Working Memory and Executive Functioning Impairment as Endophenotypes of Schizophrenia Spectrum Disorders

---

A dissertation

presented to

The College of Graduate and Professional Studies

Department of Psychology

Indiana State University

Terre Haute, Indiana

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Psychology

---

by

Carina A. Iati

August 2013

© Carina A. Iati 2012

COMMITTEE MEMBERS

Committee Chair: P. Kevin Bolinskey, Ph.D.

Associate Professor of Psychology

Indiana State University

Committee Member: June Sprock, Ph.D.

Professor of Psychology

Indiana State University

Committee Member: Patrick R. Bennett, Ph.D.

Associate Professor of Psychology

Indiana State University

ABSTRACT

Evidence indicates that impairments in working memory and executive functioning exist in individuals who have decompensated into schizophrenia, as well as their genetic relatives. Few studies, however, have examined whether these impairments function as premorbid indicators of vulnerability to schizophrenia-related disorders in the absence of genetic relatedness for risk determination. According to Meehl's (1962, 1990) model of schizotypy individuals vulnerable to schizophrenia-related disorders evidence subtle symptoms of vulnerability, referred to as *endophenotypes*, regardless of whether eventual decompensation occurs. The present study represents a cross-sectional portion of a larger longitudinal study, and investigates whether individuals who demonstrate an elevated risk for future development of schizophrenia spectrum disorders also demonstrate these impairments compared to a normal-risk group in a sample of college students. Risk status was determined by participants' Wisconsin Schizotypy Scale (WSS) scores. Working memory subtests from the Wechsler Adult Intelligence Scale–IV (WAIS-IV) and Wechsler Memory Scale-IV (WMS-IV) were compared across individuals determined to be at high risk (psychometric schizotypes; PS) and a matched comparison (MC) sample. Executive functioning, as measured by the Wisconsin Card Sorting Task (WCST), was also compared across these groups. It was hypothesized that schizotypes would exhibit impairment in both of these abilities. Additionally, it was hypothesized that a linear relationship would exist between level of deviancy demonstrated on the WSS and the level of impairment demonstrated on executive functioning and working memory tasks. Results failed

to support the hypothesis that aggregate working memory or executive functioning deficits were significantly related to schizotypy. However, performance on the WMS-IV Visual Working Memory Index (VWMI) and the Spatial Addition subtest of this measure indicated impaired performance by PS participants compared to the MC group. Similarly, this investigation failed to find support for a linear relationship between level of impairment and deviance on *PerAb* and *MagId* WSS subscales. However, scores on the *SocAnh* scale did demonstrate an inverse relationship with performance on the VWMI. Further analyses which grouped the PS participants by symptom presentation, revealed that individuals exhibiting a negative symptom presentation, as indicated by deviant scores on the *SocAnh* scale, demonstrated impairment in visual working memory in comparison to both the MC group and their *Per-Mag* counterparts who exhibited more positive symptoms. This result is in agreement previous investigations that have specified visual working memory impairment as being related to negative symptom presentation (Cameron, 2002; Park et al., 2003).

These results may be influenced by characteristics of the present sample, as the majority of individuals who reported symptoms did so on negative symptom dimensions, with only 6 individuals reporting positive symptomology. Negative symptom dimensions have been proposed to be related to working memory impairment (Gooding & Tallent, 2002), whereas positive symptoms have been proposed to be related to impairment in executive functioning (Donohoe et al., 2006; Lenzenweger & Korfine, 1994). The relative lack of individuals with positive symptom presentation in the current sample likely led to the lack of any notable results with regard to executive functioning.

Results of this investigation aid our understanding of the course of schizophrenia spectrum disorders, and join the broad body of literature investigating candidate

endophenotypes. Future directions for related research include continued investigation into the differences between verbal and visual working memory as related to schizophrenia spectrum disorders, investigation of the present candidate endophenotypes alongside other proposed markers of liability, and longitudinal investigation to determine whether individuals possessing candidate endophenotypes exhibit a greater number of schizophrenia spectrum symptoms.

ACKNOWLEDGMENTS

This dissertation is the culmination of years of hard work, and has been made possible through the support of the Psychology Department at Indiana State University. I would also like to thank the Indiana State University Graduate Student Research Fund, for providing partial grant funding for this project.

This dissertation is dedicated to the memory of my grandmothers, Rita Iati, and Jeanne Hurley; both of whom modeled for me the art of being an intelligent, kind, and elegantly stubborn woman, an art I hope to one day perfect, myself.

Many people have been part of making this project possible, whether in emotional support, academic guidance, or both. First and foremost, thank you to my parents, Michael Iati and Kathie Shriver, for all of your encouragement and support. Thank you for supporting me in pursuing my dream, even though it took me far from home. Thank you for teaching me to value knowledge, education, and curiosity. Thank you for always expecting the best from me, because now that is what I expect from myself. I would also like to thank my amazing, quirky family for being the wonderful people they are and supporting me in this. Especially, thank you to my grandfather, my brother Mario, and my cousin Marisa, who have each played an essential role in making me who I am.

Thank you to my wonderful friends, who will probably never read this, but I want your names to be forever linked to such an important part of my life. Thank you: Nora Kelly, Emily Paull, Diego de los Rios, Karina Havrilla, Beth Floyd, Erin Greene and Tim Neary. Thank you

for being there for me, even when I was under-slept, over-caffeinated, and generally cantankerous. You will never know how instrumental you were in making this possible. Without you all to remind me who I am, I may have gotten lost in this process. Thank you for understanding how important this is to me, even though it has taken me away from you at times. You get me back now.

Although he cannot read, I feel that I need to take this opportunity to thank my four-legged support system, Batman. Without him to keep my lap warm, enforce breaks by lying across my keyboard, and provide consistent comic-relief this would have been much harder. There is a big "Thank You" bag of catnip coming your way, buddy!

Thank you to my fellow lab members: Helen Hunter, Jon Novi, Alison Petrow and Dan Hudak, who have spent many late nights in the lab helping to collect this (and much more) data. Your contributions to this cannot be measured. I look forward to many more collaborations with all of you.

Thank you to my committee members, Dr. June Sprock and Dr. Patrick Bennett for lending your time and expertise to make this project the best it could possibly be. I have so much respect for you both. I am fortunate to have such talented minds contributing to my work.

Finally, thank you to my committee chair Dr. Kevin Bolinskey. Without you none of this would have been possible. Your faith in me has never shaken, even when mine did. I am truly grateful to have a mentor with just the blend of empathy, humor and tough-love to keep me moving forward. I cannot thank you enough for all time and effort you have put into this project. I am unbelievably proud to say I am a student of yours. I have so much left to learn from you.

TABLE OF CONTENTS

COMMITTEE MEMBERS ii

ABSTRACT iii

ACKNOWLEDGMENTS vi

TABLE OF CONTENTS viii

LIST OF TABLES xii

CHAPTER 1: Introduction 1

CHAPTER 2: Review of Related Literature 3

- Conceptual History of Schizophrenia 3
- Meehl's Model of Schizotypy 5
  - Schizotypy as liability to schizophrenia 6
  - Assessment of liability 8
- The Endophenotype Concept 9
  - Personality as an endophenotype of schizophrenia 11
  - Executive function and working memory as candidate endophenotypes. 11
  - Executive functioning. 12
  - Working memory. 14
- Wisconsin Schizotypy Scales (WSS) 16

Measuring Cognitive Endophenotypes 19
Wisconsin Card Sorting Task 19
WMS-IV and WAIS-IV 21
Other Proposed Markers of Liability to Schizophrenia 22
Rationale for the Present Study 22
Improved conceptualization of endophenotypes 22
Early intervention 24
Summary of Present Study 25
Hypotheses 26
CHAPTER 3: Methods 27
Overview and Design 27
Power Analysis 27
Participants 28
Initial Participant Pool 28
Final Sample 29
Measures 31
WSS 31
WAIS-IV 32
WMS-IV 33
WCST 34
Procedure 35

CHAPTER 4: Results 38

Comparisons of PS and MC participants 38

Global Indices. 38

Subscale analyses. 42

Correlations. 44

Comparisons of *SocAnh* and *Per-Mag* participants 44

Global Indices. 44

Subscale analyses. 47

Comparison of *SocAnh* and MC participants 49

Global Indices. 49

Subscale analyses. 51

Comparison of *Per-Mag* and MC participants 53

Global indices. 53

Subscale analyses. 55

CHAPTER 5: Discussion 58

Working Memory 58

Executive functioning 61

Strengths of the current study 63

Limitations of the current study 64

Future Directions 64

Summary 66

REFERENCES 68

APPENDIX A: *Means and Standard Deviations of Wisconsin Schizotypy Scales* 79

APPENDIX B: *Public License Image Similar to Computer Presentation of WCST*.....81

APPENDIX C: *Informed Consent for Phase I* 83

APPENDIX D: *Informed Consent For Phase II*.....88

LIST OF TABLES

Table 1: *Pearson Correlations Between Dependent Variables*. 38

Table 2: *Univariate statistics for parent scales by MC and PS group*. 40

Table 3: *Univariate statistics for Wechsler subscales by MC and PS group*. 42

Table 4: *Correlations for target variables with Wisconsin Schizotypy Scales*. 44

Table 5: *Univariate statistics for SocAnh and Per-Mag groups on parent scales*. 45

Table 6: *Univariate statistics for SocAnh and Per-Mag groups for Wechsler subscales*.....47

Table 7: *Univariate statistics for MC and SocAnh groups on parent scales*.....49

Table 8: *Univariate statistics for MC and SocAnh groups for Wechsler subscales*.. 51

Table 9: *Univariate statistics for MC and Per-Mag groups on parent scales*.....53

Table 10: *Univariate statistics for MC and Per-Mag groups for Wechsler subscales*.....56

CHAPTER 1

Introduction

Schizophrenia is a mental illness characterized by an inability to relate meaningfully to reality. Although individual presentations of the disorder may vary greatly, individuals with the disorder commonly experience sensory disturbances in the form of hallucinations, abnormalities in thought patterns in the form of delusional beliefs, and disorganized behavior and speech (APA, 2000). With the severe nature of its presentation, the pervasiveness of symptoms, and the resultant level of impairment in functioning, schizophrenia is often regarded as one of the most severe and persistent mental disorders. In recent years, evidence has demonstrated a strong genetic basis to the disorder, as well as a relationship to other less-severe disorders with similar qualities of presentation (APA, 2000). Following from these discoveries, an emphasis has been placed on finding and understanding risk factors and early markers of schizophrenia related disturbance in order to improve early identification efforts, treatment interventions and our overall understanding of the disorder.

The goal of the present study is to increase our understanding of the cognitive deficits in working memory and executive functioning that are associated with increased liability to schizophrenia. Meehl (1962, 1990) suggested that individuals at increased liability for the disorder will express subtle signs and symptoms, such as deficits in working memory and

executive functioning. Such indicators of liability have been termed *endophenotypes*, or intermediate phenotypes (Gottesman & Gould, 2003). Available evidence supports working memory and executive functioning as endophenotypes of schizophrenia through the demonstration that these deficits exist in the relatives of individuals with schizophrenia, with greater deficits occurring among those of closer genetic relatedness to the affected individual (Barch, Csernansky, Conturo & Snyder, 2002; de la Serna, et al, 2010; Dickinson, Ragland, Gold & Gur, 2008; Eastvold, Heathon & Cadenhead, 2007; Horan et al., 2008; O'Connor et al., 2009). Although, as Meehl noted, the single best predictor of developing schizophrenia remains having an identical twin with the disorder, Chapman and Chapman (1985) reported that 45% of individuals determined to be at risk via psychometric means had no family history of psychosis. Thus, although most studies continue to rely on genetic relatedness to determine risk, this reliance may lead researchers to overlook a significant subset of individuals having increased liability, but no family history of the disorder. Knowledge about endophenotypes may be helpful in the development of more targeted preventative interventions and a more accurate identification of individuals at increased liability for the disorder.

The present study addresses two candidate cognitive endophenotypes, working memory and executive functioning impairment, and hypothesizes that individuals found to score in the deviant range on psychometric indicators of schizotypy (psychometric schizotypes; PS) will exhibit working memory and executive functioning deficits in relation to a matched comparison (MC) group. It is further hypothesized that there will be a positive linear relationship between level of deviancy demonstrated on the WSS and the level of impairment demonstrated on executive functioning and working memory tasks.

CHAPTER 2

Review of Related Literature

Conceptual History of Schizophrenia

Schizophrenia is a debilitating brain disorder that has inspired a great deal of research on treatments, prevention, and improved understanding of the illness. The lifetime prevalence rate for schizophrenia is estimated to be approximately one percent among adults in the general population, which makes it a relatively rare disorder. Schizophrenia appears to be a relatively heterogeneous construct that exists on a spectrum which includes schizoaffective disorder, as well as schizotypal, schizoid, paranoid, and avoidant personality disorders (American Psychiatric Association [APA], 2000). Thus, individuals who do not express diagnosable symptoms of schizophrenia may actually have a related disorder, such that the genuine base rate of disorders on the schizophrenia spectrum would be much higher.

Although the conceptualization of schizophrenia has changed over time, the distinctive symptoms of the disorder have remained relatively stable. Kraepelin (1909, 1971) provided the first working description of the disorder and referred to the symptom cluster characteristic of schizophrenia as *dementia praecox*, as individuals with the disorder often displayed symptoms similar to dementia, but were significantly younger than the average age of onset for dementia. Kraepelin also noted that symptoms appeared to aggregate within families, so that relatives of

individuals with the disorder exhibited a number of anomalies including eccentric personality. He asserted that dementia praecox entailed a loss of unity among psychic functions resulting in impairment in thinking, feeling and acting.

Bleuler (1911/1950), however, argued that the term *dementia praecox* was not descriptive of the disorder. He noted that individuals with the condition did not demonstrate the traditional symptoms of dementia, nor did they necessarily exhibit the steady deterioration typical of that disorder. Instead, he used the term *schizophrenia* to describe the splitting of the psychic functions within the person. He also noted that individuals who developed the disorder tended to have idiosyncrasies of personality from an early age. He noted that these individuals tended to withdraw from others and prefer seclusion, as well as having a history of having stood out from other children.

Bleuler (1911/1950) later extended the concept of dementia praecox to include a latent version of the disorder. He asserted that the latent version was the most common form of the disorder, but that individuals with this form of the disorder rarely presented for treatment. He suggested that individuals with the latent form will express all of the symptoms, albeit far more subtly, seen in the more severe forms of the disorder.

Rado (1953) was responsible for coining the term *schizotype* as shorthand for the schizophrenic phenotype. The term was conceptualized to describe the inability to experience pleasure, and the unconventional interpretation of reality that these individuals demonstrate (Millon, 2004). Rado did not consider the pattern of behavior to be inevitably fixed, but suggested that the impairment could move among four stages: compensation, decompensation, disintegrated and deteriorated; thus, Rado seemed to acknowledge a continuum of severity within the construct.

Meehl's Model of Schizotypy

Meehl (1962, 1990) proposed a model of schizophrenia based on the notion that a single gene is responsible for the development of schizophrenia. He asserted that genetic influences on the brain during development result in faulty coding and specific types of neurological dysfunction. He referred to this dysfunction as *slippage*, which he asserted also manifested itself in behavioral counterparts on a more molar level. It is these behavioral manifestations of slippage that are the symptoms of schizophrenia.

Meehl (1962, 1990) labeled the genetic predisposition to schizophrenia as schizotaxia and asserted that as much as 10% of the population possesses this predisposition. Schizotaxia is an abnormality in brain function, characterized by cognitive slippage. This slippage may not be behaviorally observable in all cases, but it is the underlying biological irregularities that provide the underpinnings of schizophrenia. Although present research does not support Meehl's notion that a single gene is responsible for the development of schizophrenia, particular gene regions have been implicated, continuing to support a biological foundation for the disorder (Gottesman & Erlenmyer-Kimling, 2001). Furthermore, additional evidence suggests that environmental factors facilitate the expression of schizophrenia-related characteristics, underscoring the notion of schizotypy as a state with a polygenic and multifactorial etiology (Tsuang, Stone, Tarbox & Farone, 2002).

Meehl's (1962, 1990) model asserted that nearly all schizotaxic individuals develop some degree of schizotypy, which is the personality organization reflective of increased liability to schizophrenia. The four primary indicators of schizotypy are: cognitive slippage, ambivalence, anhedonia, and aversion to interpersonal interactions. These symptoms can manifest at varying degrees of compensation, and are seen as the phenotypic correlates of the underlying genetic

mechanisms resulting in neurological abnormalities. Meehl noted that in some schizotypic individuals there may be little or no observable expression of schizotypy. Thus, it may be inefficient to rely on clinical observation to accurately identify highly compensated schizotypic individuals.

Schizotypy as liability to schizophrenia. Meehl (1962, 1990) proposed that schizotypy was the underlying, latent structure of schizophrenia. His model can be viewed as a liability model, as it does not assert that all individuals are at risk for schizophrenia (Lenzenweger, 2010). Meehl proposed that the underlying anomaly responsible for the development of the schizotaxic brain was necessary for the development of schizophrenia. He emphasized, however, that this did not fatalistically determine decompensation into the full disorder, although possession may result in schizotypy. Thus, the concept of schizotypy describes the existence of liability to schizophrenia and those individuals who possess this biological liability are referred to as *schizotypes*.

According to Meehl's (1962, 1990) model, a combination of three factors is required in order for an individual to develop schizophrenia: 1) The individual must have the schizotaxic brain biology; that is, they must possess the specific neurological deficits caused by the responsible gene (s) in brain. 2) The individual must also have experienced the type of environmental stressors that can lead to the expression of schizotypy. 3) They must also possess polygenic potentiating factors that will lead to a greater likelihood of decompensation, such as a predisposition to aggression or anxiety that may reduce an individual's ability to remain compensated.

Given the necessity of all three criteria to initiate decompensation, Meehl emphasized that the modal schizotype will not develop diagnosable schizophrenia, but will express their

latent vulnerability though less severe, and less conspicuous, abnormalities. Thus, it is possible for an individual to possess increased liability to schizophrenia, but never develop the illness; their at-risk status will remain intact throughout their life, however, and some evidence of this risk will be cognitively, socially or behaviorally expressed. Lenzenweger (2010) suggested that this model represented the first of what came to be known as the "diathesis-stressor models" of psychopathology, which propose that individuals possess an underlying predisposition to psychopathology, but that the environment of the individual is critical in determining whether pathology is expressed. This has become a widely accepted model in regard to the development of a variety of psychological disorders.

With regard to the role of environmental factors in the development of schizophrenia, Meehl (1962) described the familial pattern related to schizotypy in terms of the schizophrenogenic mother (i.e., the mother fosters the development of schizophrenia by developing an inadequate relationship with the child) by suggesting that, in many cases, the schizophrenogenic mothers are, themselves, schizotypes to some degree. Their own schizotypy may lead to ambivalent engagement with and inadequate nurturing of their child, which, in turn, may provide a potentiating factor for the expression of schizotypy in the child. Meehl's model helped to refine and specify how development of schizophrenia is conceptualized, thus establishing a new direction for the study of vulnerability to the disorder. In addition, a wealth of more recent research has supported a later period of onset in women (ages 25-30) compared to men (18-25) which allows for women with the disorder to often have children before experiencing a first decompensation (APA, 2000). This creates potential for the scenario of the schiophrenogenic mother, whereas men are likely to be younger at first decompensation, and may be less likely to have children.

Assessment of liability. Following Meehl's (1962, 1990) model, three avenues for identifying individuals with increased vulnerability to schizophrenia emerged. The first of these avenues addresses the biological basis of schizotypy. Because there is an underlying genetic mechanism, schizotypy can be identified by focusing on the relatives of individuals with schizophrenia. This notion of symptoms aggregating in families can be traced back to Kraepelin (1909) and Bleuler (1911/1950), who each noted attenuated symptoms in of relatives of individuals with the disorder. These relatives, as a group, represent a concentrated sample of liability, so that the greater the genetic relatedness to the affected individual, the greater the level of schizotypy.

In addition to examining presence of familial patterns of illness, schizotypes can be identified clinically, which entails the assessment of psychiatric schizotypic psychopathology (Gooding, Tallent & Matts, 2005; Lenzenweger, 2006). This identification could come from a diagnosis of one of the disorders in the schizophrenia spectrum, such as schizoid, avoidant, paranoid schizotypal, or avoidant personality disorder, all of which reflect a schizotypic personality organization and an increased level of underlying schizotypy. This method of identification represents the foundation of our understanding of schizotypy, as this concept has largely developed as a result of observations by individuals such as Kraepelin (1909, 1971), Bleuler (1911/1950) and Rado (1953) who described individuals demonstrating schizophrenia-like, but non-psychotic symptoms. Since the time of such observations, and with the advancement of psychological research, experimental psychopathologists have demonstrated that a meaningful relationship exists between schizotypic psychopathology and liability to schizophrenia (Lenzenweger, 2010). One benefit to this method of liability identification is that it acknowledges that liability to schizophrenia is seen as continuous in nature, rather than a

categorical identification, which allows clinicians to describe the severity of symptomology with an appropriate diagnosis.

Finally, schizotypy can be identified using reliable and valid psychometric measures that indicate liability to schizophrenia (Lenzenweger, 2006). For instance, the Minnesota Multiphasic Personality Inventory-2 (MMPI-2) has been shown to be useful in identifying individuals with evidence of schizotypy (Bolinskey & Gottesman, 2010; Bolinskey, Trumbetta, Hanson, & Gottesman, 2010; Chapman et al, 1995). On the MMPI-2, schizotypes are likely to demonstrate response sets resulting in elevations on a combination of scales *2* (depression), *7* (psychasthenia), *8* (schizophrenia), and *0* (social introversion; Bolinskey & Gottesman, 2010; Chapman et al, 1995; Millon & Davis, 1996). The traditional code-type indicating schizophrenia, scales *6* (paranoia) and *8*, could be indicative of a more decompensated schizotype, or an individual in a diagnosable episode of schizophrenia (Millon & Davis, 1996). With increased interest in identifying schizotypy, additional psychometric measures have been developed explicitly for this purpose, such as the Wisconsin Schizotypy Scales (WSS; formerly known as the Chapman Psychosis Proneness Scales; Chapman, Chapman & Raulin, 1978; Eckblad & Chapman, 1983; Eckblad, Chapman, Chapman & Mishlove, 1982), which have demonstrated utility in measuring indicators of liability to schizophrenia (Gooding, Tallent & Matts, 2005). Lenzenweger (2006) suggested that one benefit of psychometric assessment of schizotypy is that it makes use of quantitative rather than qualitative measures, which can lead to enhanced precision in the measurement of schizotypic phenomena.

The Endophenotype Concept

If Meehl's (1962, 1990) proposition is accepted, we assume that liability to schizophrenia is based in a heritable, genetic foundation present from conception which is

associated with abnormal neurological development throughout life. Following such an assumption, it seems logical to posit that this underlying liability will manifest itself in some manner prior to the development of even prodromal symptoms. Gottesman and Gould (2003, p. 636) termed these early and subtle expressions of vulnerability *endophenotypes*, and described them as "measurable components unseen by the unaided eye along the pathway between disease and distal genotype."

Gottesman and Gould (2003) further proposed a set of criteria that a given sign or symptom should meet in order to be considered an endophenotype: 1) the endophenotype must be associated with an illness; 2) it must be heritable; 3) it must be state-independent, meaning that it must be present whether or not the illness is in an active state; 4) it must be prevalent among both ill and well relatives of probands; 5) it must be found in non-affected family members at a higher rate than it is found in the general population; and 6) it must be shown to reliably be associated with the given illness more than with other illnesses.

Endophenotypes can take a variety of forms; they may be neuroanatomical, neurophysiological, endocrinological, neuropsychological or cognitive in expression. A core component of the endophenotype concept is that it cannot be observed without the aid of appropriate technology as it represents a hypothetical latent entity (Gottesman & Gould, 2003). This concept appears to apply to schizophrenia in that the genotype for the disorder can begin to express itself early in the form of non-psychotic symptoms, and other minor anomalies, which will be detectable if the appropriate form of measurement is used. Therefore, if the behavior, brain, and psychology of a schizotypic individual are thoroughly examined, the liability will be identifiable. As candidate endophenotypes are identified and investigated, our understanding of the disorder becomes more complete. In regard to schizophrenia, the measurement of

endophenotypes may be particularly useful, due to the complex and heterogeneous nature of the symptom patterns; endophenotypes help to provide simpler clues to the genetic underpinnings of the disorder that may be obscured in the fully decompensated illness (Lenzenweger, 2010).

Personality as an endophenotype of schizophrenia. A long history of research into premorbid personality indicators has supported the notion that there are differences in individuals with increased liability to schizophrenia. For example, Bleuler (1911/1950) noted that individuals who develop schizophrenia demonstrated oddities in personality from childhood and were likely to be withdrawn from others. Smith, Cloninger, Harms and Csernansky (2008) reported that individuals at elevated genetic risk demonstrate reduced reward-dependence, and increased harm avoidance in relation to a comparison group, but at less extreme levels than in probands. They asserted these characteristics are likely to manifest in personality and may be evident early in life. Bolinskey et al. (2010) found that individuals who developed schizophrenia in adulthood could be discriminated from those who developed no psychiatric disorder, or other psychiatric disorders, on the basis on MMPIs completed at the age of 14. Similarly, Bolinskey and Gottesman (2010) indicated that individuals who demonstrated increased liability displayed deviance in a number of personality domains on the MMPI-2, providing additional support for personality characteristics as endophenotypes.

Executive function and working memory impairment as candidate endophenotypes. Although neurocognitive impairment is present in schizophrenia, it is often obscured by more overt symptoms, such as hallucinations or delusions. Nevertheless, it is likely to be a major contributing factor to the disability experienced by individuals with the disorder, and may signify a core feature of the disorder which leads to the expression of other features (Forbes, Carrick, McIntosh & Laurie, 2009). Recently, a number of the neurocognitive deficits observed in

individuals with schizophrenia have received noteworthy attention as candidate endophenotypes for the disorder. For example, Eastvold, Heaton and Cadenhead (2007) reported that relatives of individuals with schizophrenia demonstrate neurocognitive deficits across multiple domains in a pattern consistent with that of individuals in an active phase of the disorder, including working memory and executive functioning. This suggests, that in accordance with Meehl's (1962, 1990) model, individuals possessing the underlying genetic liability to schizophrenia will demonstrate parallel, but less severe patterns of impairment. Additionally, in a meta-analysis of neurocognitive dysfunction in schizophrenia, Nieuwenstein, Aleman and de Haan (2001) concluded that, taken together, the existing research provides evidence that schizophrenia and the spectrum disorders are related to specific anomalies in neurocognitive function. Thus, it appears that neurocognitive dysfunction satisfies the criteria for endophenotypes as outlined by Gottesman and Gould (2003). This is in contrast to the nature of the often more obvious positive symptoms of the disorder, which lack presence or severity in the spectrum disorders as well as relatives of probands (Tsuang, Stone, Tarbox & Farone, 2002). Furthermore, it is notable that the neurocognitive impairments that have been well documented not only in schizophrenia, but in schizotypy, as well, mirror the concept of *cognitive slippage* proposed by Meehl (1962) as an indicator of schizotypy. Nevertheless, the concept of neurocognitive functioning covers a broad range of abilities, or potential impairments; thus, narrowing assessment to more strictly defined constructs may provide additional information on the relationship of schizophrenia to specific domains of functioning. Recently, impairment in executive functioning and working memory have been the subject of particular consideration as endophenotypes for schizophrenia.

Executive functioning. Executive functioning is a combination of multiple processes including mental set shifting, updating and monitoring information, and inhibition (Miyake et al.,

2000). Of the neurocognitive dysfunctions associated with schizophrenia, executive functioning impairment has received notable attention in both probands and their relatives. For example, Jahshan, Heaton, Golshan and Cadenhead (2010) reported a hierarchy of impaired performance in executive functioning tasks including the WCST. The authors reported that individuals experiencing their first episode of schizophrenia performed more poorly than a group of individuals at high genetic risk; however, the high risk group demonstrated significantly impaired performance compared to a normal comparison group. Owashi et al. (2007), however, failed to find a relationship between active thought disorder and executive impairment. Although this finding may appear to contradict the role of executive functioning impairment as an endophenotype for this disorder, it provides support for the notion that these impairments act independently of the more severe symptoms of the disorder, and that observed deficits are not likely to be a result of thought disorder interference. In accordance with Gottesman and Gould's (2003) criteria, these results indicate that impairment in executive functioning appears to be heritable, is found in well relatives at a greater rate than in the general population, and that the impairment is state-independent. Furthermore, Eastvold et al. (2007) reported similar findings, as relatives performed at an intermediate level of executive functioning impairment on the WCST compared to the probands and a comparison group. They further added that relatives who at follow-up were found to have converted to psychosis demonstrated greater impairment at baseline than individuals who maintained "at risk" status. Furthermore, Nieuwenstein, et al. (2001) suggested that executive functioning impairment showed a linear relationship with disorganization symptoms of the disorder, such that the more severe the disorganization symptoms, the greater the deficit in executive function as assessed by the WCST and Continuous Performance Test. This finding provides further evidence for the relationship between illness

course and impairment in this domain, in that subtle impairments in executive functioning may precede formal decompensation, when only minimal disorganization may be evidenced. Thus, it may be possible to identify executive functioning deficits prior to more noticeable symptoms of disorganization. A proposed explanation for the deficits in executive functioning observed in schizophrenia and spectrum disorders is that individuals with these disorders lack the capacity to generate and apply cognitive inhibition, resulting in a deficit in cognitive control, and distraction by irrelevant stimuli (Everett, Lavoie, Gagnon & Gosselin, 2001).

Working memory. Baddeley (1986) defined working memory as an active unit of short-term memory systems that consist of a phonological loop for auditory stimuli and a visuospatial sketchpad for visual stimuli. The role of working memory is to control memory and action by integrating information from the environment and selecting methods of processing it.

Park and Holzman (1992) conducted the first investigation into the relationship of working memory and schizophrenia and were the first to note marked impairment compared to normal comparison subjects. A number of studies have noted working memory impairment in individuals with schizophrenia at a level that is not comparable to the impairment, due to general decompensation, seen in other areas of functioning (Dickinson, Ragland, Gold & Gur, 2008; Gold et al, 1997; Schmidt-Hansen & Honey, 2009). In fact, working memory impairment in individuals with schizophrenia has been so well documented that Lenzenweger (2010, p. 253) proposed it has achieved a level of "scientific fact." Dickinson et al. noted that, even within a pattern of generally poor task performance due to severe symptomology, working memory demonstrates a disproportionate deficit. Likewise, in a meta-analysis of investigations of working memory in schizophrenia, Forbes et al. (2009) indicated that across studies using 36 different measures of working memory, deficits have not been explainable by discrepancies in

overall intellectual ability between individuals with the disorder and healthy comparisons. They further suggested that these findings indicate that the general symptoms of schizophrenia do not completely account for the deficits observed in working memory.

Just as there appears to be a hierarchy of impairment in executive functioning, Horan et al. (2008) reported that the well relatives of individuals with schizophrenia performed significantly better on working memory tasks than their ill relatives, but demonstrated significant impairment when compared to a normal comparison group. Glahn et al. (2003) reported that working memory impairment was observed in a dose-dependent manner to genetic relatedness to probands in individuals of varying degrees of relation to individuals with schizophrenia. This finding offers evidence of the influence of genetic factors on working memory impairment, providing further evidence for its continued investigation as a candidate endophenotype. Furthermore, Jahshan, Heaton, Golshan and Cadenhead (2010) reported that, among individuals at high genetic risk for schizophrenia, those who decompensated into active psychosis during the course of the study performed worse on working memory tasks at baseline than those high-risk individuals who did not decompensate. This finding may indicate that increased impairment in this area precedes observable symptoms of schizophrenia, and may offer an early indication of pending decompensation. In accordance with this notion, Gooding and Tallent (2002) reported undergraduate college students with sub-clinical negative schizotypic symptomology demonstrated impairment in working memory compared to a comparison group. A similar pattern emerged in a study comparing functional magnetic resonance images (fMRI) of probands, their unaffected twins, and a normal comparison group (Karlsgodt et al., 2007). Probands demonstrated a pattern of activation characterizing inefficient processing, whereas unaffected twins represented intermediate efficiency. The authors indicated that this pattern of

results suggests that the inefficiency in working memory evidenced in individuals with schizophrenia is the result of genetic factors, as opposed to a symptom of the disorder itself. Similarly, and in accordance with Meehl's (1962, 1990) model, Glahn et al. (2003) suggested that findings supporting working memory impairment in probands as well as relatives uphold the notion that the genes responsible for liability to schizophrenia are likely associated with the disruption of the cognitive processes involved with encoding and storing information. Thus, working memory deficits meet criteria for consideration as an endophenotypes for schizophrenia.

Wisconsin Schizotypy Scales (WSS)

The Wisconsin Schizotypy Scales (WSS) comprise a psychometric instrument developed for the identification of individuals at elevated risk for development of future psychotic disorders, and consist of the Magical Ideation Scale (*MagId*; Eckblad & Chapman, 1983), the Perceptual Aberration Scale (*PerAb;* Chapman, Chapman & Raulin, 1978) and the Revised Social Anhedonia Scale (*SocAnh*; Eckblad, Chapman, Chapman & Mishlove, 1982). The scales were based upon Meehl's (1962,1990) description of schizotypy; thus, they assess several of the same precursors to schizophrenia that Meehl suggested. The scales assess both positive and negative symptomology associated with schizotypy. The *PerAb* and *MagId* scales address the positive symptomology such as abnormalities in perception and causal attribution, whereas *SocAnh* assesses negative dimensions such as disinterest in interpersonal relationships (Kwapil, Barrantes-Vidal & Silva, 2008). In accordance with Meehl's model of schizotypy, Chapman et al. (1994) asserted that deviant scores should not be interpreted as an indication of inevitable decompensation, but an indication that an individual demonstrates symptoms that have been shown to be statistical predictors of later development of schizophrenia spectrum disorders.

The WSS have been used in a number of investigations to determine vulnerability to schizophrenia (e.g., Bolinskey & Gottesman, 2010; Gooding et al., 2005, Laurent et al., 2001; Tallent & Gooding, 1999) and results have largely supported its ability to accurately determine group membership. Furthermore, the ability of the WSS to assess both positive and negative symptoms of schizotypy is of particular value, as evidence exists that areas of impairment may vary depending on the nature of an individual's symptom presentation. For instance, it has been proposed that, among individuals with schizophrenia, negative symptoms may be particularly related to impairments in working memory performance, whereas positive symptoms are more likely to interfere with tasks of inhibition and executive functioning (Donohoe, Corvin & Robertson, 2006). Bolinskey and Gottesman (2010) reported that individuals with deviant scores on the WSS endorsed significantly more items on the Personality Disorder Questionnaire-IV indicative of avoidant, paranoid and schizoid symptomology than did a normal comparison group, which suggests that the scales are, indeed, sensitive to schizophrenia spectrum symptoms. Additionally, these individuals were less likely to have had a close romantic relationship and more likely to have sought treatment for mental health concerns than were the comparison group, which further suggests that the scales may be helpful in identifying social disinterest, as well as the likelihood of possible current mild symptomology. Additionally, Chapman and Chapman (1987) reported that individuals who scored in the deviant range on the positive dimensions of the WSS reported more psychotic-like experiences in an interview and on 25-month follow-up than individuals who did not score in the deviant range on those scales. They noted that although the *PerAb* and *MagId* scales measure different constructs, the scales are highly correlated and individuals who score in the deviant range on one or both of these scales are often combined to create a *Per-Mag* group due to substantial overlap in identifying positive symptomology. This

demarcation has become customary in the research and has been utilized in a number of investigations, as positive symptomology has been proposed to be differentially related to other variables of interest (Gooding, 1999; Gooding & Pflum, 2011; Hazelett et al., 1997). Taken together, these findings indicate that the WSS are effective in identifying both the positive and negative components of the schizotypic personality organization that Meehl (1962, 1990) suggested was indicative of vulnerability to schizophrenia.

Information from follow-up studies has also helped to underscore the utility of the WSS in the determination of liability on a more longitudinal basis. Gooding et al. (2005) completed a follow-up assessment with individuals identified by the WSS as schizotypic 5 years after initial assessment. At follow-up, individuals identified as schizotypic were significantly more likely to report severe psychotic or psychotic-like symptoms than the comparison group. Similarly, Chapman et al. (1994) reported that in a 10-year longitudinal investigation individuals identified as schizotypic by scores on the WSS had significantly higher rates of psychosis than normal comparisons; further, those schizotypic individuals who did not exhibit active psychosis significantly exceeded the control group on schizotypal, paranoid and psychotic-like symptomology.

Additionally, longitudinal investigation of individual scales of the WSS has helped to clarify their unique contribution to the measure. For instance, at 10-year follow up, it was found that *PerAb* scores identified a subgroup of individuals who were more likely to experience diagnosable psychotic symptoms, as 30% of individuals with deviant scores met criteria for schizophrenia (Chapman et al., 1994). This may be an indication that *PerAb* is useful in identifying the subset of schizotypes who may be more likely to decompensate into diagnosable schizophrenia. Similarly, Kwapil (1998) reported that at a 10-year follow up, individuals with

deviant scores on *SocAnh* were more likely to be diagnosed with a schizophrenia spectrum disorder than those whose scores were not deviant. Specifically, 24% of the individuals with deviant scores on *SocAnh* met criteria for a spectrum disorder at follow-up, as compared to only 1% of the individuals who scored within normal limits; however, at initial assessment the two groups evidenced no difference in psychotic or psychotic-like experiences in a clinical interview.

In addition to research support, the WSS also embodies the advantages of using a psychometric method of liability assessment. Kwapil et al. (2008) asserted that psychometric inventories provide a particularly promising method to assess schizotypy, as they allow for the screening of large numbers of people, rather than basing selection on clinical impressions or genetic relation to probands. This may be a particularly meaningful implication, as it is clear from Meehl's (1962, 1990) model that symptoms may not be clinically discernible; thus, reliance on clinical suspicion to select individuals for screening may lead researchers to overlook a subset of fully compensated, but equally-liable individuals. It would, in turn, be possible for the fully compensated proband to pass on the liability without any outward indication. Psychometric risk assessment may also be helpful in identifying genuinely liable individuals who do not have a familial pattern of affliction. Chapman et al. (1994) reported that 45% of individuals identified as having increased liability to schizophrenia reported having no relatives with a history of psychosis. The use of psychometric methods of identification, such as the WSS, could help prevent the overlooking of these individuals.

Measuring Cognitive Endophenotypes

Wisconsin Card Sorting Task. The Wisconsin Card Sorting Task (Heaton et al., 1993) is one of the most widely used assessments of executive functioning (Nieuwenstein et al., 2001). The WCST requires the respondent to match a design with various shapes and colors to one of

four various other designs. The construct on which the cards are to be sorted changes throughout the task; the respondent must determine when the demands have changed, and identify the new parameters. After each attempt, the individual receives feedback on whether their answer was right or wrong, and in order to perform well, the individual must be able to quickly learn from their mistakes (Torrey et al., 1994). The task measures abstract reasoning, ability to track and maintain set, and the ability to shift set according to demands. The WCST has been used in a variety of settings, including in the assessment of individuals with schizophrenia (Torrey, Prentice, Gold, & Buchanan, 2008), as well as those at high genetic risk (Laurent, et al.,2001; Tallent & Gooding, 1999). Individuals with schizophrenia, as well as their at-risk relatives, most often demonstrate deviance in the number of categories successfully completed, and the number of trials to complete the first category (Everett, Lavoie, Gagnon, & Gosselin, 2001; Nieuwenstein et al., 2001). Lezenweger and Korfine (1994) reported that individuals at risk for schizophrenia spectrum disorders demonstrated a greater difficulty in maintaining set than a comparison group. Additionally, individuals with schizophrenia and their relatives are also more likely than healthy comparison individuals to demonstrate preservative tendencies, as evidenced by a continuation of sorting principles that no longer yield positive feedback. It has been hypothesized that these preservative tendencies may be most directly related to symptoms of anhedonia, as individuals who score higher on *SocAnh* tend to demonstrate more perseveration (Everett et al.,2001; Laurent et al., 2001).

Prentice et al. (2008) noted that the WCST may be particularly helpful in assessing schizophrenia because deficits can be noted as early as the second stimulus card. This may be because the task requires individuals to use feedback provided after incorrect responses to correct behavior, and individuals with schizophrenia appear to have deficits in this area (Prentice

et al., 2008). Additionally, Lenzenweger (2010) asserted that the complex neuropsychological demands of the WCST and the consistent pattern of impairment in individuals with schizotypy provides viable support for an endophenotype in executive functioning impairment according to Gottesman and Gould's (2003) standards. In a meta-analysis of investigations into cognitive deficits in relatives of individuals with schizophrenia, Sitskoorn, Aleman, Ebisch, Appels and Kahn (2004) reported that 19 of the 37 studies utilized the WCST as a measure of executive functioning, highlighting its extensive use in this area.

WMS-IV and WAIS-IV. The Wechsler Memory Scale-Fourth Edition (WMS-IV; Weschler, 2009a; 2009b) is an individually-administered assessment of various subsets of memory, particularly effective in the evaluation of working memory. One of the primary goals in the most recent revision of the WMS was to improve the assessment of working memory with the addition of a Visual Working Memory Index (VWMI; Cassady & Dacanay, 2009). In addition to being used in a variety of other settings, previous versions of the WMS have been used to assess working memory deficits in individuals with schizophrenia as well as individuals at high risk (Horan et al, 2008; Skelley, Goldberg, Egan, Weinberger & Gold, 2008).

The Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Weschler, 2008a; 2008b) was designed to assess a more broad range of cognitive ability. Similar to the WMS, the most recent revision resulted in an improvement in assessment of working memory, which may make it of particular use for evaluating impairment in this area (Canivez, 2009).

Furthermore, the Wechsler scales have been used to assess the working memory deficits in populations liable to schizophrenia as well. Forbes et al. (2009) reported that of the 200 studies included in a meta-analysis of cognitive deficits in probands, 38 used the Digit Span Forward task from the WAIS, 31 used Digit Span Backward, and 19 used the Spatial Span

subtest of the WMS. Similarly, Sitskoorn et al. (2004) reported that 18 of the 37 studies included in a meta-analysis utilized a version of the WAIS and/or WMS to assess working memory deficits in individuals at high genetic risk, underscoring their utility in this context.

Other Proposed Markers of Liability to Schizophrenia

Recent investigations have proposed additional markers of liability to schizophrenia which are more easily observable. For instance, atypical handedness has been asserted to be a marker of schizophrenia proneness (Dane et al., 2009; DeLisi et al., 2002; Dragovic & Hammond, 2005; Dragovic, Hammond, Badcock, & Jablensky, 2005; Orr, Cannon, Gilvarry, Jones, & Murray, 1999; Reilly et al., 2001; Sommer, Aleman, Ramsey, Bouma, & Kahn, 2001), meaning that individuals who fail to assert a dominant-hand preference may be more likely to demonstrate schizotypy. Similarly, some investigations have indicated that season of birth demonstrates a relationship to schizotypy, as individuals born in winter or early spring months demonstrate a greater likelihood of exhibiting schizotypy (Modestin, Ammann, & Wuermle, 1995; Torrey, Rawlings, Ennis, Merrill, & Flores, 1996). These observable markers of liability serve to further assist our understanding of schizotypy and identifying patterns that may help to decipher underlying causal factors.

Rationale for the Present Study

Improved conceptualization of endophenotypes. Currently, the majority of the literature on early indicators of schizophrenia is focused on studies of relatives of probands; however, this may not be the most efficient strategy to facilitate better understanding of the underlying mechanisms of the disorder. Gooding et al. (2005) noted that the results of a psychometric risk assessment revealed that individuals identified as at risk did not differ from the comparison group in terms of proportion of participants with a family history of schizophrenia.

Furthermore, there are methodological concerns regarding use of relatives of probands to investigate markers of the disorder. For example, relatives of probands may experience other forms of psychopathology that are unrelated to genetic risk for spectrum disorders, which could confound the results of risk studies. Likewise, investigations of cognitive deficits in this population may overestimate impairments due to the interference of unrelated symptomology (Heydebrand, 2006). The identification of candidate endophenotypes, and the investigation of those indicators in individuals without explicit genetic history of the disorder, may help to avoid the possible confounds of existing psychopathology (Gooding et al., 2005). Furthermore, many individuals who decompensate into psychosis lack traceable genetic connections due to loss of contact with family (Chapman et al., 1994). This handicaps the ability of studies relying on genetic relatedness to provide a complete picture of what constitutes liability to schizophrenia.

Concern also exists about providing preemptive treatment to those considered to be genetically at risk, as many individuals may be unnecessarily exposed to side effects of medications or other interventions (Eastvold et al., 2007). The nature of genetics logically leads to the conclusion that not all individuals who are related to a carrier will exceed the genetic risk threshold. Up to 80% of individuals with "at risk" genetic status never develop any symptoms and do not decompensate into the illness (Lenzenweger, 2010). Although there is strong support for a genetic component to the disorder, the substantial discordance in incidence of illness even among monozygotic twins supports the notion that genetics are not the sole factor in determining illness status. A better understanding of endophenotypes may assist in being able to account for genetic vulnerability and shifting focus to the environmental factors influencing likelihood of symptom expression.

Early intervention. As our ability to study the neurocognitive impairments in schizophrenia improve, there is promise that endophenotypes may be revealed that could help lead to the identification of individuals at risk for the disorder without unnecessarily providing preemptive treatment to those not genuinely at risk (Heydebrand, 2006). The early identification of individuals at increased liability to schizophrenia may be helpful to patients, their families, and the mental health system. Untreated psychotic symptoms have been linked to poor prognosis; early recognition of individuals at risk to develop the disorder would be an important step in improving quality of life for individuals with the disorder and reducing the responsibility that may be placed on caretakers (Bender, Weisbrod & Resch, 2009). With regard to quality of life and independent functioning of individuals with schizophrenia, Ritsner (2007) asserted that early intervention and maintenance of cognitive functioning should be targeted, as this will contribute to an improved quality of life for individuals with the disorder. A better understanding of neurocognitive and psychosocial processes that lead to the expression of schizotypy may not only be helpful in identifying areas in need of early intervention, but may also help to identify protective factors that defend against decompensation (Kwapil et al., 2008).

One challenge in the early identification of schizotypy is that prior to decompensation, symptoms are not specific enough to indicate need for intervention (Bender, Weisbrod & Resch, 2009). With continued research, endophenotypes for schizophrenia may become better validated, making it possible to use these subtle markers to identify individuals with increased liability to the disorder. The use of endophenotypes to identify individuals at risk will help to circumvent the challenge presented by the absence of more overt symptoms, as the former are present regardless of whether symptomology is notable. Another advantage of using endophenotypes to determine liability is the possibility of early detection of at-risk individuals by means other than

genetic relatedness to an individual with schizophrenia, as these indicators would likely identify some at-risk individuals who would not otherwise be identified (Gooding et al, 2005). Eastvold et al. (2007) proposed that over time, the uncovering of endophenotypes may enable the development of a predictive algorithm for risk that may enhance predictive power, thus making it possible to more accurately predict the level of decompensation an affected individual is likely to experience.

Summary of Present Study

The present study took place as cross-sectional portion of a larger, longitudinal study investigating a number of proposed indicators of risk for schizophrenia spectrum disorders. The current study investigated working memory and executive functioning in psychometric schizotypes (PS) as compared to normal matched comparison (MC) participants to assess differences in performance.

Participants were selected from a group of 349 individuals between the ages of 18 and 25 years old who were recruited from introductory psychology courses at Indiana State University. The age of onset for first episode of schizophrenia typically falls within this age range (APA, 2000), which increases the likelihood of identifying liable individuals prior to decompensation or behavioral expression. Because the focus of the study is a prospective investigation of candidate endophenotypes, assessing individuals prior to any noticeable signs was imperative. According to Lenzenweger (2010) approximately 10% of individuals demonstrate liability status; thus, out of the 349 individuals recruited, it was expected that approximately 34 individuals would demonstrate liability as assessed by the WSS. Individuals who demonstrated liability were paired with an individual who did not, based on gender, age, ethnicity and college major. The process of pairing individuals served to control for possible confounding demographic variables.

Individuals were assessed on the WSS in order to determine risk status. Use of psychometric inventories, like the WSS for the assessment of schizotypy have the benefit of enabling for the screening of large numbers of people, and allowing for the identification of liable individuals who may not otherwise be identified due to the absence of behavioral expression of symptoms (Kwapil, 1998). Following determination of liability status, identified PS and MC participants were assessed on the WCST in order to evaluate executive functioning and working memory subscales of the WMS-IV and WAIS-IV. Working memory and executive functioning impairment have been proposed as possible endophenotypes for schizophrenia (Lenzenweger, 2010), so that investigation of these impairments in PS participants will lend to the understanding of early phenotypic markers of the disorder.

Hypotheses.

Based on the results of previous research, the following hypotheses were suggested:

1. PS participants would exhibit impairment in working memory and executive functioning tasks compared to the MC group.
2. A positive linear relationship would exist between the level of deviancy demonstrated on the WSS and the level of impairment demonstrated on executive functioning and working memory tasks.

CHAPTER 3

Methods

Overview and Design

The present study is a cross-sectional portion of a larger, longitudinal study investigating working memory and executive functioning, among other candidate endophenotypes. The present study utilized the WSS in order to determine group membership. Individuals who scored more than 1.96 standard deviations above the mean (See Appendix A) on at least one of the WSS scales were considered to be a PS participant for the purpose of this study. PS participants and the MC group were compared on working memory and executive functioning as evaluated by the WCST and the working memory scales of the WAIS-IV and WMS-IV.

Power Analysis

Given that the base rate of schizotypy has been estimated to be approximately 10% of the general population (Lenzenweger, 2010), it was expected that the number of participants included in the second phase of analysis would represent about 20% of initial sample. An a priori power analysis was conducted based on a prediction of 300 participants are recruited for the initial participant pool.

Significance values of .10 or higher are commonly reported in similar studies, since some indicators will likely have small individual effects. However, the power calculations below are all based on $p < .05$.

Since an earlier pilot study found a multivariate effect size (f^2) of .55, a smaller effect (f^2 = .25, with 3 response variables) was chosen for the purposes of this estimation. Using this effect size and the intended sample size, power to find a multivariate effect was estimated at 89.5%. For between-groups comparisons of individual variables the power estimation was 60.6% when predicting a medium (d = .3, one-tailed) effect size, since the pilot study indicated medium effects for many variables at initial assessment.

Participants

Initial Participant Pool. Valid data was available for 349 undergraduate students from Indiana State University who were recruited from Introductory Psychology courses as part of the larger study. As expected, women and Caucasians were overrepresented, as a function of the gender and ethnic make-up of the University's student population. In order to ensure that the 10-year time period of the larger study follows participants during the period of greatest risk for development of psychosis, participants were limited to individuals between 18 and 25 years of age, inclusive. Individuals in the initial participant pool completed the WSS, as well as the PDQ-IV, MMPI-2, a family and personal history questionnaire, and the Edinburgh Handedness Inventory[1]. Standards for validity for the PDQ-IV and the WSS were taken from their respective manuals. Individuals' data were deemed invalid, and removed from further investigation, if they endorsed three or more items on the WSS *Infrequency* scale, more than two items on the *Too Good* scale of the PDQ-IV, and had a score greater than zero on the *Suspect Questionnaire* scale of the PDQ-IV. Determination of validity in MMPI-2 profiles, however, presented a greater

[1] the latter measures represent additional self-report measures that are part of the larger, longitudinal study

challenge, as seemingly invalid profiles may not indicate genuine invalidity, but instead indicate more severe psychopathology. In order to avoid eliminating potentially valid profiles, while still protecting the validity of responses, a moderate set of validity criteria was adopted, such that individuals with profiles meeting any of the following criteria were removed from further investigation: *VRIN* ≥ 13, *TRIN* < 5 or > 13, *F*≥ 30, *Fb* > 20, *Fp* T score > 120, *Cannot Say* ≥ 20, and *L* T score ≥ 83. Individuals whose profiles met the validity criteria were assessed for deviancy on the WSS and those who scored more than 1.96 standard deviations above the mean on any scale were assigned to the PS group.

Of the 349 participants with valid data, 32 demonstrated psychometric schizotypy on the WSS (Lenzenweger, 2010). Following Bolinskey and Gottesman (2010), an MC participant was selected for each PS participant on the basis of (in order) gender, ethnicity, age, and college major from the remaining participants with valid protocols. When a match was not possible on one of these criteria, the match was made with the participant closest to the PS participant on that particular criterion. For two individuals in the PS group, MC counterparts have not yet been determined, resulting in two participants in the PS group without matches. Those participants from the initial sample who were not included in the PS and MC groups were dropped from the study. PS and MC participants were invited to continue in the study, at which time they completed the WCST, the working memory subscales of the WAIS-IV and WMS-IV, and other measures not included in the current study. Participants received $20.00 for their time.

Final Sample. The final sample consisted of 32 individuals (5 men, and 27 women) identified as psychometric schizotypes (PS) based on their scores on the WSS, and 30 individuals (5 men, and 25 women) in a matched comparison group (MC). All pairs were matched on gender, with the two additional PS participants being women. Twenty-nine pairs

(96.7%) were matched on ethnicity; one pair of men was not matched on ethnicity, although both were minorities. The additional PS participants included one Caucasian and one Hispanic woman. Approximately 77% of the participants were matched on age, with all pairs being matched within 12 months.

Age of PS participants ranged from 18 through 21 years (M = 18.78, SD = .86); ethnic group membership consisted of 21 Caucasians, 9 African-Americans, and 2 Hispanic individuals. Age of MC participants ranged from 18 through 21 years (M = 18.86, SD = .75); ethnic group membership consisted of 20 Caucasians, 9 African-Americans, and 1 Hispanic individuals. As noted above, matches for two individuals in the deviant group were not yet available at the time of data analyses; however, given small effect sizes predicted, data for these PS participants was retained. Preliminary analyses were utilized to verify that the inclusion of these individuals would not result in a meaningful difference in demographic variables between groups. A one-way ANOVA revealed no significant differences in age between the PS and MC groups, F (1, 60) = 1.27, p= .29. A Chi-Square test of independence revealed that groups did not vary significantly based on ethnicity, χ^2 (2, N = 62) = 0.29, p = .86.

Among the PS participants, the mean score on *SocAnh* for those who were deviant on the scale was 20.74 (SD = 3.54); the means score for the MC group was 7.57 (SD = 4.36). For *PerAb*, the deviant individuals had a mean score of 20.50 (SD = 2.12), whereas the MC group had a mean score of 4.23 (SD = 3.81). Finally, on *MagId* those who scored in the deviant range had a mean of 22.20 (SD = .84). It is worth noting that one individual in the PS group and one in the MC group reported a family history of schizophrenia.

Measures

WSS. The Wisconsin Schizotypy Scales (WSS; see above) are comprised of three scales intended to measure different components of the construct of schizotypy. All scales of the measure were administered via computer. The WSS are comprised of the Magical Ideation Scale (*MagId*; Eckblad & Chapman, 1983), the Perceptual Aberration Scale (*PerAb*; Chapman, Chapman & Raulin, 1978) and the Revised Social Anhedonia Scale (*SocAnh*; Eckblad, Chapman, Chapman & Mishlove, 1982; See Appendix A).Test-retest reliabilities have been calculated between .75 or .80 when the three scales are used together (Chapman et al.,1994). Each of the three scales has a 'cut score' of 1.96 standard deviations above the mean that indicates deviance (Kwapil, 2002). Results of a confirmatory factor analysis support the factor structure of the WSS by demonstrating consistency of the factor structure across sex and ethnicity (Kwapil et al., 2008). All of the scales of the WSS have been constructed with social desirability and acquiescence in mind, taking measures to avoid influences of both as much as possible while maintaining internal consistency and construct and content validity (Lenzenweger, 2010).

MagId is a 30-item true or false scale intended to measure the cognitive oddities emphasized by Meehl (Chapman & Chapman, 1985). *MagId* identifies magical ideation as "a belief in forms of causation that by conventional standards of society are not valid, but magical" (Chapman & Chapman, 1985, p.164). This scale consists of items intended to assess the level of magical thinking an individual is experiencing. Items address aspects of magical ideation such as attributions of causation and rituals to avoid negative consequences. Cronbach's alpha for the *MagId* has been reported at .83 for women and .85 for men (Kwapil, 2002). Deviant scores on the scale are ≥ 21 for women, and ≥ 22 for men. Scores range from 0 to 30.

The Perceptual Aberration Scale (*PerAb*) is a 35-item true or false scale assessing oddities in physical perceptions of self and interpretations of external stimuli (Chapman & Chapman, 1985). It is intended to operationalize the reports of body-image distortion and perceptual abnormalities that are plentiful in clinical observations of individuals with schizophrenia (Lenzenweger, 1994). Cronbach's alpha is .89 and the cut score for both genders is ≥19 (Kwapil, 2002). Scores on this scale range from 0 to 35.

The final scale of the WSS is the Revised Social Anhedonia Scale (*SocAnh*). The *SocAnh* is a 40-item true or false scale that was developed to assess social disinterest, with notable attention paid to ensuring that items related to social anhedonia without assessing social anxiety (Chapman & Chapman, 1985). *SocAnh* is used to assess absence of pleasure relate to social interaction. Social anhedonia has been identified as a symptom commonly present throughout the course of schizophrenia, in addition to being a central feature of schizotypal and schizoid personality disorders (APA, 2000). *SocAnh* has demonstrated a Cronbach's alpha of .79 for both genders. The cut score is ≥ 20 for men and ≥16 for women.

WAIS-IV. The WAIS-IV is a well-validated measure of cognitive functioning intended to address a range of intellectual abilities. The Wechsler intelligence scales have undergone nearly 70 years of research and adjustments have been made, through four revisions, to address concerns of continued validity (Wechsler, 2008a). The newest revision, the WAIS-IV, is a measure of intelligence which assesses a number of domains of functioning. The Working Memory Index (WMI) portion of the test includes two subtests: Digit Span (DS), and Arithmetic (AR). The DS subtest requires individuals to repeat a series of numbers to the examiner with a variety of manipulations. In DS Forward (DSF) the respondent simply repeats the series of numbers back to the examiner with the series increasing in length at each trial. DS Backward

(DSB) requires that the individual repeat the number in reverse order, and DS Sequencing (DSS) requires the numbers to be repeated back in numerical order from lowest to highest, increasing the working memory demand of the task (Wechsler, 2008b). The DS subtest involves working memory, transformation of information, visuospatial imaging and mental manipulation, while shifting from one DS task to the next requires mental alertness and cognitive flexibility. Test-retest reliability for the DS subtests has been reported at .93 (Wechsler, 2008b). In the AR subtest, the testing participant is presented a mathematical word-problem in oral form and they must solve the problems without using written calculations within a specified duration of time. This task requires concentration, mental manipulation, short and long-term memory, and numerical reasoning. The AR subtest has demonstrated test-retest reliability of .88 (Wechsler, 2008b). Cronbach's alpha coefficients for the individual WMI subtests range between .88 and .93. Test-retest reliabilities for the individual subtest are between .76 and .82, with an overall stability coefficient of .87 for the WMI.

WMS-IV. The Wechsler Memory Scale (Wechsler, 2009a; 2009b) is a well-validated measure of memory ability (Cassady & Dancanay, 2009). The most recent edition, the WMS-IV, published in 2009, was co-normed with the WAIS-IV to facilitate their use together. The WMS-IV includes seven subtests and provides five index scores including a Visual Working Memory index, utilizing the scaled scores of the spatial addition (SA) and symbol span (SS) subtests. The SA subtest requires the respondent to create a design after compiling information from a number of stimuli with various colored dots in various spatial organizations; this task assesses spatial working memory, the ability to store and manipulate information, and a test participant's skill in ignoring competing stimuli. Test- retest reliability for the SA subtest has been reported at .91 (Wechsler, 2009b). The SS task is considered to be the visual analog of the WAIS-IV digit span

task. It requires the respondent to recall symbols in the order in which they were presented to them; the complexity and the number of symbols to be recalled increase as the task progresses. The SS subtest assesses the participant's ability to maintain a mental image of a design and the ability to assess an object's relative position in space. The SS subtest has demonstrated a test-retest reliability of .85 (Wechsler, 2009b). The WMS-IV demonstrates moderate to high internal consistency, with a Cronbach's alpha of .88 for the symbol span subtest (Wechsler, 2009b). Moreover, a stability coefficient of .72 indicates that it demonstrates adequate test-retest reliability. Furthermore, the WMS-IV has demonstrated notable external validity, as it has been shown to correlate with concurrent academic functioning, and daily living skills.

WCST. The Wisconsin Card Sorting Test (WCST; see Appendix B) is a widely used measure of executive functioning. The test assesses an individual's abstract reasoning abilities and cognitive strategies in response to changes in external demands (Heaton, Chelune, Talley, Kay & Curtiss, 1993). The respondent is asked to match 128 response cards to a set of four stimulus cards according to a construct (i.e. color, shape, number) that an individual must discern after feedback following each response. Once the individual obtains a certain number of consecutive correct responses, the sorting principle is changed, and the respondents must re-adjust their response strategy. Validity for the WCST has been supported by correlations with physiological measures of executive functioning, including cerebral blood flow to the dorsolateral prefrontal cortex, an area associated with abstract reasoning and problem solving abilities (Heaton et al., 1993). Blood flow to this area has been negatively correlated with perseverative errors on the WCST, indicating that the measure is reflective of genuine executive functioning ability or dysfunction. It has also been shown to demonstrate sensitivity to frontal

lobe dysfunction, so that individuals with dysfunction and known injury will perform at an impaired level.

Among the scores derived from the WSCT are measures that evaluate respondents on the number of categories they are able to successfully complete, the number of trials required to complete each category, and scores that reflect the qualities of their response patterns. For instance, the Learning to Learn index score reflects whether a participant demonstrated improved efficiency throughout the process of completing the test. The Perseverative Errors score reflects the participant's tendency to continue to respond in the manner of the previous scoring principle after this principle has changed and the participant has received feedback that the response is incorrect. The Failure to Maintain Set index provides information on the individual's ability or inability to maintain set, which reflects consistency in responding to the scoring principle until receiving feedback that it is no longer correct. Finally, an additional score reflects the number of trials that were necessary for the testing participant to complete the first category, as this is indicative of their ability to determine what they are required to do, and conform their behavior in order to successfully complete the task. Generalizability coefficients for the WCST have ranged from .37 to .72, with a mean of .57.

Procedure

Participants were recruited as part of the larger longitudinal study, and completed a number of assessments in person. Participants completed an informed consent (see Appendix C) prior to any data collection. In order to protect confidentiality, participants received ID numbers and all data contain this unique identifier. Personally-identifying information was kept separately from the study ID number, with the exception of a single database on a password-protected

computer in a locked room. All assessment results are stored in a locked cabinet in a locked room.

The initial in-person data collection consisted of two self-report measures, which are part of the longitudinal study and a registration form consisting of contact information. Participants were then asked to complete another portion of the initial assessment online consisting of the WSS and other measures that were not included in this study. Participants in this initial phase of the project were be informed that approximately 20% of them would be invited to continue in the study, for which they would receive financial compensation for their time. Individuals with valid data, as determined by the procedures outlined above, and who scored more than 1.96 standard deviations above the mean on the WSS were classified as PS participants. As noted above, each PS participant was matched with an individual who scored within normal limits on the WSS. The researcher and research assistants were blind to participants' group membership (PS or MC), as group membership was determined by the senior researcher on the larger study, who, in turn, had no contact with participants. The true nature of the study was not revealed to the participants, as the nature of the term *schizotype* may have caused unnecessary distress; instead participants were informed that the present project focused on "Mental Health Development in Early Adulthood".

Participants selected to continue in the study were contacted via email and/or phone to let them know they were selected to participate in the next phase of the study and to schedule a time to complete additional assessment if they were interested in continued participation. Individuals who elected to participate completed a second informed consent (see Appendix D) at the time of arrival. Participants then completed a computer administration of the WCST, as well as individual administrations of the working memory subscales of the WAIS-IV and the WMS-IV, along with a structured diagnostic interview that was completed as part of the longitudinal study.

Graduate research assistants trained in assessment administered all measures and remained blind to group membership to aid in avoiding unintended bias in administration and scoring. Individual item scoring for the Wechsler measures was reviewed by the senior researcher prior to scoring the index scores, which were scored using a computerized scoring program.

CHAPTER 4

Results

Comparisons of PS and MC participants

Of the individuals identified for membership in the PS group, 27 had scores in the deviant range on *SocAnh*, 5 had deviant scores on *MagId*, and 2 on *PerAb*. Two individuals were deviant on more than one scale.

All data analyses were performed using the IBM SPSS Statistics 19.0 (SPSS, 2010) package. Multicollinearity among the dependent variables (i.e., WCST, the WMI on the WAIS-IV, and the VWMI on the WMS-IV) was assessed using Pearson correlations to ensure that none of the observed relationships were greater than $r = .70$. This was done to ensure that variables are not redundant, and that each makes a unique contribution to further analyses. As can be seen in Table 1, the highest correlation between these variables was found to be between the WAIS Working Memory Index and the WCST Preservative Errors T-score ($r = .52$, n= 62, $p < .001$). As the correlations between dependent variables were not excessive, MANOVA was employed.

Global Indices. MANOVA was utilized to test the first hypothesis that PS participants would exhibit impairment in working memory and executive functioning tasks compared to the MC group. The results of this analysis indicated no significant differences in the linear combination of working memory and executive functioning performance based on risk status, *F*

Table 1:

Pearson Correlations Between Dependent Variables.

	VWMI	*WMI*	*Perseverative Errors*	*Trials to Complete First*	*Failure to Maintain Set*	*Learning To Learn*
VWMI	-					
WMI	.437	-				
Perseverative Errors	.394	.522	-			
Trials to Complete First	-.395	-.389	-.549	-		
Failure to Maintain Set	-.128	-.280	-.417	.216	-	
Learning To Learn	-.139	.093	.151	.371	-.144	-

Note: VWMI = Visual Working Memory Index, WMI = Working Memory Index

*(*5, 52)= 1.40, *p* = .23. Wilks' lambda for the multivariate test was .881, which indicates that roughly 12% of the variance in the multivariate composite scores can be accounted for by group membership. Although the multivariate test did not reach the necessary significance criterion, each dependent variable was examined, individually, for differences by group.

Univariate analyses were utilized to examine relationships between group membership and performance on the indices of interest. These results can be viewed in Table 2. Although none of the global index scores reached the criterion of significance with α set at .05, differences in the VWMI by risk group were significant at the level of α =.10, as PS participants (*M* = 100.78, *SD* = 15.01) scored lower than their MC counterparts (*M* = 107.47, *SD* = 12.85), *F (*1,60) = 3.53, *p* =.065. Further, the differences between the two groups reflected an effect of moderate magnitude (*d* =.48).

The remainder of the indices failed to reach significance with α set at either .05 or the more relaxed standard of .10. For instance, there was only a small difference (*d* =.11) between PS (*M* = 95.78, *SD* = 11.65) and MC (*M* = 97.07, *SD* = 11.23) participants on the WAIS WMI.

Likewise, there were no significant differences on the indices of the WCST. Although there was a small effect (*d*=.21) for PS participants (*M* = 56.29, *SD* = 10.62) evidencing slightly more perseverative errors than the MC participants (*M* = 53.86, *SD* = 12.50) on the Perseverative Errors T-score index, this difference was not significant by either level of alpha employed in the current study. There was a small effect (*d* = .18), in the hypothesized direction, for group differences on the Failure to Maintain Set index. On this index, PS participants (*M* = .84, *SD* = 1.02) evidenced slightly more difficulty in staying on task than did MC participants (*M* = .67, *SD* = .96), although the observed level of difference did not cross the threshold for statistical

Table 2:

Univariate statistics for parent scales by MC and PS group.

Variable	*Group*	*N*	*Mean*	*SD*	*F*	*d*
VWMI	MC	30	107.47	12.85	3.53*	.48
	PS	32	100.78	15.01		
WMI	MC	30	97.07	11.23	0.19	.11
	PS	32	95.78	11.65		
Perseverative Errors	MC	29	53.86	12.50	0.66	.21
	PS	31	56.29	10.62		
Trials to 1st	MC	30	13.83	6.81	0.12	.09
	PS	32	13.34	4.26		
Fail to Maintain	MC	30	.67	.96	0.49	.18
	PS	32	.84	1.02		
Learning to Learn	MC	28	-.58	3.03	0.65	.21
	PS	32	-.03	2.26		

Note: VWMI = Visual Working Memory Index, WMI = Working Memory Index. * = $p < .10$

significance. There was essentially no difference (*d* =.09) between PS (*M* = 13.34, *SD* = 4.26) and MC (*M* = 13.83, *SD* = 6.81) participants on the Trials to Complete First Category index scores. There was a small effect (*d* =.21), for group differences on the Learning to Learn index, although this difference is contrary to what was hypothesized. On this index, the PS participants (*M* = -.03, *SD* = 2.26) evidenced slightly better learning than did the MC group (*M* = -.58, *SD* = 3.03).

Subscale analyses. Further examinations of PS/MC group differences were also performed at the subtest level (see Table 3). With regard to the VWMI subscales, and consistent with the hypothesis of decreased working memory abilities, there was a moderately strong effect (*d* = .57) in which the PS group (*M* = 8.94, *SD* = 3.27) scored significantly lower, F (1, 60) = 5.00, *p* = .029, on the Spatial Addition subtest of the WMS-IV than did the MC group (*M* = 10.60, *SD* = 2.50). There was a small (*d* = .23), but non-significant effect for the PS participants (*M* = 11.34, *SD* =2.79) performing slightly worse than the MC group (*M* = 11.97, *SD* = 2.72) on the Symbol Span subtest.

The subscales comprising the WAIS WMI were also examined separately. Unlike the VWMI scales of the WMS, there were only negligible differences between the two groups on these scales. For example, there was virtually no difference (*d* = .10) between PS (*M* = 9.38, *SD* = 2.47) and MC (*M* = 9.60, *SD* = 2.08) participants on the DS Total scale. Likewise, there was little difference (*d* = .12) in the both the DS Forward scores between PS (*M* = 8.72, *SD* = 2.85) and MC (*M* = 9.03, *SD* = 2.28) participants, as well DS Sequencing (*d* = .08) between the PS (*M* = 10.06, *SD* = 2.91) and MC (*M* = 10.30, *SD* = 2.91) groups. On DS Backward, the difference between PS (*M* = 10.00, *SD* = 2.30) and MC (*M* = 10.03, *SD* = 2.06) participants was virtually non-existent (*d* = .02). Finally, there was little difference (*d* = .12) performance between PS (*M* =

Table 3:

Univariate statistics for Wechsler subscales by MC and PS group.

Variable	*Group*	*N*	*M*	*SD*	*F*	*d*
Spatial Addition	MC	30	10.60	2.50	5.00*	0.57
	PS	32	8.94	3.27		
Symbol Span	MC	30	11.97	2.72	0.79	0.23
	PS	32	11.34	2.79		
Digit Span Total	MC	30	9.60	2.08	0.15	0.10
	PS	32	9.38	2.47		
Digit Span Forward	MC	30	9.03	2.28	0.23	0.12
	PS	32	8.72	2.85		
Digit Span Backward	MC	30	10.03	2.06	0.00	0.02
	PS	32	10.00	2.30		
Digit Span Sequencing	MC	30	10.30	2.77	0.11	0.08
	PS	32	10.06	2.91		
Arithmetic	MC	30	9.40	2.57	0.20	0.11
	PS	32	9.13	2.30		

Note: The Spatial Addition and Symbol Span scales comprise the Visual Working Memory Index of the WMS-IV. The Digit Span subscales and Arithmetic scale comprise the Working Memory Index of the WAIS-IV. * = $p < .05$

9.13, *SD* = 2.30) and MC (*M* = 9.40, *SD* = 2.57) participants on the AR subtest of the WAIS WMI.

Correlations. Additionally, Pearson correlations between individual WSS scores and scores on the WCST, WMS-IV and WAIS-IV were obtained to examine the hypothesis that a positive linear relationship will exist between the level of deviancy demonstrated on the WSS and the level of impairment demonstrated on executive functioning and working memory tasks (see Table 4).

In support of this hypothesis, *SocAnh* scores were found to be negatively correlated with scores on the WMS-IV VWMI (r = -.25, n = 62, p = .047), but not with WAIS-IV WMI Scores or any of the WCST index scores. Within the subscales of the VWMI, *SocAnh* scores were found to be negatively correlated with Spatial Addition scores (r = -.25, n = 62, p = .032). Neither *MagId* nor *PerAb* scores, however, demonstrated a significant relationships with any of the variables of interest.

Comparisons of *SocAnh* and *Per-Mag* participants

Global Indices. In order to further examine variations in performance within the PS group based on symptom presentation, one-way ANOVAs were utilized to examine differential performance on parent and subscales between *SocAnh* and *Per-Mag* groups, which was consisted of individuals who were deviant on either *PerAb*¸ *MagId*, or both (see Table 5). Although none of the global index scores reached the criterion of significance with α set at .05, differences on the WMI were significant at the level of α =.10. On this comparison, the *SocAnh* group (*M* = 94.12, *SD* = 10.94) scored notably lower than the *Per-Mag* group (*M* = 103.00, *SD* = 12.92); Cohen's *d* for this difference was .79.

Table 4:

Correlations for target variables with Wisconsin Schizotypy Scales.

Target Variable	*Revised Social Anhedonia*	*Magical Ideation*	*Perceptual Aberration*
Working Memory Index	-.18	-.06	-.12
Digit Span Total	-.19	.06	.00
Digit Span Forward	-.19	.14	.10
Digit Span Backward	-.11	.05	-.08
Digit Span Sequencing	-.10	-.11	-.08
Arithmetic	-.13	-.16	-.21
Visual Working Memory Index	-.25*	-.13	-.04
Spatial Addition	-.27*	-.13	-.12
Symbol Span	-.15	-.09	.06
Perseverative Errors	.09	-.07	-.06
Trials to Complete First	.03	.08	.01
Failure to Maintain Set	.14	.18	.17
Learning To Learn	.11	.07	-.03

* Significant at $p < .05$

Table 5:

Univariate statistics for SocAnh and Per-Mag groups on parent scales.

Variable	*Group*	*N*	*Mean*	*SD*	*F*	*d*
VWMI	SocAnh	26	100.08	15.49	0.30	0.25
	Per-Mag	6	103.83	13.53		
WMI	SocAnh	26	94.12	10.94	3.02*	0.79
	Per-Mag	6	103.00	12.92		
Perseverative Errors	SocAnh	26	55.96	9.75	0.12	0.16
	Per-Mag	6	57.67	14.77		
Trials to 1st	SocAnh	26	13.23	4.34	0.09	0.14
	Per-Mag	6	13.83	4.22		
Fail to Maintain	SocAnh	26	0.88	0.99	0.22	0.21
	Per-Mag	6	0.67	1.21		
Learning to Learn	SocAnh	26	-0.18	2.37	0.63	0.36
	Per-Mag	6	0.64	1.74		

Note: VWMI = Visual Working Memory Index, WMI = Working Memory Index. * = $p < .10$

The remaining global indices failed to reach significance at either α level; however, the Learning to Learn index on the WCST did evidence a moderate effect (*d* = .36), as individuals in the *Per-Mag* group (*M* = .64, *SD* = 1.74) evidenced better learning than those in the *SocAnh* group (*M* = -.18, *SD* = 2.37). Similarly, the VWMI indicated a small effect (*d* = .25), as *Per-Mag* participants (*M* = 103.83, *SD* = 13.53) scored somewhat higher than the *SocAnh* (*M* = 100.08, *SD* = 15.49) group. Likewise, a small effect (*d* = .21) was noted on the Failure to Maintain Set index on the WCST, with the *SocAnh* group (*M* = 0.88, *SD* = 0.99) demonstrating more difficulty in maintaining set than did the *Per-Mag* (*M* = 0.67, *SD* = 1.21) group. The effect sizes were negligible (*d* = .16) for Perseverative Errors T-scores differences between the *SocAnh* (*M* = 55.96, *SD* = 9.75) and *Per-Mag* (*M* = 57.67, *SD* = 14.77) groups, as well as for the Trials to Complete First Category index (*d* = .14), as the means for the *SocAnh* (*M* = 13.23, *SD* = 4.34) and *Per-Mag* groups (*M* = 13.83, *SD* = 4.22) showed little difference.

Subscale analyses. *SocAnh* and *Per-Mag* group differences on the WAIS-IV and WMS-IV subscales were also examined through the use of one-way ANOVA (see Table 6). Analysis of group differences on the WAIS-IV WMI subscales revealed a very large effect (*d* = 1.04), as the *SocAnh* (*M* = 8.92, *SD* = 2.23) group performed significantly worse than the *Per-Mag* group (*M* = 11.33, *SD* = 3.67) on Digit Span Total, *F* (2, 30) = 5.27, *p* = .029. Within this subtest, there was also a very substantial difference (*d* = 1.34) for the *SocAnh* (*M* = 8.08, *SD* = 2.23) group scoring significantly lower on the Digit Span Forward task than the *Per-Mag* group (*M* = 11.50, *SD* = 3.78) , *F* (2, 30)= 8.77, *p* = .006. Although the difference between the *SocAnh* (*M* = 9.73, *SD* = 2.03) and Per-Mag groups (*M* = 11.17, *SD* = 3.20) was not significant on the Digit Span Backward task, a notable effect size (*d* = .63) was observed for the mean difference. Likewise, a small effect (*d* = .25) was detected for mean DS Sequencing between the *SocAnh* (*M* = 9.92, *SD*

Table 6:

Univariate statistics for SocAnh and Per-Mag groups for Wechsler subscales.

Variable	*Group*	*N*	*M*	*SD*	*F*	*d*
Spatial Addition	SocAnh	26	8.85	3.37	0.10	0.15
	Per-Mag	6	9.33	3.08		
Symbol Span	SocAnh	26	11.19	2.90	0.40	0.29
	Per-Mag	6	12.00	2.37		
Digit Span Total	SocAnh	26	8.92	1.94	5.27*	1.04
	Per-Mag	6	11.33	3.67		
Digit Span Forward	SocAnh	26	8.08	2.23	8.77**	1.34
	Per-Mag	6	11.50	3.78		
Digit Span Backward	SocAnh	26	9.73	2.03	1.96	0.63
	Per-Mag	6	11.17	3.19		
Digit Span Sequencing	SocAnh	26	9.92	2.88	0.31	0.25
	Per-Mag	6	10.67	3.20		
Arithmetic	SocAnh	26	9.00	2.42	0.40	0.29
	Per-Mag	6	9.67	1.75		

Note: The Spatial Addition and Symbol Span scales comprise the Visual Working Memory Index of the WMS-IV. The Digit Span subscales and Arithmetic scale comprise the Working Memory Index of the WAIS-IV. * = $p < .05$, ** = $p < .01$

= 10.67) and Per-Mag (*M* = 11.17, *SD* = 3.20) groups. Comparisons of scores on the Arithmetic subtest of the WAIS-IV WMI subtest also resulted in a small (*d* = .29), but non-significant effect in which the *SocAnh* (*M* = 9.00, *SD* = 2.42) group performed worse than the *Per-Mag* (*M* = 9.67, *SD* = 1.75) group.

Analyses of the subtests of the WMS-IV VWMI failed to indicate significant differences at either α = .05 or α = .10. However, a small effect (*d* = .29) was found for the *SocAnh* (*M* = 11.19, *SD* = 2.90) group performing slightly worse than the *Per-Mag* group (*M* = 12.00, *SD* = 2.37) on the Symbol Span subtest. Group differences on the Spatial Addition subtest were small (*d* = .15), but consistent in direction, as the *SocAnh* (*M* = 8.85, *SD* = 3.35) group performed slightly worse than the *Per-Mag* group (*M* = 9.33, *SD* = 3.08).

Comparison of *SocAnh* and MC participants

Global Indices. The next group of analyses compared the participants with deviant scores on *SocAnh* to the MC participants. One-way ANOVAs were employed to examine scores on the variables of interest; these results can be viewed in Table 7. Although none of the global index scores reached the criterion of significance with α set at .05, differences in the VWMI by risk group were significant at the level of α =.10, as *SocAnh* participants (*M* = 100.19 *SD* = 15.20) scored lower than their MC counterparts (*M* = 107.47, *SD* = 12.85), *F (*1,60) = 3.53, *p* =.065. Further, the differences between the two groups reflected an effect of moderate magnitude (*d* =.52).

On the WAIS-IV WMI no significant difference between group means was detected at either α level. However, a small effect was detected (*d* = .27) for the *SocAnh* group (*M* = 94.15, *SD* = 10.73) performing slightly worse than the MC group (*M* = 97.07, *SD* = 11.22).

Table 7:

Univariate statistics for Matched Comparison and SocAnh groups on parent scales.

Variable	*Group*	*N*	*Mean*	*SD*	*F*	*d*
VWMI	MC	30	107.47	12.85	3.84*	0.52
	SocAnh	27	100.19	15.20		
WMI	MC	30	97.07	11.22	1.00	0.27
	SocAnh	27	94.15	10.73		
Perseverative Errors	MC	30	53.86	12.50	0.41	0.17
	SocAnh	27	55.77	9.60		
Trials to 1st	MC	30	13.83	6.81	0.09	0.08
	SocAnh	27	13.37	4.32		
Fail to Maintain	MC	30	0.67	0.96	0.51	0.19
	SocAnh	27	0.85	0.99		
Learning to Learn	MC	30	-0.58	3.03	0.22	0.12
	SocAnh	27	-0.25	2.34		

Note: VWMI = Visual Working Memory Index, WMI = Working Memory Index. * = $p < .10$

Likewise, there were no significant differences between the groups on any of the WCST indices. The largest effect found within this group of scales was on the Failure to Maintain Set index, which demonstrated a small (*d* = .19) difference in *SocAnh* (*M* = 0.67, *SD* = 0.96) and MC (*M* = 0.85, *SD* = 0.99) performance. The next largest effect (*d* = .17) was found for Perseverative Errors, on which the *SocAnh* group (*M* = 55.77, *SD* = 9.60) evidenced a slight tendency toward more perseveration than did the MC group (*M* = 53.86, *SD* = 12.50). Group differences on the Learning to Learn scale not only failed to demonstrate significance, but were of a very small effect (*d* = .12), as there was a great deal of overlap among the *SocAnh* (*M* = -0.58, *SD* = 3.03) and MC (*M* = -0.25, *SD* = 2.34) group scores. A similar phenomenon occurred when comparing the scores of the *SocAnh (M* = 13.83, *SD* = 6.81) and MC (*M* = 13.37, *SD* = 4.32) individuals on the Trials to Complete First Category index failed, which indicated a negligible (*d* = .08) effect for the difference between groups.

Subscale analyses. The *SocAnh* and MC groups' subscale scores on the WAIS-IV WMI and WMS-IV VWMI were also compared. The results of these analyses can be viewed in Table 8.

With regard to the VWMI subscales, and in line with the results of the PS/MC group comparisons, there was a significant difference, F (1,56) = 4.67, p = .035, on the Spatial Addition subtest between the *SocAnh* and MC groups as the former (*M* = 8.93, *SD* = 3.33) evidenced moderately weaker performance (*d* = .57) than the latter group (*M* = 10.60, *SD* = 2.50). Similarly, there was a small (*d* = .29), but non-significant effect for the *SocAnh* participants (*M* = 11.15, *SD* = 2.85) performing slightly worse than the MC group (*M* = 11.97, *SD* = 2.72) on the Symbol Span subtest.

Table 8:

Univariate statistics for Matched Comparison and SocAnh groups for Wechsler subscales.

Variable	*Group*	*N*	*M*	*SD*	*F*	*d*
Spatial Addition	MC	30	10.60	2.50	4.67*	0.57
	SocAnh	27	8.93	3.33		
Symbol Span	MC	30	11.97	2.72	1.23	0.29
	SocAnh	27	11.15	2.85		
Digit Span Total	MC	30	9.60	2.08	1.62	0.34
	SocAnh	27	8.93	1.90		
Digit Span Forward	MC	30	9.03	2.28	2.62	0.43
	SocAnh	27	8.07	2.18		
Digit Span Backward	MC	30	10.03	2.06	0.16	0.11
	SocAnh	27	9.81	2.04		
Digit Span Sequencing	MC	30	10.30	2.77	0.31	0.15
	SocAnh	27	9.89	2.83		
Arithmetic	MC	30	9.40	2.57	0.37	0.16
	SocAnh	27	9.00	2.37		

Note: The Spatial Addition and Symbol Span scales comprise the Visual Working Memory Index of the WMS-IV. The Digit Span subscales and Arithmetic scale comprise the Working Memory Index of the WAIS-IV. * = $p < .05$

None of the WAIS-IV WMI subscale analyses yielded significant results. However, the group differences on the DS Total scale reflected a small effect (*d* = .34), as the *SocAnh* group (*M* = 8.93, *SD* = 1.90) performed slightly worse than did the MC group (*M* = 9.60, *SD* = 2.08). Among the DS subscales, the DS Forward scores evidenced the greatest disparity between group scores as *SocAnh* group (*M* = 8.07, *SD* = 2.18) performed less well than the MC group (*M* = 9.03, *SD* = 2.28); this difference is consistent with an effect of moderate magnitude (*d* = .43). As with the PS/MC group comparisons, however, there was little difference in the two groups' scores on the remaining WMI subscales. Of the remaining scales, the AR subscale revealed the greatest difference (*d* = .16) between the *SocAnh* (*M* = 9.00, *SD* = 2.37) and MC groups (*M* = 9.40, *SD* = 2.57). Next in magnitude was the difference (*d* = .15) in DS Sequencing scores between the *SocAnh* (*M* = 9.89, *SD* = 2.83) and MC (*M* = 10.30, *SD* = 2.77) groups. Finally, with regard to mean differences on the Digit Span Backward task, there was only a very small difference (*d* = .11) between *SocAnh* (*M* = 9.81, *SD* = 2.04) and MC (*M* = 10.03, *SD* = 2.06) participants.

Comparison of *Per-Mag* and MC participants

Global indices. The final group of analyses compared the participants with deviant scores on *Per-Mag* to the MC participants. One-way ANOVAs were employed to examine scores on the variables of interest; these results can be viewed in Table 9. None of the global indices demonstrated differences at either α level utilized in this study. Two of the analyses revealed small effects in the hypothesized direction; however, two analyses revealed moderate effects that were in the opposite direction than what was predicted.

A comparison of scores on the WMS-IV VWMI evidenced a small effect (*d* = .28) wherein the *Per-Mag* group (*M* = 103.83, *SD* = 13.53) did not perform as well as the MC group

Table 9:

Univariate statistics for Matched Comparison and Per-Mag groups on parent scales.

Variable	*Group*	*N*	*Mean*	*SD*	*F*	*d*
VWMI	MC	30	107.47	12.85	0.39	0.28
	Per-Mag	6	103.83	13.53		
WMI	MC	30	97.07	11.22	1.33	0.52
	Per-Mag	6	103.00	12.92		
Perseverative Errors	MC	29	53.86	12.50	0.43	0.30
	Per-Mag	6	57.67	14.77		
Trials to 1st	MC	30	13.83	6.81	0.00	0.00
	Per-Mag	6	13.83	4.22		
Fail to Maintain	MC	30	0.67	0.96	0.00	0.00
	Per-Mag	6	0.67	1.21		
Learning to Learn	MC	28	-0.58	3.03	0.89	0.43
	Per-Mag	6	0.64	1.74		

Note: VWMI = Visual Working Memory Index, WMI = Working Memory Index.

(*M* = 107.47, *SD* = 12.85). Likewise, there was a small effect (*d* = .30) for the *Per-Mag* group (*M* = 53.86, *SD* = 12.50) to exhibit more perseverative errors than the MC group (*M* = 57.67, *SD* = 14.77) on the WCST.

There was no difference (*d* = .00) between the *Per-Mag* (*M* = 13.83, *SD* = 4.22) and MC (*M* = 13.83, *SD* = 6.81) groups on the WCST Trials to Complete First Category. Neither was there any difference, at all, (*d* = .00) between *Per-Mag* (*M* = 0.67, *SD* = 0.96) and MC (*M* =0.67, *SD* = 1.21) participants on the Failure to Maintain Set index.

Scores on the WAIS-IV WMI subscales indicated that the *Per-Mag* (*M* = 103.00, *SD* = 12.92) group performed moderately (*d* = .52) better than the MC group (*M* = 97.07, *SD* = 11.22). The WCST Learning to Learn index evidenced a moderate effect (*d* = .43), such that the *Per-Mag* (*M* = 0.64, *SD* = 1.74) group performed better than the MC group (*M* = -0.58, *SD* = 1.74).

Subscale analyses. Further examinations of *Per-Mag*/MC group differences were also performed at the subtest level (see Table 10). As noted above, there was a small effect for the *Per-Mag* performing at a lower level than the MC participants on the WMS VWMI. An examination of the subscales of that index revealed a moderate effect (*d* = .49) on the Spatial Addition subtest. On this task the *Per-Mag* (*M* = 9.33, *SD* = 3.08) group evidenced lower levels of ability than did the MC group (*M* = 10.60, *SD* = 2.50). On the Symbol Span subtest there was virtually no difference (*d* = .01) in performance between the *Per-Mag (M* = 12.00, *SD* = 2.27) and MC groups (*M* = 11.97, *SD* = 2.72).

Also as noted above, there was a moderate, but non-significant effect for the *Per-Mag* group to perform better than the MC participants on the WAIS-IV WMI. Analyses of the DS Total scale revealed a large-sized effect (*d* =. 73) for the *Per*-Mag group (*M* = 11.33, *SD* = 3.67) to outperform the MC participants (*M* = 9.60, *SD* = 2.08. Further examination of the DS

subscales revealed a large effect (d = .96) for the *Per-Mag* group (M = 11.50, SD = 3.78) performed significantly better, F (1,35) = 4.65, p = .038, than the MC group (M = 9.03, SD = 2.28) on the DS Forward subscale. Similarly, DS backward demonstrated a moderate effect (d = .50), for the *Per-Mag* (M = 11.17, SD = 3.19) group outperforming the MC group (M = 10.03, SD = 2.06). The effects for mean differences by group on the remaining subscales of the WMI were quite small. The DS Sequencing subtest score comparison revealed only a very small difference (d = .13) between *Per-Mag* (M = 10.67, SD = 3.20) and MC (M = 10.30, SD = 2.77) performance. Finally, there was also only a small (d = .11) difference on the AR subscale between *Per-Mag* (M = 9.67, SD = 1.75) and MC (M = 9.40, SD = 2.57) groups.

Table 10:

Univariate statistics for Matched Comparison and Per-Mag groups for Wechsler subscales.

Variable	*Group*	*N*	*M*	*SD*	*F*	*d*
Spatial Addition	MC	30	10.60	2.50	1.19	0.49
	Per-Mag	6	9.33	3.08		
Symbol Span	MC	30	11.97	2.72	0.00	0.01
	Per-Mag	6	12.00	2.37		
Digit Span Total	MC	30	9.60	2.08	2.65	0.73
	Per-Mag	6	11.33	3.67		
Digit Span Forward	MC	30	9.03	2.28	4.65*	0.96
	Per-Mag	6	11.50	3.78		
Digit Span Backward	MC	30	10.03	2.06	1.26	0.50
	Per-Mag	6	11.17	3.19		
Digit Span Sequencing	MC	30	10.30	2.77	0.08	0.13
	Per-Mag	6	10.67	3.20		
Arithmetic	MC	30	9.40	2.57	0.06	0.11
	Per-Mag	6	9.67	1.75		

Note: The Spatial Addition and Symbol Span scales comprise the Visual Working Memory Index of the WMS-IV. The Digit Span subscales and Arithmetic scale comprise the Working Memory Index of the WAIS-IV. * = $p < .05$

CHAPTER 5

Discussion

A notable finding of the present study is the support for Meehl's (1962, 1990) proposal that approximately 10% of individuals will express some symptoms of schizotypy. Of the 349 individuals in the initial sample, 32 demonstrated schizotypy as assessed by the WSS. As the present sample consisted of currently enrolled undergraduate students with presumably high functioning, this finding provides additional evidence to support Meehl's suggestion that schizotypes may not necessarily demonstrate any clinically significant symptoms, or have any severe disturbance in functioning. Further, these findings support the use of the WSS in the detection of schizotypy, as they demonstrate utility in detecting these features at the expected base rate and underscore the utility of the WSS in identifying schizotypes who may not come to clinical attention or be considered at risk due to genetic factors, as only two individuals in the present study reported a family history of schizophrenia. This may assist in future research, or aid in the future clinical identification of at-risk individuals.

Working Memory

Results of the present study failed to provide support for the hypothesis that aggregate working memory performance would vary significantly between PS and MC participants. This finding runs contrary to previous investigations of global working memory performance in

individuals at risk for schizophrenia spectrum disorders (Glahn et al., 2003; Horan et al., 2008; Jahshan et al., 2010). However, differential performance on the VWMI of the WMS-IV approached significance and demonstrated a notable effect with PS participants evidencing less effective working memory than their MC counterparts. Moreover, both the Spatial Addition and Symbol Span subtests of the VWMI indicated some evidence of impaired PS performance, with differences on Spatial Addition demonstrating statistical significance as well as a notable effect, and the Symbol Span subtest demonstrating a small, but non-significant effect. The WMI of the WAIS-IV failed to produce significant results with regard to differentiating PS and MC participants both as an aggregate index score and when examined as individual subtests.

Results also failed to provide support for the hypothesis that a negative linear relationship would exist between WSS scores and scores on all working memory assessments. However, such a relationship was observed specifically between scores on the *SocAnh* subscale of the WSS and the VWMI. This indicates that individuals with these particular schizotypic features may demonstrate greater visual working memory impairment as symptoms increase.

Results of analyses based on sub-group membership of PS participants indicated that individuals with elevated scores on the *SocAnh* scale of the WSS performed notably worse on the WMI and VWMI than did individuals in the *Per-Mag* sub-group, although only the WMI achieved significance. Both the *SocAnh* and *Per-Mag* groups demonstrated notably impaired performance comparison on the VWMI and WMI in comparison to the MC group, however only the impairment of the *SocAnh* group on the VWMI demonstrated statistically significant results.

These results suggest that some relationship between psychometric schizotypy and working memory impairment may exist, although the sample in the present study may be insufficient to detect it. A number of the analyses performed yielded small to moderate effects in

the hypothesized direction, although they failed to reach statistical significance. It should be noted that although the effects observed are small to moderate, they are consistent with those found in previous studies (c.f., Bolinskey & Gottesman, 2010). The fact that relatively robust effects were achieved in the absence of statistically significant results suggests that, with a larger sample, clearer, significant results might be obtained.

Additionally, the present results provide differential support for visual working memory and auditory working memory. Results indicate that the VWMI was the only index that demonstrated a difference between in the comparison of PS and MC groups. This may indicate that visual working memory, specifically, may be more representative of the deficits present in the sub-group of schizotypes represented in this sample. In the present study, a majority of individuals who demonstrated schizotypic features did so on a measure of negative symptomology, the *SocAnh* scale. It has been suggested that individuals exhibiting the negative symptoms of schizotypy, such as social anhedonia, demonstrate particular impairment in visual working memory, although studies examining this hypothesis have obtained inconsistent results. Some investigations (e.g., Cameron et al., 2002; Park et al., 2003) have reported visual working memory impairments, as opposed to general working memory impairment, to be particularly related to negative symptoms in individuals with schizophrenia. However, Gooding and Tallent (2002) failed to find support for specific visual working memory impairment, but instead suggested that working memory impairments in individuals with social anhedonia were not domain specific. Even within the results of the present study, analysis beyond aggregate group difference yielded inconsistent findings. That is, although the VWMI indicated a significant discrepancy between PS and MC scores, the WMI demonstrated the most notable discrepancy between the *SocAnh* and *Per-Mag* sub-groups, although the VWMI indicated a less substantial

difference. One consideration in the present study, is that the WMI subtests are comprised of verbal tasks, relying on verbal working memory. It may be that individuals with both positive and negative symptoms exhibit impairment in visual working memory to some degree, but impairment in verbal working memory is associated to a greater degree with negative symptoms. Thus, the present results agree somewhat with Gooding and Tallent, in suggesting that working memory deficits are not domain-specific in individuals with the negative symptoms of schizotypy, although current results suggest that deficits may, indeed, be more domain-specific in individuals with more positive symptoms. Although the present results do not appear to indicate definitive support to either proposal, they certainly serve to underscore the need for additional information regarding specific working memory impairments in positive vs. negative presentations of schizotypy.

Executive functioning

Scores on the WCST indices failed to exhibit significant differences between PS and MC participants. However, there was a small effect for PS participants making a greater number of perseverative errors than MC participants, a finding which is consistent with previous findings results (Eastvold et al., 2007; Jashan et al., 2010). This finding may be particularly notable in the present study, as perseverative tendencies have been particularly linked to social anhedonia (Everett et al., 2001; Laurent, et al., 2001). The population of the PS participant group in the present study, which was largely comprised of individuals reporting symptoms of social anhedonia, may have made this finding more accessible, in the absence of others. Additionally, there was a small effect for PS participants having more difficulty maintaining set than did MC participants. Although the effect was small, its direction is consistent with the hypothesis and previous findings (Lenzenweger & Korfine, 1994).

Results also failed to provide support for the hypothesis that a negative linear relationship would exist between deviance on WSS and executive functioning. This may indicate that a relationship does not exist between level of deviance on the WSS and executive functioning. However, another possibility is that the sample utilized in the present study was ill-equipped to detect the relationship, as executive functioning deficits have been proposed to be primarily related to positive symptomology (Donohoe et al., 2006; Lenzenweger & Korfine, 1994), which few of the participants in the present study exhibited.

A surprising finding was that PS participants scored slightly higher than MC participants on the Learning to Learn scale, a scale which is reflective of improvement in performance throughout the test and insight into testing principles (Heaton et al., 1993). Upon further investigation between sub-groups of PS participants, it was found that the *Per-Mag* group outperformed both the MC and *SocAnh* group in this regard, a particularly surprising finding, as executive functioning deficits have been proposed to be particularly related to *PerAb* item endorsement (Lenzenweger &Korfine, 1994). The present finding fails to support the existing literature. It may be that this finding is anomalous, given that only 6 participants demonstrated deviance on the *Per-Mag* dimensions; it may be that these 6 individuals are not reflective of the typical individuals deviant on those dimensions.

Taken together, the present results in regard to executive functioning suggest that some differences may exist, although the sample utilized in this study may have been insufficient for detecting those differences. Prior studies have suggested that the most notable differences in executive functioning are associated with positive symptomology (Donohoe et al., 2006; Lenzenweger & Korfine, 1994). Thus, the sample utilized in the present study, which was mostly comprised of individuals with negative symptom presentation, may have been insufficient to

detect any significant or robust results in regard to executive functioning. For example, Lenzenweger (1994) reported notable impairments across a number of domains of executive functioning, although his sample was restricted to individuals who scored in the deviant range of the *PerAb* scales of the WSS. It may be that individuals reporting the perceptual abnormalities assessed by the *Per-Mag* scales scale differ in a meaningful way, in terms of executive functioning, from individuals who report other symptoms of schizotypy. If this is the case, it is likely that the small number of *Per-Mag* deviant scorers in this sample was not sufficient to detect such a result.

Strengths of the current study

Strengths of the present study include the use of psychometric measures to identify increased liability to schizophrenia spectrum disorders, rather than limiting the high-risk sample to individuals who are genetically related to probands. Furthermore, the present study utilized well-validated and widely-used measures in order to investigate variables of interest. A particular strength in this area is the use of the WMS-IV VWMI, which has yet to be included in investigations of schizotypy and schizophrenia proneness due to its recent availability. Additionally, the present study takes place as part of a larger longitudinal study investigating a number of proposed endophenotypes; therefore, the present sample will continue to be built upon and will be followed over a 10-year period in order to further inform our understanding of endophenotypes of schizophrenia spectrum disorders. Finally, the present study is supported by strong theoretical underpinnings, as the rationale for this study is highly influenced by Meehl's (1962, 1990) model.

Limitations of the current study

The present study is not without limitations. Although the larger study from which the current investigation is derived is of a prospective design, the current investigation incorporates only a single time point. The cross-sectional nature of the current investigation does not allow for long term assessment of participants, and does not provide information on whether individuals who demonstrated deficits in working memory and executive functioning will be more likely to develop symptomology of schizophrenia spectrum disorders. Additionally, the PS sample represented a somewhat one dimensional view of schizotypy, as a majority of individuals obtained deviant scores only on the *SocAnh* scale, which primarily assesses negative symptomology. Therefore, deficits more closely related to positive symptoms would necessarily be less likely to be observed in this sample. Further, the demographic makeup of the sample, in which women and Caucasians are over-represented, is not likely representative of the population, at large; thus, it is unclear whether similar results would be obtained in an ethnically diverse sample or with a greater number of men. Furthermore, not all PS participant pairs were able to be perfectly matched on all desired variables (gender, age, ethnicity, and college major); it is possible that imperfect matches in some cases may have introduced additional variance into the sample, obscuring results.

Future Directions

Future investigations should examine whether deficits in working memory and executive functioning are linked to greater symptomology on a longitudinal basis. It would be beneficial to replicate the present methods in a larger, more diverse sample in order to determine whether the present results have been largely affected by sample size. It may also be worthwhile to replicate methods in a sample whose members demonstrate both positive and negative dimensions of

schizotypy. As the most notable finding in the present study was the difference in performance between PS and MC participants on the VWMI of the WMS-IV, a recently available index, future investigations should include this index to further examine how the different process associated with these two types of memory are associated with schizophrenia liability, specifically with regard to positive and negative symptoms of schizotypy.

It would be beneficial for the candidate endophenotypes of interest in the current study to be examined in conjunction with other candidate endophenotypes that have also been the subjects of recent independent investigation, such as personality characteristics (Bolinskey et al., 2010; Bolinskey & Gottesman, 2010; Smith et al., 2008). It may also be beneficial to examine working memory and executive functioning deficits in conjunction with minor physical anomalies that have been indicated as markers of the disorder (Torrey et al., 1994). Investigations including a variety of proposed markers of increased vulnerability may help to provide a more complete picture of schizophrenia proneness.

As previously noted, the present study is a cross-sectional portion of a larger longitudinal study investigating the role of a number of candidate endophenotypes and other proposed markers in the development schizophrenia spectrum illnesses. Among the markers being investigated, in addition to working memory and executive functioning, are personality characteristics, minor physical anomalies, season of birth (Modestin, Ammann, & Wuermle, 1995; Torrey, Rawlings, Ennis, Merrill, & Flores, 1996) and atypical handedness (e.g., Dane et al., 2009; Dragovic & Hammond, 2005; Reilly et al., 2001; Sommer, Aleman, Ramsey, Bouma, & Kahn, 2001). Individually, these markers have well-documented relationships to schizotypy; however, in most cases, they have not the subjects of concurrent investigation.

The parent study will allow for each of the above-noted indicators, as well as those that are the subject of the current investigation, to be observed in the same sample over an extended period of time. Preliminary findings from the larger study have indicated support for some of these candidate endophenotypes, as both atypical handedness (Bolinskey, Iati, Hunter, & Novi, 2012) and abnormalities in personality (Bolinskey, Iati, Novi, Hunter, & Petrow, 2012) have demonstrated notable trends toward a relationship to psychometric schizotypy. By continuing to increase the size of the sample, and collecting follow-up data at 1, 2, 5, 7, and 10 years, the longitudinal study will assist in clarifying the relationship between psychometric schizotypy and working memory, executive functioning and the other proposed markers.

Summary

Existing research has offered evidence that differences in the expression of endophenotypes may be related to the dimension on which symptoms are experienced; that is, expression may vary based on whether symptoms are positive or negative (Donohoe et al., 2006). The present results support this notion. The largely homogenous sample in terms of symptom presentation and demographics produced both expected and unexpected results, which can largely be explained by the symptomology of the sample. It is possible that the similar symptom features of the present sample allowed for specific deficits to be detectable, while other abnormalities, which may be more associated with positive symptomology, were not. That is, differences associated with negative symptom presentation, such as deficits in verbal working memory and perseverative tendencies were attainable, whereas those most closely related to positive symptomology were not.

The most notable result in the present study is the abnormalities in visual working memory evidenced by PS participants. This lends support to previous research which has

indicated a meaningful demarcation between verbal and visual working memory, and that they may be differentially related to schizotypy in different presentations (Cameron et al., 2002; Park et al., 2003). Additionally, the measure of visual working memory utilized in this study, the WMS-IV VWMI, is a recently available index, introduced in 2010 as part of the new edition of the WMS and has yet to be widely used in research. The present results reflect the first exploration of its utility in investigations of schizotypy.

In addition, it is worth noting that, although many of the results in the present study failed to achieve significance, the majority demonstrated trends in the expected directions, and with effect sizes of the expected magnitude. Given a larger sample, these trends would have greater likelihood of achieving significance. An exception to this, and a peculiar finding was PS participants performing better on the Learning to Learn index of the WCST. This finding runs contrary to expectations and present literature.

These results join the growing body of literature that informs our knowledge of markers of schizophrenia spectrum disorders. A better understanding of endophenotypes of schizophrenia may be helpful in leading to the earlier identification of individuals with an increased liability, who may or may not be genetically related to an individual with the disorder. Furthermore, improved knowledge of endophenotypes may facilitate a better understanding of the biological underpinnings of the disorder.

REFERENCES

Allen, A. J., Griss, M. E., Folley, B. S., Hawkins, K. A., & Pearlson, G. D. (2009). Endophenotypes in schizophrenia: a selective review. *Schizophrenia Research, 109* (1-3), 24-37.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (*Revised 4th ed.). Washington, DC: Author.

Baddeley. A. D. (1986). *Working memory*. Oxford, UK: Oxford University Press.

Barch, D. M., Csernansky, J. G., Conturo, T., & Snyder, A. Z. (2002). Working and long-term memory deficits in schizophrenia: Is there a common prefrontal mechanism? *Journal of Abnormal Psychology, 111* (3), 478-494. doi: 10.1037/0021-843x.111.3.478

Bender, S., Weisbrod, M., & Resch, F. (2009). Functional and structural endophenotypes in schizophrenia. In M. S. Ritsner (Ed.), *The handbook of neuropsychiatric biomarkers, endophenotypes and genes, Vol 2: Neuroanatomical and neuroimaging endophenotypes and biomarkers.* (pp. 67-85). New York, NY US: Springer Science + Business Media.

Bleuler, E. (1911/1950). *Dementia praecox or the group of schizophrenias* (J. Zinkin, Trans.). New York: International Universities Press.

Bolinskey, P. K., & Gottesman, I. I. (2010). Premorbid personality indicators of schizophrenia-related psychosis in a hypothetically psychosis-prone college sample. *Scandinavian Journal of Psychology, 51* (1), 68-74. doi: 10.1111/j.1467-9450.2009.00730.x

Bolinskey, P. K., Iati, C. A., Hunter, H. K., & Novi, J. H. (2012). *Season of birth, atypical handedness, and psychometric schizotypy: Preliminary results from a prospective study.* Manuscript submitted for publication.

Bolinskey, P. K., Iati, C. A., Novi, J. H., Hunter, H. K., & Petrow, A. (2012). *Revisiting the blurry boundaries of schizophrenia: Spectrum disorders in psychometrically-identified psychosis prone individuals.* Manuscript in preparation.

Bolinskey, P. K, Trumbetta, S. L., Hanson, D. R., & Gottesman, I. I. (2010). Predicting adult psychopathology from adolescent MMPIs: Some victories. *Personality and Individual Differences 49,* 324–330. doi:10.1016/j.paid.2010.01.026

Braff, D. L., & Freedman, R. (2002). Endophenotypes in studies of the genetics of schizophrenia. In K. L. Davis, Charney, D.S., Coyle, J.T., Nemeroff, C. (Ed.), *Neuropsychopharmacology: The fifth generation of progress* (pp. 703-716). Philadelphia: Lippincott, Williams & Wilkins.

Canivez, G. L. (2009). Wechsler Adult Intelligence Scale- Fourth Edition (Test Review). Available from Ovid. Mental Measurements Yearbook Online Retrieved October 8, 2010

Cassady, J. D. (2009). Wechsler Memory Scale- Fourth Edition. (Test Review). Available from Ovid. Mental Measurements Yearbook Online Retrieved October 8, 2010

Chapman, L. J., & Chapman, J. P. (1987). The Search for Symptoms Predictive of Schizophrenia. *Schizophrenia Bulletin, 13* (3), 497-503.

Chapman, J. P., Chapman, L.J., & Kwapil, T. (1995). Scales for the measurement of schizotypy. In T. L. A. Raine, S.A. Mednick (Ed.), *Schizotypal personality* (pp. 70-106). New York: Cambridge University Press.

Chapman, L. J., & Chapman, J. P. (1985). Psychosis proneness. In M. Alpert (Ed.), *Controversies in schizophrenia: Changes and constancies: Proceedings of the 74th Annual Meeting of the American Psychopathological Association, New York City, March 1-3, 1984.* (pp. 157-172). New York, NY US: Guilford Press.

Chapman, L. J., Chapman, J. P., Kwapil, T. R., Eckblad, M., & Zinser, M. C. (1994). Putatively psychosis-prone subjects 10 years later. *Journal of Abnormal Psychology, 103* (2), 171-183. doi: 10.1037/0021-843x.103.2.171

Chapman, L. J., Chapman, J. P., & Raulin, M. L. (1976). Scales for physical and social anhedonia. *Journal of Abnormal Psychology, 85* (4), 374-382. doi: 10.1037/0021-843x.85.4.374

Chapman, L. J., Chapman, J. P., & Raulin, M. L. (1978). Body-image aberration in schizophrenia. *Journal of Abnormal Psychology, 87* (4), 399-407. doi: 10.1037/0021-843x.87.4.399

Dane, S., Yildirim, S., Ozan, E., Aydin, N., Oral, E., Ustaoglu, N., & Kirpinar, I. (2009). Handedness, eyedness, and hand-eye crossed dominance in patients with schizophrenia: Sex-related lateralisation abnormalities. *Laterality: Asymmetries of Body, Brain and Cognition, 14 (1),* 55-65. doi: 10.1080/13576500802061883

DeLisi, L. E., Svetina, C., Razi, K., Shields, G., Wellman, N., & Crow, T. J. (2002). Hand preference and hand skill in families with schizophrenia. *Laterality: Asymmetries of Body, Brain and Cognition, 7 (4),* 321-332. doi: 10.1080/13576500143000294

de la Serna, E., Baeza, I., Toro, J., Andreas, S., Puig, O., Sanchez-Guistau, V., . . . Castro-Fornieles, J. (2010). Relationship between clinical and neuropsychological characteristics in child and adolescent first degree relatives of subjects with schizophrenia. *Schizophrenia Research, 116* (2-3), 159-167. doi: 10.1016/j.schres.2009.09.001

Dickinson, D., Ragland, J. D., Gold, J. M., & Gur, R. C. (2008). General and specific cognitive deficits in schizophrenia: Goliath defeats David? *Biological Psychiatry, 64* (9), 823-827. doi: 10.1016/j.biopsych.2008.04.005

Donohoe, G., Corvin, A., & Robertson, I. H. (2006). Evidence that specific executive functions predict symptom variance among schizophrenia patients with a predominantly negative symptom profile. *Cognitive Neuropsychiatry, 11* (1), 13-32. doi:10.1080/13546800444000155

Dragovic, M., & Hammond, G. (2005). Handedness in schizophrenia: A quantitative review of evidence. *Acta Psychiatrica Scandinavica, 111 (6)*, 410-419. doi: 10.1111/j.1600-0447.2005.00519.x

Dragovic, M., Hammond, G., Badcock, J. C., & Jablensky, A. (2005). Laterality phenotypes in patients with schizophrenia, their siblings and controls: Associations with clinical and cognitive variables. *British Journal of Psychiatry, 187 (3)*, 221-228. doi: 10.1192/bjp.187.3.221

Eastvold, A. D., Heaton, R. K., & Cadenhead, K. S. (2007). Neurocognitive deficits in the (putative) prodrome and first episode of psychosis. *Schizophrenia Research, 93* (1-3), 266-277. doi: 10.1016/j.schres.2007.03.013

Eckblad, M., & Chapman, L. J. (1983). Magical ideation as an indicator of schizotypy. *Journal of Consulting and Clinical Psychology, 51* (2), 215-225. doi: 10.1037/0022-006x.51.2.215

Eckblad, M. B., Chapman, L. J, Chapman, J. P. & Mishlove, M. (1982). *The Revised Social Anhedonia Scale: Unpublished test.* University of Wisonsin at Madison. Madison, WI.

Everett, J., Lavoie, K., Gagnon, J.-F. o., & Gosselin, N. (2001). Performance of patients with schizophrenia on the Wisconsin Card Sorting Test (WCST). *Journal of Psychiatry & Neuroscience, 26* (2), 123-130.

Forbes, N. F., Carrick, L. A., McIntosh, A. M., & Lawrie, S. M. (2009). Working memory in schizophrenia: A meta-analysis. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences, 39* (6), 889-905. doi: 10.1017/s0033291708004558

Glahn, D. C., Bearden, C. E., Cakir, S., Barrett, J. A., Najt, P., Monkul, E. S., . . . Soares, J. C. (2006). Differential working memory impairment in bipolar disorder and schizophrenia: Effects of lifetime history of psychosis. *Bipolar Disorders, 8* (2), 117-123. doi: 10.1111/j.1399-5618.2006.00296.x

Gold, J. M., Carpenter, C., Randolph, C., Goldberg, T. E., & Weinberger, D. R. (1997). Auditory working memory and Wisconsin Card Sorting Test performance in schizophrenia. *Archives of General Psychiatry, 54* (2), 159-165.

Gooding, D. C. (1999). Antisaccade task performance in questionnaire-identified schizotypes. *Schizophrenia Research, 35* (2), 157-166. doi:10.1016/S0920-9964 (98)00120-0Gooding, D. C., Tallent, K. A., & Matts, C. W. (2005). Clinical status of at-risk individuals 5 years later: Further validation of the psychometric high-risk strategy. *Journal of Abnormal Psychology, 114* (1), 170-175. doi: 10.1037/0021-843x.114.1.170

Gooding, D., & Pflum, M. (2011). Theory of Mind and psychometric schizotypy. *Psychiatry Research, 188* (2), 217-223. doi:10.1016/j.psychres.2011.04.029

Gottesman, I. I., & Erlenmeyer-Kimling, L. (2001). Family and twin strategies as a head start in defining prodromes and endophenotypes for hypothetical early-interventions in schizophrenia. *Schizophrenia Research, 51* (1), 93-102.

Gottesman, I. I., & Gould, T. D. (2003). The endophenotype concept in psychiatry: etymology and strategic intentions. *American Journal of Psychiatry, 160*, 636-645.

Hazlett, E. A., Dawson, M. E., Filion, D. L., Schell, A. M., & Nuechterlein, K. H. (1997). Autonomic orienting and the allocation of processing resources in schizophrenia patients and putatively at-risk individuals. *Journal Of Abnormal Psychology, 106* (2), 171-181. doi:10.1037/0021-843X.106.2.171

Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G., & Curtiss, G. . (1993). *Wisconsin Card Sorting Test Manual*. Lutz, FL: Psychological Assessment Resources.

Heydebrand, G. (2006). Cognitive deficits in the families of patients with schizophrenia. *Current Opinion in Psychiatry, 19* (3), 277-281. doi: 10.1097/01.yco.0000218598.38807.b0

Holzman, P. S. (1974). Eye-tracking dysfunctions in schizophrenic patients and their relatives. *Archives of General Psychiatry, 31* (2), 143-151.

Horan, W. P., Braff, D. L., Nuechterlein, K. H., Sugar, C. A., Cadenhead, K. S., Calkins, M. E., . . . Green, M. F. (2008). Verbal working memory impairments in individuals with schizophrenia and their first-degree relatives: Findings from the Consortium on the Genetics of Schizophrenia. *Schizophrenia Research, 103* (1-3), 218-228. doi: 10.1016/j.schres.2008.02.014

Ingram, L. J. (1995). Family-genetic research and schizotypal personality. In T. L. A. Raine, S.A. Mednick (Ed.), *Schizotypal Personality* (pp. 19-42). New York: Cambridge Univerisity Press.

Jahshan, C., Heaton, R. K., Golshan, S., & Cadenhead, K. S. (2010). Course of neurocognitive deficits in the prodrome and first episode of schizophrenia. *Neuropsychology, 24* (1), 109-120. doi: 10.1037/a0016791

Kim, J., Glahn, D. C., Nuechterlein, K. H., & Cannon, T. D. (2004). Maintenance and manipulation of information in schizophrenia: further evidence for impairment in the central executive component of working memory. *Schizophrenia Research, 68* (2-3), 173-187. doi: 10.1016/s0920-9964 (03)00150-6

Kraepelin, E. (1971). Dementia praecox and paraphrenia. (R. M. Barclay, Trans.). In G. M. Robertson (Ed.). Huttington, NY: Krieger.

Kwapil, T. R. (1998). Social anhedonia as a predictor of the development of schizophrenia-spectrum disorders. *Journal of Abnormal Psychology, 107* (4), 558-565. doi: 10.1037/0021-843x.107.4.558

Kwapil, T. R., Barrantes-Vidal, N., & Silvia, P. J. (2008). The dimensional structure of the Wisconsin Schizotypy Scales: Factor identification and construct validity. *Schizophrenia Bulletin, 34* (3), 444-457. doi: 10.1093/schbul/sbm098

Kwapil, T. R., Miller, M. B., Zinser, M. C., Chapman, J., & Chapman, L. J. (1997). Magical ideation and social anhedonia as predictors of psychosis proneness: A partial replication. *Journal of Abnormal Psychology*, *106* (3), 491-495. doi: 10.1037/0021-843x.106.3.491

Laurent, A., Duly, D., Murry, P., Foussard, N., Boccara, S., Mingat, F. O., . . . d'Amato, T. (2001). WCST performance and schizotypal features in the first-degree relatives of patients with schizophrenia. *Psychiatry Research, 104* (2), 133-144. doi: 10.1016/s0165-1781 (01)00306-7

Lenzenweger, M. (1994). Psychometric high-risk paradigm, perceptual aberrations, and schizotypy: An update. *Schizophrenia Bulletin*, 20 (1), 121-135.

Lenzenweger, M. F. (2006). Schizotypy: An organizing framework for schizophrenia research. *Current Directions in Psychological Science, 15* (4), 162-166. doi: 10.1111/j.1467-8721.2006.00428.x

Lenzenweger, M. F. (2010). *Schizotypy and schizophrenia: The view from experimental psychopathology*. New York: Guilford.

Lenzenweger, M. F., & Korfine, L. (1994). Perceptual aberrations, schizotypy, and the Wisconsin Card Sorting Test. *Schizophrenia Bulletin*, *20* (2), 345-357.

Meehl, P. E. (1962). Schizotaxia, schizotypy, schizophrenia. *American Psychologist*, *17* (12), 827-838. doi: 10.1037/h0041029

Meehl, P. E. (1990). Toward an integrated theory of schizotaxia, schizotypy, and schizophrenia. *Journal of Personality Disorders, 4* (1), 1-99.

Millon, T. (2004). *Masters of the mind: Exploring the ancient story of mental illness from ancient times to the new millenium*. Hoboken, N.J.: John Wiley & Sons Inc.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: a latent variable analysis. *Cognitive Psychology, 41* (1), 49-100.

Modestin, J. J., Ammann, R. R., & Würmle, O. O. (1995). Season of birth: Comparison of patients with schizophrenia, affective disorders and alcoholism. *Acta Psychiatrica Scandinavica, 91 (2),* 140-143. doi:10.1111/j.1600-0447.1995.tb09755.x

Nieuwenstein, M. R., Aleman, A., & de Haan, E. H. F. (2001). Relationship between symptom dimensions and neurocognitive functioning in schizophrenia: A meta-analysis of WCST and CPT studies. *Journal of Psychiatric Research, 35* (2), 119-125. doi: 10.1016/s0022-3956 (01)00014-0

O'Connor, M., Harris, J. M., McIntosh, A. M., Owens, D. G. C., Lawrie, S. M., & Johnstone, E. C. (2009). Specific cognitive deficits in a group at genetic high risk of schizophrenia. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences, 39* (10), 1649-1655. doi: 10.1017/s0033291709005303

Onzgurdal, S., Littmann, E., Hauser, M., von Reventlow, H., Gudlowski, Y., Witthaus, H., . . . Juckel, G. (2009). Neurocognitive performances in participants of at-risk mental state for schizophrenia and in first-episode patients. *Journal of Clinical and Experimental Neuropsychology, 31* (4), 392-401. doi: 10.1080/13803390802206406

Orr, K. G. D., Cannon, M., Gilvarry, C. M., Jones, P. B., & Murray, R. M. (1999). Schizophrenic patients and their first-degree relatives show an excess of mixed-handedness. *Schizophrenia Research, 39 (3),* 167-176. doi: 10.1016/s0920-9964 (99)00071-7

Owashi, T., Iwanami, A., Nakagome, K., Higuchi, T., & Kamijima, K. (2009). Thought disorder and executive dysfunction in patients with schizophrenia. *International Journal of Neuroscience, 119* (1), 105-123. doi: 10.1080/00207450802324127

Park, S., & Holzman, P. S. (1992). Schizophrenics show spatial working memory deficits. *Archives of General Psychiatry, 49* (12), 975-982.

Park, S. H., (1992). Schizophrenics show working memory deficits. *Archives of General Psychiatry, 49,* 975-982.

Park, S., Püschel, J., Sauter, B. H., Rentsch, M., & Hell, D. (2003). Visual object working memory function and clinical symptoms in schizophrenia. *Schizophrenia Research, 59* (2/3), 261.

Prentice, K. J., Gold, J. M., & Buchanan, R. W. (2008). The Wisconsin Card Sorting impairment in schizophrenia is evident in the first four trials. *Schizophrenia Research, 106* (1), 81-87. doi: 10.1016/j.schres.2007.07.015

Rado, S. (1953). Dynamics and classification of disordered behavior. *The American Journal of Psychiatry, 110,* 406-426

Reilly, J. L., Murphy, P. T., Byrne, M., Larkin, C., Gill, M., O'Callaghan, E., & Lane, A. (2001). Dermatoglyphic fluctuating asymmetry and atypical handedness in schizophrenia.

Ritsner, M. S. (2007). Predicting quality of life impairment in chronic schizophrenia from cognitive variables. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care & Rehabilitation, 16* (6), 929-937. doi: 10.1007/s11136-007-9195-3

Schmidt-Hansen, M., & Honey, R. C. (2009). Working memory and multidimensional schizotypy: Dissociable influences of the different dimensions. *Cognitive Neuropsychology, 26* (7), 655-670. doi: 10.1080/02643291003644501

Sitskoorn, M. M., Aleman, A., Ebisch, S. J. H., Appels, M. C. M., & Kahn, R. S. (2004). Cognitive deficits in relatives of patients with schizophrenia: a meta-analysis. *Schizophrenia Research, 71* (2-3), 285-295. doi: 10.1016/j.schres.2004.03.007

Skelley, S. L., Goldberg, T. E., Egan, M. F., Weinberger, D. R., & Gold, J. M. (2008). Verbal and visual memory: Characterizing the clinical and intermediate phenotype in schizophrenia. *Schizophrenia Research, 105* (1-3), 78-85. doi: 10.1016/j.schres.2008.05.027

Smith, M. J., Cloninger, C. R., Harms, M. P., & Csernansky, J. G. (2008). Temperament and character as schizophrenia-related endophenotypes in non-psychotic siblings. *Schizophrenia Research, 104* (1-3), 198-205.

SPSS, Inc. (2010). *IBM SPSS Statistics 19.0 Command Syntax Reference*. Chicago: SPSS Inc.,

Tallent, K. A., & Gooding, D. C. (1999). Working memory and Wisconsin Card Sorting Test performance in schizotypic individuals: A replication and extension. *Psychiatry Research, 89* (3), 161-170. doi: 10.1016/s0165-1781 (99)00101-8

Thurston-Snoha, B.-J., & Lewine, R. R. J. (2007). Intact Wisconsin Card Sorting Test performance: Implications for the role of executive function in schizophrenia. *British Journal of Clinical Psychology, 46* (3), 361-369. doi: 10.1348/014466507x173772

Torrey, E. F., Bowler, A. E., Taylor, E. H. & Gottesman, I. I. (1994). *Schizophrenia and manic-depressive disorder: The biological roots of mental illness as revealed by the landmark study of identical twins.* . New York: Basic Books.

Torrey, E., Miller, J., Rawlings, R., & Yolken, R. H. (1997). Seasonality of births in schizophrenia and bipolar disorder: A review of the literature. *Schizophrenia Research, 28 (1),* 1-38. doi:10.1016/S0920-9964 (97)00092-3

Tsuang, M. T., Stone, W. S., Tarbox, S. I., & Faraone, S. V. (2002). An integration of schizophrenia with schizotypy: Identification of schizotaxia and implications for research on treatment and prevention. Schizophrenia Research, 54 (1-2), 169-175.

Wechsler, D. (2008a). *Wechsler Adult Intelligence Scale—Fourth Edition*. San Antonio, TX: Pearson Assessment.

Wechsler, D. (2008b). *Wechsler Adult Intelligence Scale—Fourth Edition: Technical and interpretive manual*. San Antonio, TX: Pearson Assessment.

Wechsler, D. (2009a). *Wechsler Adult Memory Scale—Fourth Edition*. San Antonio, TX: Pearson Assessment.

Wechsler, D. (2009b). *Wechsler Adult Memory Scale—Fourth Edition: Technical and interpretive manual*. San Antonio, TX: Pearson Assessment.

Wood, S. J., Tarnawski, A. U., Proffitt, T. M., Brewer, W. J., Savage, G. R., Anderson, V., . . . Pantelis, C. (2007). Fractionation of verbal memory impairment in schizophrenia and schizophreniform psychosis. *Australian and New Zealand Journal of Psychiatry, 41* (9), 732-739. doi: 10.1080/00048670701517926

APPENDIX A

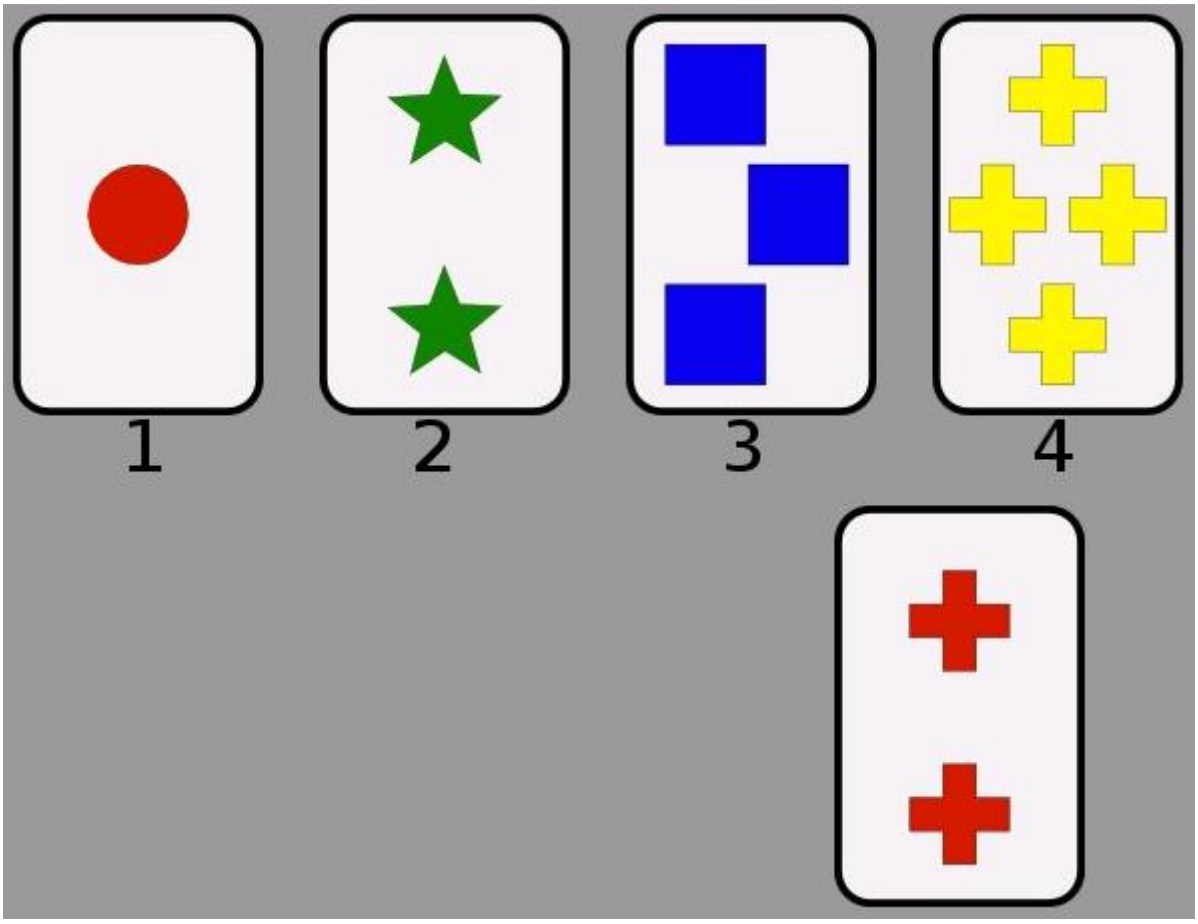
Means and Standard Deviations of Wisconsin Schizotypy Scales

MALES (n = 775)		FEMALES (n = 840)	
Magical Ideation Scale			
Mean =	9.73	Mean =	9.33
S.D. =	5.83	S.D. =	5.47
Alpha =	.85	Alpha =	.83
Cutoff =	22	Cutoff =	21
Perceptual Aberration Scale			
Mean =	6.87	Mean =	6.57
S.D. =	6.06	S.D. =	5.88
Alpha =	.89	Alpha =	.89
Cutoff =	19	Cutoff =	19
Revised Social Anhedonia Scale			
Mean =	8.91	Mean =	6.78
S.D. =	5.12	S.D. =	4.49
Alpha =	.79	Alpha =	.79
Cutoff =	20	Cutoff =	16

(Kwapil, 2002)

APPENDIX B

Public license image similar to computer presentation of Wisconsin Card Sorting Task


1
2
3
4

APPENDIX C

Informed Consent for Phase I

CONSENT TO PARTICIPATE IN RESEARCH

Mental Health Development in Early Adulthood

You are being invited to participate in a longitudinal research study being conducted by Kevin Bolinskey, Ph.D. and Carina Iati, M.S. from the Psychology Department at Indiana State University. Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

You are being asked to participate in this study because you are a student in an undergraduate psychology course at Indiana State University. If you are under 18 years of age, or if you have previously participated in this study, you are not eligible to participate at this time.

- **PURPOSE OF THE STUDY**

This study seeks to examine personality development throughout early adulthood in order to help us better understand the relationship between mental health development and future mental health status.

- **PROCEDURES**

This is a longitudinal study of approximately 10 years duration. By agreeing to participate in the initial phases of data collection, you agree to allow the researchers to contact you about participating in follow-up procedures, although you are not necessarily agreeing to participate in future data collection procedures.

Initial data collection will be followed up by the secondary phase of data collection with selected participants. Participants in the secondary phase of data collection will then have the option to participate in 1- 2-, 5-, 7-, and 10-year follow-up assessments. Not all participants will be invited to participate in the follow-up portions of the study.

If you volunteer to participate in this study, you will be asked to do the following things in the initial data collection procedures:

1. To provide contact information in the case that you are asked to participate in follow-up data collection.
2. To complete a 567-item questionnaire concerning thoughts and experiences you are currently having.
3. To complete a 100-item questionnaire concerning experiences and feelings you may have had over the past several years.

Participation in this phase of data collection should require approximately one and a half hours.

Following completion of in-person portion of data collection, you will be asked to complete additional questionnaires online. These questionnaires will consist of:

1. a survey containing demographic information about yourself (e.g., name, age, date of birth, gender).

2. a 39-item self-report questionnaire concerning various aspects of your life, such as relationship status, family status, substance use history, and mental health history. This questionnaire will also ask for information regarding the mental health history of your family.
3. an 11-item questionnaire concerning which hand you use to complete various tasks.
4. a 179-item questionnaire concerning various ways of thinking or perceptual experiences you might have had.
5. viewing 40 facial images and selecting the emotion displayed from a list of options.
6. a 35-item questionnaire asking about experiences you may enjoy or look forward to.

Participation in the online portion of data collection should require approximately one and a half hours.

Should you be asked to participate in the secondary phase of the research study, you will be asked to do the following tasks:

1. Complete a clinical interview with either a graduate student in clinical psychology or a doctoral level psychologist.
2. Complete a cognitive assessment (i.e., intelligence test) with either a graduate student in clinical psychology or a doctoral level psychologist.
3. Be assessed for dominant-hand preference.
4. Consent to having your fingerprints taken; these fingerprints will be used **ONLY** for comparison of ridge counts and swirl patterns across hands and will not be used for any other purpose nor released to any other agency. Fingerprint images will be destroyed after ridge count and swirl pattern data has been ascertained.

Participation in the secondary phase of data collection will require approximately three to three and one half hours of your time. If you are selected for participation in the secondary phase of data collection and choose to participate, you will be paid $20.00 for your time. There is also the possibility that, if selected for the secondary phase of the data collection, you may be asked to engage in 1-, 2-, 5-, 7-, and 10-year follow-ups, for which you will also receive financial compensation.

- **POTENTIAL RISKS AND DISCOMFORTS**

The risks associated with participating in this study, both short-term and long-term, are considered minimal and are not greater than those encountered in daily life or during the performance of routine physical or psychological examinations. We expect that any potential discomforts or inconveniences will be minor; if discomforts become a problem, you may discontinue your participation at any time with no penalty for withdrawal from the study.

- **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

There are no direct benefits to participants for their involvement in this portion of the study, although participants who participate in later stages of the study will be financially compensated for their time. The information gained from this study, however, may benefit society by advancing our knowledge of the relationship between personality development and mental health through early adulthood.

- **PAYMENT FOR PARTICIPATION**

You will receive class credit, amount to be determined by your individual class instructor, for your participation in the initial phase of data collection. If you complete this portion of the study, your participation time will be reported as 1.5 hours; if you withdraw from the study, your actual participation time will be reported to your instructor.

Should you be contacted for the secondary phase of data collection, you will be paid $20.00 for your time. Should you participate in the 1-, 2-, 5-, 7-, or 10-year follow-ups, you will be financially compensated ($20) for each additional evaluation.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of using participant ID numbers, rather than names, to identify individuals in the study's database. All information regarding names and/or contact information will be kept separate from any and all other evaluation forms. All personally-identifying information and contact information for follow-up evaluations will be stored in a separate database in password protected, encrypted files; these files will be stored in a locked cabinet in Dr. Bolinskey's office. All data will be erased three years following the completion of the proposed study, or approximately 13 years from today.

Since you will be receiving financial compensation through the University's financial offices, it is possible that an auditor could tie this compensation to this study, which means that it is possible that someone could know that you participated in this study as a result of your payment. These individuals, however, will not have any form of access to item responses or any other study data.

- **PARTICIPATION AND WITHDRAWAL**

You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits to which you are otherwise entitled. You may also refuse to answer any questions you do not want to answer. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled. If you withdraw from the study you will not be asked to participate in additional follow-up assessments.

The investigator may withdraw you from this research if circumstances arise which warrant doing so. If you are under 18 years of age, or if you have already participated in this study, you will not be permitted to participate at this time.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about this research, please feel free to contact

P. Kevin Bolinskey, Ph.D.
Principle Investigator
Assistant Professor of Psychology

B-214 Root Hall
Indiana State University
Terre Haute, IN 47809
812-237-2463
bolinskey@indstate.edu

Carina Iati, M.S.
Co-Investigator

B-227 Root Hall
Indiana State University
Terre Haute, IN 47809
812-237-2463
ciati@indstate.edu

- **RIGHTS OF RESEARCH SUBJECTS**

If you have any questions about your rights as a research subject, you may contact the Indiana State University Institutional Review Board (IRB) by mail at 114 Erickson Hall, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at irb@indstate.edu. You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with ISU. The IRB has reviewed and approved this study.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____
Printed Name of Participant

_____ _____
Signature of Participant Date

APPENDIX D

Informed Consent for Phase II

CONSENT TO PARTICIPATE IN RESEARCH

Mental Health Development in Early Adulthood

You are being invited to participate in the second phase of a longitudinal research study being conducted by Kevin Bolinskey, Ph.D. and Carina Iati, M.S. from the Psychology Department at Indiana State University. You have been selected to participate in this phase of the study on the basis of your participation in the previous phase of the study. Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

- **PURPOSE OF THE STUDY**

This study seeks to examine personality development throughout early adulthood in order to help us better understand the relationship between mental health development in early adulthood and future mental health status.

- **PROCEDURES**

This is a longitudinal study of approximately 10 years duration; this is the second phase of the study. By agreeing to participate in this phase of data collection, you agree to allow the researchers to contact you about participating in follow-up procedures, although you are under no obligation to participate in future data collection procedures.

If you agree to participate in this portion of study, you will be asked to complete the following tasks:

5. Complete a cognitive assessment (i.e., intelligence test, memory tests, logic tests) with either a graduate student in clinical psychology or a doctoral level psychologist.
6. Complete a clinical interview with either a graduate student in clinical psychology or a doctoral level psychologist.
7. Consent to having your fingerprints taken; these fingerprints will be used **ONLY** for comparison of ridge counts and swirl patterns across hands and will not be used for any other purpose nor released to any other agency. The hard copy of your fingerprints will be destroyed as soon as they are scanned into a password protected computer database, electronic images will be erased once ridge count and swirl pattern data have been entered into an electronic database.

Participation in this phase of data collection will require approximately two to two and one-half hours hours of your time. You will be asked to engage in 1-, 2-, 5-, 7-, and 10-year follow-ups via phone interview, for which you will also receive financial compensation ($20.00 for each follow-up).

You will be contacted annually in order to keep our contact information up to date. If we are unable to contact you using your primary contact information, we will try to contact you using the secondary contact information that you provided.

- **POTENTIAL RISKS AND DISCOMFORTS**

The risks associated with participating in this study, both short-term and long-term, are considered minimal and are not greater than those encountered in daily life or during the performance of routine physical or psychological examinations. We expect that any potential discomforts or inconveniences will be minor; if discomforts become a problem, you may discontinue your participation at any time with no penalty for withdrawal from the study.

- **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

There are no direct benefits to participants for their involvement in this study. The information gained from this study, however, may benefit society by advancing our knowledge of the relationship between personality development and mental health through early adulthood.

- **PAYMENT FOR PARTICIPATION**

You will be paid $20.00 for your time. Even if you withdraw from the study before completing this portion of the assessment, you will still receive payment in the amount of $20.00. Should you participate in the 2-, 5-, 7-, or 10-year follow-ups, you will be financially compensated ($20) for each additional evaluation.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of using participant ID numbers, rather than names, to identify individuals in the study's database. All information regarding names and/or contact information will be kept separate from any and all other evaluation forms. All personally-identifying information and contact information for follow-up evaluations will be stored in a separate database in password protected, encrypted files; these files will be stored in a locked cabinet in Dr. Bolinskey's office. All data will be erased three years following the completion of the proposed study (i.e., thirteen years after you began the study).

Since you will be receiving financial compensation through the University's financial offices, it is possible that an auditor could tie this compensation to this study, which means that it is possible that someone could know that you participated in this study as a result of your payment. These individuals, however, will not have any form of access to item responses or any other study data.

- **PARTICIPATION AND WITHDRAWAL**

You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits to which you are otherwise entitled. You may also refuse to answer any questions you do not want to answer. If you agree to participate, you are under no obligation to participate in any follow-up assessments. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled. If you withdraw from the study you will not be asked to participate in additional follow-up assessments.

The investigator may withdraw you from this research if circumstances arise which warrant doing so. If you are under 18 years of age, or if you have already participated in this study, you will not be permitted to participate at this time.

- **CONTACT INFORMATION OF INVESTIGATORS**

If you have any questions or concerns about this research, please feel free to contact

P. Kevin Bolinskey, Ph.D.
Principle Investigator
Assistant Professor of Psychology

B-214 Root Hall
Indiana State University
Terre Haute, IN 47809
812-237-2463
bolinskey@indstate.edu

Carina Iati, M.S.
Co-Investigator

B-227 Root Hall
Indiana State University
Terre Haute, IN 47809
812-237-2463
ciati@indstate.edu

- **RIGHTS OF RESEARCH SUBJECTS**

If you have any questions about your rights as a research subject, you may contact the Indiana State University Institutional Review Board (IRB) by mail at 114 Erickson Hall, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at irb@indstate.edu. You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with ISU. The IRB has reviewed and approved this study.

I understand the procedures described above. I am at least 18 years of age. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____
Printed Name of Participant

_____ _____
Signature of Participant Date
