * Social Anhedonia	-0.010	0.065	-0.006	-0.150	0.880

Notes. R Squared = 0.061 (p < 0.001)

Table 24

Multiple Regression of Perceptual Aberration Standardized Weighed Sum Score on Working Memory Moderated by Patient Status

Model	B	Std. Error	β	t	p-value
Constant	10.157	0.056		182.936	0.000
Pt. Status	-1.15	0.202	-0.189	-5.530	0.000
Perceptual Aberration	-0.037	0.018	-0.084	-2.038	0.042
Pt. Status * Perceptual Aberration	-0.023	0.029	-0.034	-0.784	0.433

Notes. R Squared = 0.060 ($p < 0.001$)

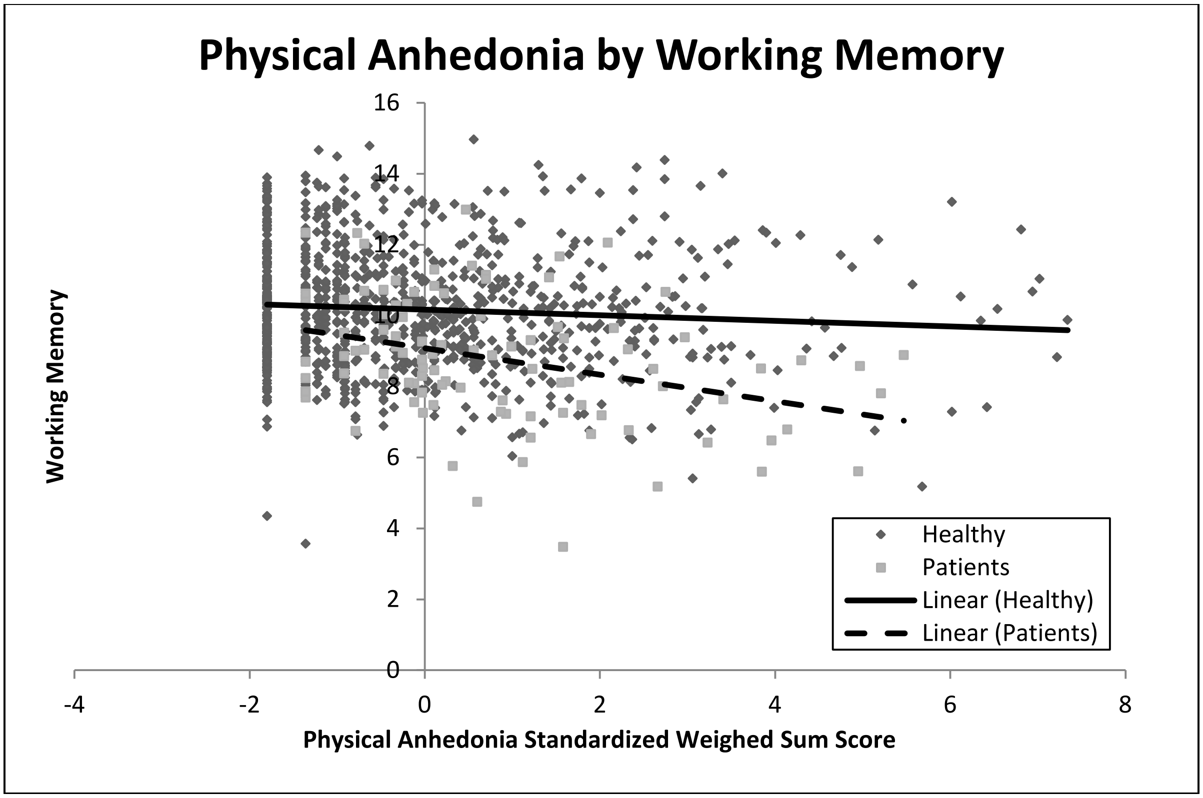

*Figure 1.*Physical Anhedonia by Working Memory. This figure shows the relationship between physical anhedonia standardized weighed sum score and working memory composite score in individuals with schizophrenia and bipolar disorder as well as community participants.

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