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Cognitive Style, Laterality, And Executive Functioning

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COGNITIVE STYLE, LATERALITY, EXECUTIVE FUNCTIONING: EXAMINING THE RELATIONSHIP BETWEEN CREATIVITY AND SCHIZOTYPY FROM A NEUROPSYCHOLOGICAL PERSPECTIVE

by

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DEDICATION

To my biggest supporter, Steve DeMaagd, and to my parents who instilled in me a love of learning and taught me to never give up.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Cognitive Style, Laterality, and Executive Function

Researchers have long linked creativity to psychopathology; there are numerous studies and descriptions of famous musicians, artists, and scientists who reportedly suffered from mental health problems (N. C. Andreasen, 1978, 1987; J. Kaufman, 2014; Silvia & Kaufman, 2010). Yet, this relationship between creativity and psychopathology is not restricted to high achievers. In particular, everyday creativity is positively associated with schizotypy, a personality style with a possible relationship with schizophrenia. Schizotypy is associated with superstition, belief in magical concepts, perceptual peculiarity, and possible abnormalities in cognitive functioning. The purpose of this dissertation is to examine the relationship between schizotypy and creativity from a neuropsychological perspective. The first part of this project examines the strength and nature of the relationship between schizotypy and creativity in a large non-clinical sample. The two remaining parts of the project examine these constructs in relationship to the two fundamental organizing principles within the brain: top-down executive control and left-right information processing (hemispheric asymmetry and inter-hemispheric transfer of information).

Chapter 2: Study One

Schizotypy, Creativity, and Related Concepts

Schizotypy

Paul Meehl popularized the term "schizotypy" in his 1962 article describing his conception of the process by which genetics and learning factors contribute to the development of schizophrenia (Meehl, 1962). Schizotypy is often characterized as a subclinical presentation of those with the genetic predisposition for schizophrenia, though the literature vacillates on the strength of the relationship between these two conditions. More broadly, it categorizes those who are prone to psychosis, though few individuals who show schizotypic features later receive a diagnosis of schizophrenia. Large scale studies support the notion that schizotypia is dimensional and present throughout the community (M. Nelson, Seal, Pantelis, & Phillips, 2013). Brod (1997) clarifies the definition stating that schizotypy:

> refers to a set of behavioral, affective, and cognitive eccentricities, which in addition to forming some of the underpinnings for episodes of psychotic illness, also exist in the normal population at a non-clinical level. A person can have above average to high scores on one or several of the schizotypy scales and never develop a psychotic illness. This will not depend just upon an interaction between schizotypy and psychological stressors, but also upon a number of interacting influences (pg. 276).

Thus, it has been argued that schizotypy is continuously distributed throughout the normal population and may be associated several healthy and advantageous abilities and traits including flexibility and receptiveness to new ideas (Mohr & Claridge, 2015; Poreh, Whitman, & Ross, 1993).

Chapman and colleagues created several well-known scales of schizotypy, the Wisconsin Schizotypy Scales. There are four scales measuring independent factors of schizotypy: the Perceptual Aberration Scale, the Magical Ideation Scale, the Physical Anhedonia Scale, and the Social Anhedonia Scale. Factor analysis of the scales revealed two overarching factors of

Positive and Negative schizotypy, with anhedonia scales loading on negative schizotypy and the Social Anhedonia, Perceptual Aberration, and Magical Ideation scales on positive schizotypy (Kwapil, Barrantes-Vidal, & Silvia, 2008). Negative schizotypy is characterized by blunted affect, introversion, and social alienation while positive schizotypy is more representative of psychotic-like symptoms. The existence of the two underlying factors, positive and negative schizotypy, has been well-validated by many studies (Vollema & van den Bosch, 1995). A large factor analysis of the many questionnaires used to measure schizotypy revealed four factors: unusual experiences, cognitive disorganization, introvertive anhedonia, and impulsive nonconformity (Claridge et al., 1996). As positive schizotypy shows theoretical and empirical relationships to the other constructs of interest (e.g. creativity, executive functioning, and laterality), it will be the focus in the following studies.

Creativity

The construct of creativity is complex and difficult to define. Following an extensive review and integration of the definitions of creativity in the literature, Plucker, Beghetto, and Dow (2004) defined creativity as, "the interaction among aptitude, process, and environment by which by which [one] produces a perceptible product that is novel and useful in a social context" (pg. 90). In Plucker's definition, creativity is judged in terms of its production and value to society. Alternatively, creativity can also be considered as cognitive process (Kozbelt, Beghetto, & Runco, 2010). In this perspective, creativity is judged by the cognitive process leading to novel conceptualizations rather than value or nature of the output. The creative cognitive process allows for creative products and a creative personality.

The construct of creativity can be measured through multiple methods. Questionnaires typically measure aspects of creative personality, while performance-based measures tap creative

ability, production, and divergent thinking (Batey & Furnham, 2008). These tests differ somewhat from traditional tests of cognitive abilities, which often require a specific answer or test process. In fact, meta-analysis shows only weak relationships (r = .17) between intelligence and creativity (Kim, 2005). Creativity can also be measured by considering an individual's life achievements, a performance-based measure embedded in society. In general, some researchers believe that people are able to adequately self-report creativity and it may be a preferred option because tests of divergent thinking correlate highly with intelligence (Batey & Furnham, 2008). Nonetheless, since there is no agreed upon way in which to measure creative process or product, it would be important to include multiple methods in a study of creativity in order to fully examine the construct.

Creativity and Schizotypy

There is considerable evidence that creativity is associated with psychoticism. A long list of writers, musicians, and scientific geniuses have either a history, or rumored history, of mental illness (e.g. Dostoyevsky, Dickens, Newton, Alexander the Great, Van Gough, Shelley, Newton, Schumann etc.). There may be a greater instance of mental health problems or psychosis proneness in highly creative individuals of more everyday success (Prentky, 1980). However, several studies using those with active psychosis or schizophrenia failed to find relationships to creativity or have found reductions in creativity (N. J. Andreasen & Powers, 1975; Eisenman, 1990). Instead, creativity may relate to subclinical psychotic symptoms or schizotypy, which is overrepresented in families of those with psychotic illness. In a large epidemiological study completed in Sweden, Kyaga et al. (2011) found that siblings and parents of those with schizophrenia are more likely to pursue creative occupations. These findings were later replicated in a larger sample (Kyaga et al., 2013).

Schizotypic symptoms may be overrepresented in creative achievers. Rybakowski, Klonowska, and Patrzała (2008) found an increased risk for psychotic disorder in relatives of people who are highly creative. Nelson and Rawlings (2010) sampled a group of artists and found heightened scores on measures of positive schizotypy and openness to experience. Other studies have concluded that positive schizotypic traits are over-represented in groups that pursue creative study (Burch, Pavelis, Hemsley, & Corr, 2006; O'Reilly, Dunbar, & Bentall, 2001).

In a study using a measure purporting to more effectively measure schizotypy in the normal population, Nettle (2006) found that several factors of schizotypy including unusual experience, cognitive disorganization, and impulsive nonconformity to be positively related to pursuit of poetry. Unusual experience, impulsive nonconformity, and introvertive anhedonia were predictive of pursuits in the visual arts. Those who considered their creative pursuit to be serious scored similar to participants with schizophrenia, with the exception of scores on the introvertive anhedonia scale. Similarly, Rawlings and Locarnini (2008) found greater scores on unusual experience and cognitive disorganization in artists. They also found that artistic profession (compared to math/science profession) and positive schizotypy predicted creative responses on a word association test.

There is considerable research support for a shared biological vulnerability between creativity and the psychotic spectrum. Kéri (2009) studied the genetic relationship between psychosis and creativity. He found that those who carry the T/T genotype of a neuregulin 1 promoter gene score significantly higher on objective tests of creativity and self-reported creative achievement. This particular genotype is also associated with risk for psychosis. In a recent fMRI study, Fink et al. (2013) found similar patterns of brain activation in creative persons and schizotypic individuals. In particular, they showed less deactivation in the right parietal and

precuneus regions during a creativity task compared to controls, and greater originality was associated with a greater reduction of deactivation (Fink et al., 2013). Folley and Park (2005) found that those high on schizotypy performed better than those with schizophrenia and healthy controls on a task of divergent thinking. Using near-infrared optical spectroscopy, researchers determined that performance on this task was also associated with greater right prefrontal activation in the schizotypal sample. Jung, Grazioplene, Caprihan, Chavez, and Haier (2010) reported that openness, divergent thinking, and the schizophrenia spectrum disorders all predict a reduction in myelination and axonal coherence in the frontal lobes, as measured through diffusion tensor imaging.

On a more cognitive level, those with schizotypy and creativity share a cognitive style characterized by over-inclusive or allusive thinking. In his conceptualizations of dimensional psychoticism, Eysenck (1993) argues that psychoticism and creativity are closely related through the commonality of "wide associative horizons" (p.171) or a tendency for over-inclusive thought patterns. Leonhard and Brugger (1998) define over-inclusive thought as "the tendency of a subject to perceive things that are considered to be distinct by most others as related" (pg. 180). According to Barrantes-Vidal (2004), in allusive thinkers "filtering mechanisms are impaired and permit intrusion of irrelevant associations, with vague thought processes dominated by intuition" (pg. 68). Thus, those high on schizotypy and creativity are similar in that they are both able to draw together remote ideas and broad associations (Gianotti, Mohr, Pizzagalli, Lehmann, & Brugger, 2001; Mohr, Graves, Gianotti, Pizzagalli, & Brugger, 2001). Fundamentally, this style of over-inclusive thinking is a fundamental trait of both groups (Acar & Sen, 2013; Stavridou & Furnham, 1996).

In general, review of the literature supports the presence small to moderate correlations in self-reported schizotypy and creativity in non-clinical populations (Batey & Furnham, 2008; Michalica & Hunt, 2013). Findings are similar when creativity is measured through performance-based methods. Schuldberg, French, Stone and Heberle hypothesized that the relationship between schizotypy and creativity arises from perceptual flexibility, or an ability to see the world in a new or unique way. In their research study, undergraduates who scored high on Chapman's schizotypy scales scored significantly higher on multiple measures (questionnaires and tasks) of creativity when compared to controls (Schuldberg, French, Stone, & Heberle, 1988). Stavridou and Furnham (1996) found that psychoticism predicted performance on divergent thinking tasks, yielding small to moderate correlations. Findings from these studies are consistent with those found in our lab. Poreh et al. (1993) found that students who score high on schizotypy scales scored higher than controls on nonverbal creativity tests from the Torrance Test of Creativity battery. Conversely, Claridge and Blakey (2009) found small to moderate correlations between scores on the Creativity Scale Questionnaire and the Oxford-Liverpool Inventory of Feelings and Experiences (OLIFE) which measures schizotypy in the normal population, but failed to find significant effects for OLIFE scores predicting performance on measures of divergent thinking.

In a recent meta-analysis, Acar and Sen (2013) found that type of schizotypy was a significant moderator of the relationship between schizotypy and creativity. Positive (.14) and unspecified symptoms (.11) had direct relationships with creativity, but negative symptoms were negatively correlated with creativity (-.09). Additional moderators investigated, including type of measure, content of measure, and use of indices, were not significant. Other researchers have

also found similar effects regarding type of schizotypy (Batey & Furnham, 2008; Michalica & Hunt, 2013)

Taken together, these genetic, biological, cognitive, and behavioral studies show consistent connections between schizotypy and creativity. Correlations between the constructs are typically positive and small to moderate in magnitude, though the exact nature of the relationship between schizotypy and creativity is unclear. For example, Fodor (1995) found that psychosis proneness is associated with creativity only when it is coupled with high ego strength. Zanes, Ross, Hatfield, Houtler, and Whitman (1998) found that creative performance was related to schizotypia only in those who score inconsistently on measures of psychosis-proneness. There may be mediating variables or relationships could be reciprocal (Richards, 1981). In a review of the relationship between creativity and psychosis, Barrantes-Vidal (2004) writes "in the presence of [schizotypal] traits per se would not guarantee a creative advantage; most likely many other factors would need to be favorable for a creative outcome to happen, both from an individual (e.g. intelligence, persistence etc.) and from a situational perspective " (pg. 62). Similarly, Silvia and Kaufman (2010) suggested that mental illness and creativity covary because of a third variable, such as a form of shared experience or common personality trait. Openness to experience is one variable may be partially responsible for the relationship.

The Role of Openness

Openness to experience belongs traditionally to the "Big Five" personality traits and was previously referred to as "culture" or "intellect" (Goldberg, 1990). Later conceptualizations consider openness to represent more aspects of imagination and originality (McCrae & Costa, 1987). According to McCrae and Costa (1997), "openness is seen in the breadth, depth, and permeability of consciousness, and in the recurrent need to enlarge and examine experience" (pg.

826). It “combines intellectual curiosity with broad interests, liberal views, adventurous tendencies, and a need for variety” (McCrae, 1994, pg. 257).

Vollema and van den Bosch (1995) suggested that openness and positive schizotypy share a common lack of tight conscious regulation and a tendency for over-inclusive thought. Yet, findings vary throughout the literature on the statistical relationship between schizotypy and openness. While some have failed to find correlations (Cicero & Kerns, 2010), others reported small to moderate correlations. In a large-scale validation study, Gross, Silvia, Barrantes-Vidal, and Kwapil (2012) found that responses on the Wisconsin Schizotypy short forms correlated significantly (in the .20-.30 range) with NEO-PI-R measures of openness. Kwapil et al. (2008) found that openness directly correlated with positive schizotypy (.33) and showed an inverse relationship with negative schizotypy (-.40). Ross, Lutz, and Bailley (2002) also reported positive correlations between positive schizotypy symptoms (.26) and negative correlations with negative symptoms (-.28). In a cluster analysis of several measures, openness to experience loaded on a cluster with symptoms of positive schizotypy (Barrantes-Vidal, Lewandowski, & Kwapil, 2010).

There is considerable evidence for a moderate-sized relationship between openness and creativity. Openness predicts scores on various divergent thinking tasks as well as Gough’s Creative Personality Scale (McCrae, 1987; Wolfradt & Pretz, 2001). J. Kaufman, Pumaccahua, and Holt (2013) reported large correlations between openness and self-reported creativity and small relationships between openness and performance on a remote associates test, which is often used to measure creativity.

In a recent review article discussing the relationship between creativity and schizophrenia spectrum disorders, S. Kaufman and Paul (2014) propose the role of openness as a potential

mediator between schizotypy and creativity. They propose that when there is an adequate degree of intellect, as would be expected in a non-clinical population, psychosis proneness may result in an increase in openness and therefore greater creativity. This hypothesis was supported by Miller and Tal (2007) who tested the relationships between these variables. Positive schizotypy had small, significant correlations with tests of creativity and openness. Openness, creativity, and IQ were all positively correlated, but the correlation between positive schizotypy and IQ was not significant. In a multiple regression analysis including IQ, positive and negative schizotypy, and each of the Big Five traits as predictors of creativity, only IQ and openness were significant predictors. Consequently, the authors suggested that openness to experience serves as a mediator between schizotypy and creativity.

The Current Study

In view of this background, the first study examined the relationship between creativity and schizotypy in a non-clinical population. We hypothesized that creativity and schizotypy would be significantly correlated, though this correlation might be explained by openness to experience.

Methods Part One

Participants

Participants were 1,005 undergraduate students with no significant history of head injury, seizure, or stroke. Participants completed a series of questionnaires through the online system, Qualtrics. Participants received 0.5 extra credit points through the SONA online psychology student extra credit system. The survey took 30-60 minutes to complete. Participants were also asked to provide basic contact information (email address or phone number), so that we were able to contact them for the second part of the study.

Materials and procedure

Participants completed the following questionnaires as part of the online survey:

Schizotypy Scales.

Wisconsin Schizotypy Scales. Participants completed the short-form versions of Chapman's Perceptual Aberration and Magical Ideation Scales (Winterstein et al., 2011) that measure typical schizotypy symptoms of perceptual distortion and atypical beliefs. These questionnaires are 15 items each and require participants to mark statements as true or false. Example items include "At times I perform certain little rituals to ward off negative influences" and "Sometimes I have felt that I could not distinguish my body from other objects around me." These scales have shown to have adequate reliability (Cronbach alpha of scores on the Perceptual Aberration Scale = .84 and Cronbach alpha of scores the Magical Ideation Scale = .76) (Gross et al., 2012). The full versions of these scales load strongly on factors of positive schizotypy (Vollema & van den Bosch, 1995).

Creativity.

Gough's Creativity Personality Scale. The Gough Creative Personality Scale requires participants to endorse which of 30 adjectives best describe them. Example adjectives include "clever" and "sincere." Scores on this scale have a six month test-retest reliability around .8 and internal consistency around .7 (Gough, 1979).

IPIP creativity scale adapted from the HEXACO. This 10-item questionnaire asks participants to rate the accuracy of a statement on a five point Likert scale. Cronbach's alpha of scores on the scale is .85. Items include, "I have a vivid imagination" and "I am full of ideas" (Ashton, Lee, & Goldberg, 2007).

Openness to Experience.

Big Five Inventory. This personality inventory asks participants to rate 44 statements about themselves on a 5-point Likert scale. Items include "is full of energy" and "is inventive" (John, Donahue, & Kentle, 1991). Factors include extraversion, agreeableness, conscientiousness, neuroticism, and openness. Cronbach's alpha for scores on each factor ranges from .75 to .9 and mean three month test-retest reliability for the entire inventory is .85. The BFI is highly correlated (>.9) with other well established measures of the Big Five including the NEO-FFI (John, Naumann, & Soto, 2008).

Response Validity. Participants also completed the unpublished Chapman 13-item infrequency scale. This scale asks the reader to mark true or false to a set of statements that are frequently answered in a certain matter. For example, "I cannot remember a time when I talked with someone who wore glasses." Response validity comes into question when numerous items are marked in the infrequent direction. Protocols with greater than two endorsements of infrequent items were not used for analysis and responders were not eligible for part two of the study.

Results Part One

Seven hundred and fifty-three participants provided valid data as determined by a score of <3 on the Chapman validity scale. Data was tested for the presence of univariate and multivariate outliers according to suggestions made by Tabachnick and Fidell (2007). Composites for schizotypy and creativity were created by averaging standardized scores from appropriate measures. Data from schizotypy measures, which tended to be positively skewed were transformed to increase normality. The schizotypy composite improved with log transformation, but remained significantly skewed. In a sample of this size, deviation from normality usually does not substantially affect analysis or conclusions (Tabachnick and Fidell

(2007). The final sample consisted of 27% males and 73% female, with college age students (*M* = 21.95, *SD* = 5.10) who were in their second year on average. Bivariate correlations between variables are seen in Table 1.

Multiple regression was used to test the model that openness mediates the relationship between positive schizotypy and creativity. Schizotypy and creativity were positively related (B = .625, $t(751) = 3.55$, $p < .001$). Schizotypy was also significantly related to the proposed mediator, openness to experience (B = .595, $t(751) = 5.25$, $p < .001$). Lastly, openness to experience was related to creativity (B = 1.054, $t(751) = 25.801$, $p < .001$). As all paths in the model were significant, mediation analysis was run using a bootstrapping method. Bootstrapping provides confidence estimates that correct for bias using a 95% confidence interval and 5000 bootstrapped samples (Preacher & Hayes, 2004). Bootstrap results indicated that openness was indeed a significant mediator of the relationship between schizotypy and openness (B = .627, CI = .370 to .855). Furthermore, when openness was introduced into the model, the relationship between schizotypy and creativity was no longer significant (B = -.002, $t(751) = -.018$, $p = .986$). Bootstrapped results are displayed in Figure 2.

Discussion Part One

The small relationship between positive schizotypy and creativity supports the hypothesis regarding association between these constructs. The strength of the relationship found is consistent with prior meta-analysis conducted by Acar and Sen (2013). The findings from this study also support the hypothesis that this relationship is indirect, as openness explains the relationship between schizotypy and creativity. This finding supports the theory presented by S. Kaufman and Paul (2014) that a common personality factor shapes a person's worldview and leads to both creative nature and patterns of unusual thoughts and beliefs. From a cognitive

perspective, openness is consistent with the types of over-inclusive, broad thought patterns shared by those high in creativity and schizotypy.

It is important to note that this study was completed using a non-clinical population in which characteristics of schizotypy were rarely endorsed. There is considerable debate within the psychopathology literature on the dimensional versus discontinuous nature of disorders, particularly personality and psychotic disorders (Barrantes-Vidal, Grant, & Kwapil, 2015; Esterberg & Compton, 2009) Future research could address these questions by considering whether or not this relationship holds true in populations extreme on either creative achievement or psychosis proneness.

This study is somewhat limited by the use of solely self-report measures. Though a validity indicator was used to screen out random responding, there was no control for the effects of social desirability. Parts two and three will address this concern with the addition of a performance based measure of creativity and an additional questionnaire to measure schizotypy which authors claim better detects schizotypic traits.

Chapter 3: Study Two

Creativity, Schizotypy, and Executive Function

Introduction to Executive Function

Carson (2011) suggested a shared genetic vulnerability between creativity and psychopathology. Evolutionary psychologists have proposed that the genes for psychosis liability have been perpetuated because the relationship with creativity that brings along with it an advantage for survival (Barrantes-Vidal, 2004; Glazer, 2009). In her model (see figure 1), Carson (2011) outlines shared vulnerabilities including reduced latent inhibition, increased sensitivity to novelty salience, and neural connectivity. She proposed intellect and aspects of executive functioning act as protective factors for those who are creative but do not develop mental illness. Similarly, reductions in executive functioning may be a risk factor for psychopathology

Part two aimed to consider the major constructs of interest in relation to executive functioning. Though small correlations were found between schizotypy and creativity in part one, these constructs may be differentially related to cognitive control, or executive functioning as suggested in Carson's model.

Executive functioning is a multi-dimensional neuropsychological construct typically associated with frontal lobe functioning. The frontal lobes are richly connected with numerous cortical and subcortical areas, particularly the limbic system, which allows the frontal lobes to monitor and modulate function (Nauta, 1971). Of note, the terms "executive function" and "frontal lobe function" are sometimes used interchangeably; however, those with frontal lobe lesions do not always have executive function deficits and those with executive function deficits do not always have frontal lobe lesions (Miyake et al., 2000). Rather, executive function is an

emergent higher cortical function that is not "localized," but disruption of frontal lobe integrity often interferes with executive function.

One might also consider executive functioning as a measure of cognitive control. The role of executive functioning is akin to the role of an orchestra director (Postal & Armstrong, 2013). It organizes, monitors and keeps control of various other functions. Lezak (2004) considers executive function abilities to be the higher order cognitive abilities that help people live independent or purposeful lives. This definition is very broad and researchers have operationalized executive function in a multitude of ways. The low correlations between scores on various neuropsychological tests of executive functioning attest to the multiple definitions and the multidimensional nature of the construct (Miyake et al., 2000).

Several researchers have studied the factors underlying the broad concept of executive functioning. Greatest support is found for a model of three correlated factors, which has been consistently found in samples of various ages as well as neurological and psychiatric samples (P. Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Gioia, Isquith, Retzlaff, & Espy, 2002; Huizinga, Dolan, & van der Molen, 2006; Latzman & Markon, 2010; Miyake et al., 2000). Though various research groups give these factors differing names, they generally represent: (1) inhibition, (2) monitoring/updating/working memory, and (3) cognitive flexibility. Tests with greater complexity that purport to measure abstract thinking and planning typically tap some combination of these underlying factors.

Of note, many executive functioning tasks are "impure" or measure additional constructs outside of executive functioning. For example, many tests also require verbal/language abilities, processing speed, visuospatial abilities, and general cognitive ability. Scores on measures of executive functioning correlate with IQ scores, and tests of executive functioning often load on

the "G" factor (Floyd, Bergeron, Hamilton, & Parra, 2010; Floyd et al., 2006). In meta-analytic review, intelligence has been shown to be strongly related (r = .47) to the executive functioning component of monitoring/working memory (Ackerman, Beier, & Boyle, 2005). It has been suggested that other aspects of executive functioning may not significantly relate to intelligence in a healthy population (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014; Friedman et al., 2006; Gilhooly, Fioratou, Anthony, & Wynn, 2007). Authors of the Delis Kaplan Executive Function System (DKEFS), a popular system of tests to measure executive function suggest that intellectual functioning and achievement explains only 4%-16% of the variance in executive functioning (Delis, Kaplan, & Kramer, 2001).

Schizotypy and Executive Functioning

Neuropsychological correlates of schizotypy are variable and may relate to type of schizotypy under consideration (Richardson, Mason, & Claridge, 1997). Though there is considerable evidence that schizotypy is inversely related with multiple aspects of executive functioning (M. Nelson et al., 2013), neurocognitive deficits relate most strongly with negative symptoms of schizotypy (Giráldez, Caro, Rodrigo, Piñeiro, & González, 1999). In general, meta-analysis suggests that working memory and cognitive flexibility are the cognitive functions most affected by schizotypy (Chun, Minor, & Cohen, 2013), with small effect sizes seen across studies.

Some researchers believe that both schizophrenia and schizotypy are directly tied to reduced latent inhibition, which varies as a function of dopamine level (Cassaday, 1997). Higher scores on the Oxford Liverpool Inventory Feelings and Experiences Scale (another measure of schizotypy) are associated with poorer scores on inhibition tasks like the Stroop or the DKEFS color word interference test (Cimino & Haywood, 2008; Louise et al., 2015). There is also

evidence that psychoticism is characterized by reduced negative priming, a common way to measure cognitive inhibition (Cochrane, Petch, & Pickering, 2012; M. Green & Williams, 1999).

There is also evidence for reduced abilities specific to the cognitive flexibility dimension of executive function. Positive and negative schizotypy predict performance on measures of divergent thinking (Batey & Furnham, 2008). Poreh, Ross, and Whitman (1995) found that a group of participants who scored high on schizotypy measures scored worse than controls on the Trail Making Test B, Booklet Category Test, and the Wisconsin Card Sorting Test. Deficits on the Wisconsin Card Sorting Test, in particular, have been found in multiple samples (Chang et al., 2011; Giakoumaki, 2012; Gooding, Kwapil, & Tallent, 1999; Tallent & Gooding, 1999). Daly, Afroz, and Walder (2012) found scores on the schizotypal personality questionnaire to be related to performance on Block Design from the WAIS-IV. They considered this task to measure visuospatial abilities, though it also measures complex reasoning, planning and mental flexibility.

Like those with schizophrenia, schizotypes have difficulty with maintaining context, a skill associated with the prefrontal cortex (Fisher, Heller, & Miller, 2007). This may result in deficits within the monitoring/updating aspect of executive functioning. Fluency has also been found to be negatively impacted by positive and negative schizotypy (Cochrane, Petch, & Pickering, 2012; Batey & Furnham, 2008).

In summary, though studies vary on the domain of executive functioning affected, it appears that schizotypy is generally associated with decreased executive functioning.

Creativity and Executive Functioning

Whereas the literature indicates a negative relationship between frontal lobe functioning and schizotypy, creativity is typically associated with increased executive functioning.

(Rybakowski, Klonowska, Patrzała, & Jaracz, 2008). Frontal damage is associated with a reduction in creativity when compared to controls (de Souza et al., 2010), as patients with this damage may lose the executive abilities to control thoughts and associations to form useful concepts.. In a recent fMRI study, Abraham et al. (2012) found significant activation in several frontal areas during a creativity task when compared to a working memory control task. Elliot (1986) argued that the frontal lobes are crucial for the synchronization necessary for creative productivity.

Zabelina and Robinson (2010) described creativity as a process that is both automatic and controlled. The automatic part allows free and uninhibited connections while the controlled process corrals and sustains creative thought and prevents perseveration. The authors add, "Undercontrolled individuals would be spontaneous but lack the discipline for sustained creative efforts. On the other hand, overcontrolled individuals would be persistent but lack spontaneity" (p. 136). Carson (2011) wrote, "creatively productive people [can] exert meta-cognitive control over bizarre or unusual thoughts, enabling the person to take advantage of such thoughts without being overwhelmed by them" (pg. 145). Thus, theory supports the notion that a creative personality would be associated with increased executive control. This control is flexible in nature; those high on creativity can inhibit information when necessary, but they also quickly generate new concepts and ideas.

Following the notion of flexible cognitive control, creativity is associated with increased monitoring and inhibition. Self-report and performance-based creativity predicts fluency, in line with the theory of increased connectivity between broad concepts and better cognitive control monitoring of intrusions and perseverations (Benedek, Jauk, Fink, et al., 2014; Benedek, Jauk, Sommer, et al., 2014; McCrae & Costa, 1987). Zabelina and Robinson (2010) found that creative

individuals, as determined by an abbreviated Torrance Test of Creativity, showed greater cognitive flexibility on a Stroop-like task. Additional studies have shown reduced interference in creative persons using the Stroop (Gamble & Kellner, 1968; Golden, 1975) and other Stroop-like tasks (Groborz & Necka, 2003).

Study Two Aims and Hypotheses

The purpose of study two was to examine how schizotypy and creativity differentially relate to the three aspects of executive functioning. Consistent with the research and theories, it was hypothesized that creativity would be associated positively aspects of executive functioning whereas schizotypy would be negatively related to executive functioning. Specifically, prior research supports the notion that creativity would be strongly related to the updating/monitoring and inhibition components and schizotypy may show negative relationships to all three domains.

This study also considered the role of intellect, as it has been found to be related to creativity, executive functioning, and psychotic disorders (Batey & Furnham, 2008; Benedek, Jauk, Sommer, et al., 2014; S. Kaufman & Paul, 2014) Intellect was measured and included in models in this study to examine its predictive contribution. It was hypothesized that the above relationships would be present even when considering intellect as an additional predictor.

As study one was somewhat limited by the use of only self-report measures, this study also included a performance-based measure of creativity. It was expected that creativity questionnaires would show small to moderate relationships with scores on the performance based measure. In addition, another measure of schizotypy was also added for this study, as its authors claim this scale is more sensitive to schizotypic characteristics in a non-clinical population (Mason, Linney, & Claridge, 2005).

Methods Part Two

Participants

Participants were recruited using contact information from study 1 (n = 43) and also through the SONA extra credit system (n = 64). Only students from part one who provided valid data, as determined by the Chapman Response Validity Scale were eligible for recruitment. Participants were between the ages of 18-50, English proficient, and denied history of head injury, seizure, and stroke. Data was collected from 107 participants, though data was dropped from analysis for three participants, as it was questionable whether or not these participants met study criteria. Participants were compensated with 2 SONA extra credit points or $20. Participants with data in the final analysis included 80 females and 24 males. Forty-six participants were Caucasian, 34 participants were African American, 3 were Hispanic, 20 were Asian, and 1 did not have a racial/ethnicity group identified. The average age was slightly older than typical college age, but consistent with the Wayne State University student population (*M* = 23.76, *SD = 5.5).* Estimated intellectual functioning was in the average range across participants and showed considerable variability, which is consistent with prior studies done with the psychology department at this university (*M = 98.53, SD* = 13.1).

Materials & Procedure

Participants completed a 1.5-2 hour study visit at the laboratory at Wayne State University. If the participants were not a part of study 1, they completed the questionnaires in the lab. During the lab visit, participants completed the following tasks:

Wisconsin Schizotypy Scales. (Described above)

Gough's Creativity Personality Scale. (Described above)

IPIP creativity scale adapted from the HEXACO. (Described above)

Chapman Response Validity Scale (Described above)

Oxford-Liverpool Inventory of Feelings and Experiences Unusual Experiences Short Scale. Participants also completed the short-form version of Claridge's OLIFE Unusual Experience scale (Mason et al., 2005), which looks at expression of schizotypal traits in the normal population. The short form scale is a 12-item questionnaire requiring a yes-no response. The scale measures a one-dimensional construct. Example items include "Does a passing thought ever seem so real it frightens you?" and "Are your thoughts sometimes so strong that you can almost hear them?" Cronbach alpha for scores on this inventory is .8. Authors claim that this scale is appropriate for use in a non-clinical population.

Abbreviated Torrance Test for Adults. The Abbreviated Torrance Test for Adults, or the ATTA, is a shortened version of the Torrance Test of Creative Thinking (Goff, 2002) that can be administered in less than 15 minutes. The Torrance Test of Creative Thinking is considered to be the gold standard test for the measurement of creativity (Kim, 2008). The shortened battery consists of three tasks (1 verbal, 2 nonverbal). The test yields a total creativity score, as well as sub-scores for fluency, originality, elaboration, and flexibility. For the purpose of this study, the total creativity index was used as an overall performance-based measure of creativity. This task is included in the present study to allow for comparison of self –reported and performance based creativity. The Scholastic Testing Service scoring service scored individual tests. This company reports inter-rater reliabilities ranging from .95-.99 in the test manual.

Test of Premorbid Functioning. All participants completed the Test of Premorbid Functioning (TOPF), a word reading test similar to its predecessor, the Wechsler Test of Adult Reading, which is predictive of full scale IQ and considers word reading ability. This test was co-normed with the D-KEFS. For this study, age-adjusted standard scores were used.

Delis Kaplan Executive Function System. The Delis Kaplan Executive Function System (D-KEFS) is a set of co-normed tests adapted mostly from well-known tests of executive function. The test battery gives numerous scores to measure both total performance and process. Validity has been shown using a variety of neurological and psychiatric samples. D-KEFS scores are related to IQ; however, up to 20% of individuals have IQ and D-KEFS scores that vary by greater than one standard deviation (Delis & Kramer, 2004). Researchers have found support for the 3 factor model of executive functioning using the D-KEFS tests (Latzman & Markon, 2010) and the original tests on which the D-KEFS was based (P. Burgess et al., 1998; Miyake et al., 2000). To fully tap the three factors underlying executive functioning participants completed the following tests from the D-KEFS: D-KEFS trail making test, D-KEFS verbal fluency test, D-KEFS design fluency test, D-KEFS Color-Word Interference test, D-KEFS Sorting Test, and the D-KEFS 20 questions test. Age-adjusted standard scores were used for analysis.

D-KEFS trail making test. The D-KEFS trail making test is a visual-motor task that requires set shifting and cognitive flexibility. It is modeled off the traditional Trail Making Test from the Halstead Reitan battery and has five conditions to allow the administrator to examine different processes: visual scanning, number sequencing, letter sequencing, number-letter switching, and motor speed. Number-letter switching is the primary task requiring executive functioning and requires participants to connect a series of numbers and letters in an alternating sequence. The standard error of measurement of scores for the age group of interest in the normative sample ranged from 1.41 to 1.66. Internal consistency of scores for the same ages ranged from .69 to .78 (Delis et al., 2001). This test generally measures the inhibition aspect of executive functioning (Latzman & Markon, 2010). The variable utilized in this study is the age-corrected standard score for total time to complete condition four.

D-KEFS verbal fluency test. This test is a word generation task in which the participant names as many words as possible in one minute based off the appropriate rules. The three conditions include phonemic fluency, semantic fluency and a category switching. Standard errors of measurement of scores in the normative sample for the appropriate age groups ranged between .97 and 2.27 (Delis et al., 2001). This test taps monitoring/updating/working memory and inhibition (Latzman & Markon, 2010). The scores used for this study are the primary phonemic fluency, semantic fluency, category fluency total score, and category fluency switching score.

D-KEFS design fluency test. This test considers the participants ability to generate as many differing designs as possible within in one minute. There are three conditions including a simple dot connection, a condition in which there are distractor dots, and a switching condition. SEMs of the scores ranged between 1.94 and 2.47 in the specified age group of the normative sample (Delis et al., 2001). This test loads on the inhibition factor of executive functioning (Latzman & Markon, 2010). The score on this test used for this study is the total composite score.

D-KEFS Color-Word Interference test. This test, similar to the traditional Stroop test, considers the participant's ability to inhibit dominant reposes. There are four conditions: a color naming task, a word reading task, the traditional Stroop interference task, and a task that requires the examinee to switch back and forth between word reading and color naming. The SEMs for these test scores range between 1.28 and 1.59 in the normative sample. Internal consistency ranged from .72 to .82 (Delis et al., 2001). This test is a strong measure of inhibition (Latzman & Markon, 2010; Miyake et al., 2000). Scores used in this study were completion times for conditions three and four, which are the inhibition and switching conditions.

D-KEFS Sorting test. This test was designed to measure problem solving, reasoning, and concept formation. It requires participants to group cards according to categories and recognize categories of cards sorted by the examiner. Internal consistency of the scores ranged between .72- .83 and SEM of scores fell between 1.24- 1.59 in the normative sample (Delis et al., 2001). This test taps the cognitive flexibility aspect of executive function (Latzman & Markon, 2010). Total score, description score, and recognition scores were used for analysis in this study.

D-KEFS 20 questions test. The twenty question task requires participants to identify the correct item out of 30 total items using as few yes-no questions as possible. This task is considered to measure concept formation and planning. Internal consistency ranged from .10-.85 and the SEM ranged from 1.24- 2.85 for our targeted age group in the normative sample published in the test manual. This test requires multiple aspects of executive functioning (Latzman & Markon, 2010). Total questions and the abstraction score were the scores used in this study.

Data Analysis

Data was cleaned and screened for assumptions of the general linear model according to the suggestions provided in Tabachnick and Fidell (2007). Univariate outliers were winsorized, and data was screened for multivariate outliers using Mahalanobis Distance, Cooks Distance, and Leverage statistics. There was a total of 1.675% missing data in the database. Given the small portion of missing values and the fact that the data were missing completely at random (Little's MCAR test, $\chi 2(352) = 372.407$, $p = .22$), expectation maximization (EM) algorithm was used to replace missing values for the 104 participants in the sample. This type of missing data analysis improves validity in comparison to list-wise or pairwise deletion, improves statistical power, and is generally appropriate when there are very small amounts of missing data (Enders, 2001;

Scheffer, 2002). For the instances of missing data in questionnaire items, which were often dichotomous, scale composites were calculated using the mean of completed items rather than a total sum. Age data was missing for two participants; therefore, standard scores for the neuropsychological tests were derived using the 20-29 age group as the majority of the sample fell into this age range. Chapman scale scores were not used for one participant, as three of the embedded validity items were endorsed in the wrong direction.

Pearson correlations of the individual scales and predictor variables can be found in table 2. As the schizotypy measures were highly correlated, a composite was created to more fully measure the full construct of schizotypy and to increase power in subsequent analyses. This composite was then log transformed to increase normality. As the creativity measures were correlated only moderately, they were left as individual predictors in the models in order to see if they were differentially related to dependent variables.

Next, composites were created to measure the three components of executive functioning: Monitoring/Updating, Inhibition, and Cognitive Flexibility. Composites were created two different ways, and results for both versions are included below. In both instances, composites were created by averaging the age-corrected standard scores for each of the subtests. The first method created composites based off a combination of theory and the exploratory factor analyses completed by Latzman & Markon (2010). In this instance, Monitoring consisted of the phonemic fluency total score, the semantic fluency total score, the category fluency total accuracy score, and the category fluency switching score. Inhibition consisted of the trails condition 4 total score, the design fluency total score, and the color-word condition 3 & 4 total scores. The cognitive flexibility domain consisted of the card sorting total accuracy score, the card sorting description score, and the card sorting recognition score. Of note, scores on the 20-question test did not load

consistently on any of the factors in the study by Latzman & Markon and was therefore not included in the first version of the analysis. In a second version, a data reduction technique was performed using the current data. Regression analyses were then run with estimated intelligence, schizotypy, self-reported creativity measures, and performance-based creativity entered in as predictors of different aspects of executive functioning.

Results Part Two

Principal components analysis with an Oblimin delta = 0 rotation was run allowing the factors to correlate, as supported by prior literature. The first attempt at this data reduction technique determined 5 factors based on Eigenvalues greater than one. Most tests loaded on factor one, there were numerous cross-loadings and negative loadings and the analysis was deemed largely uninterruptable. Of note, the presence of 5 factors with Eigenvalues greater than one matched the general factor structures found by Latzman and Markon, though they only interpreted the first three factors. In a second attempt at data reduction, the number of factors was set to be three, which produced an interpretable result mostly consistent with the factors found by Latzman and Markon. The Kaiser-Meyer-Olkin measure of sampling adequacy was .73, above the recommended value of .6, and Bartlett's test of sphericity was significant (χ^2 (78) = 801.36, p < .001) suggesting that this data was appropriate for component analysis. This resulting component structure accounted for 59.77% of the total variance, with 35.54% explained in the first component, 13.46% in the second component, and 10.77% in the third component. Composites were created using scores for each component that had a loading greater than .3. No differences arose in the monitoring component. The inhibition component included the same variables with the addition of a cross loading with semantic fluency. The cognitive flexibility composite included the same variables as before with the addition of a Trails condition 4 cross

loading, the total 20-question score, and the 20-questions abstraction score. Factor loadings for each variable can be found in table 3.

With regards to predictor variables, a significant correlation was found between estimated intelligence and performance based creativity, $r(102) = .390$, $p < .001$. Performance-based creativity was significantly related to self-reports of creativity on the IPIP creativity scale ($r(102) = .197$, $p = .05$) but not reports on the Gough Creative Personality Scale ($r(102) = .136$, $p = .168$). The two self-report creativity questions were significantly correlated, $r(102) = .349$, $p < .001$. Contrary to the findings of the previous study, the schizotypy composite did not show significant relationship with any of the creativity measures. Means and standard deviations of each of the predictor and outcome variables can be found in table 4.

To test the relationship between the five predictor variables (estimated intelligence, schizotypy, performance-based creativity, and two self-reports of creativity) and aspects of executive functioning, five separate multiple regressions were conducted (1 for each variant of inhibition and flexibility, and 1 for the monitoring component). Zero-order correlations and regression information can be found in tables 5-7. The overall model predicting monitoring was significant, $R^2 = .341$, $F(5, 98) = 10.16$, $p < .001$. In this model, estimated intelligence ($\beta = .320$), performance-based creativity ($\beta = .343$), and creativity reports based on the Gough Creative Personality Scale ($\beta = .203$) were significant positive predictors.

The overall model predicting inhibition according to the Latzman and Markon model was significant, $R^2 = .326$, $F(5, 98) = 9.49$, $p < .001$. In this model, estimated intelligence ($\beta = .458$) and performance-based creativity ($\beta = .191$) were significant positive predictors. The overall model predicting inhibition according to the principal component analysis was significant and showed a similar pattern of results to the other inhibition model, $R^2 = .351$, $F(5, 98) = 10.61$, $p <$

.001. In this model, estimated intelligence (β = .436) and performance-based creativity (β = .249) were significant positive predictors.

The overall model predicting cognitive flexibility according to the Latzman and Markon model was significant, R^2 = .349, $F(5, 98) = 10.49$, $p < .001$. In this model, estimated intelligence (β = .441), performance-based creativity (β = .229), and schizotypy (β = .185) were significant positive predictors. The overall model predicting cognitive flexibility according to the principal component analysis was significant and showed a similar pattern of results to the other flexibility model, R^2 = .387, $F(5, 98) = 12.38$, $p < .001$. In this model, estimated intelligence (β = .483), performance-based creativity (β = .192), and schizotypy (β = .211), were significant positive predictors.

Discussion Part Two

These results suggest that predicted intellect and performance based-creativity are small to moderate positive predictors of all three components of executive functioning. Consistent with the prior literature, this supports the hypotheses that intelligence and creativity are positively related to executive functioning. The Gough Creative Personality Scale was a significant predictor of only the monitoring component of executive functioning. The IPIP creativity scale was not a significant predictor in any model. Contrary to the hypothesis that schizotypy would be associated with poorer executive functioning, schizotypy was a small but positive significant predictor of cognitive flexibility.

Creativity was associated with each aspect of executive functioning, even when intellect was included in the model. This supports prior theory that these constructs are related over and above a common “G” factor. Though there is some overlapping content between the measures of creativity and executive function (e.g. both measure fluency), the test differ primarily because

creativity is seen as divergent thinking whereas executive functioning is more convergent thinking. As previously described, both forms of problem solving have been associated with frontal lobe functioning and would be expected to co-vary (Abraham et al., 2012; Rybakowski, Klonowska, Patrzała, et al., 2008).

This study also supports hypotheses and prior findings that self-reported creativity and performance-based creativity show only small relationships. This study does not investigate why measures of the same construct would be so disparate. It is possible that people are not accurate reporters of their abilities (Hogan & Nicholson, 1988; Shedler, Mayman, & Manis, 1993) Another explanation may be that creative personality and thought patterns do not translate to actual verbal and non-verbal creative abilities; that is, personality traits may not always predict action. This is consistent with the small to moderate relationships found between intellect measured in personality questionnaires and actual intellectual functioning (Ashton, Lee, Vernon, & Jang, 2000; Schretlen, van der Hulst, Pearlson, & Gordon, 2010). In general, these findings echo the claims of several creativity researchers that the construct is difficult to measure and should be measured in multiple ways to maximize content validity.

This study supports the views of prior literature that concepts of intelligence, executive functioning, and creativity are related but separate constructs. One might say that all of these tests tap a unitary construct known as "G" but also contain unique and unrelated content. In this study, performance on a word-reading task was used as a proxy for intelligence, as it is predictive of verbal intellect. It is possible that other subcomponents of intelligence (e.g. perceptual reasoning) more closely map onto constructs like executive functioning or performance-based activities because both require some degree of abstract reasoning and problem solving. Future research should focus specifically on the relationship between these

constructs using a more thorough and direct measure of intellect. Inclusion of participants with more extreme scores than those in the present study may be helpful in determining if there are any threshold effects in the above relationships.

There are certain limitations to note in this study, which may help to explain the pattern of these results. First, little variability was noted across the sample on scores on the IPIP creativity scale and the schizotypy measures. This lack of variability may relate, somewhat, to socially desirable responding. There was greater variability in the Gough Creative Personality Scale. This scale allows for a wider range of responding, but it is also less face valid. There are several items on this scale (e.g. honest, well-mannered) that are socially desirable, but result in a lower score on the creativity composite. Though this study included a validity measure, this scale was included to prevent random or fixed responding rather than test for honest responding. Future research on these constructs could include a measure of social desirability or under/over reporting.

Despite the inclusion of the unusual experiences subscale of the OLIFE, schizotypy was again a difficult construct to measure, with very few persons endorsing questionnaire items. The distributions for schizotypy scales were positive skewed and the composite required transformation. Though theories hold that schizotypy is normally distributed, this study and the prior study including a very large sample did not yield such results. This may be a function of the questionnaires that are used, which may not adequately measure lower levels of schizotypic indicators. Future research on schizotypy could focus on other tools or measures of this construct. For example, it is possible that the unusual beliefs and experiences could be presented as more normalized in an interview format, which could lead to greater endorsement in the non-clinical population.

This study also operated under the assumption that schizotypy, as a normally distributed construct, is linearly related to other constructs of interests. It is possible that schizotypy may show non-linear relationships with other constructs of interest if it were measured across the full range of the continuum. For example, researchers have proposed an inverted U-shaped relationship between dimensionally conceptualized psychoticism and creativity (B. Nelson & Rawlings, 2010). A similar relationship may be present for schizotypy and cognitive flexibility. This study, which found a restricted range of schizotypy on the low end may represent the theory that moderate degrees of schizotypy increase cognitive flexibility. This idea is consistent with theories relating schizotypy to over-inclusive or broad patterns of thinking (Eysenck, 1993) and some studies showing that schizotypal traits in healthy populations may be associated with better problem solving in certain conditions (Karimi, Windmann, Güntürkün, & Abraham, 2007; Stoneham & Coughtrey, 2009) At a non-clinical level, those who endorse a few items may be more open to ideas and able to look at stimuli in multiple ways, but as they endorse an even greater number of symptoms they begin to have more executive dysfunction, like that noted in schizophrenia.

Chapter Four: Study Three

Creativity, Schizotypy and Laterality

Part three considered the relationship of schizotypia and executive function to laterality, another fundamental organizing principle within the brain. It has previously been suggested that schizotypy and creativity may be related as the result of patterns of laterality and inter-hemispheric functioning within the brain (Claridge & Broks, 1984; Leonhard & Brugger, 1998; Poreh et al., 1993). It has been argued (Lindell, 2014) that "atypical lateralization prompts a cognitive processing style that enhances both creativity and schizotypy, suggesting a potential biological foundation for the link" (pg. 1). Therefore the aim of this study was for patterns of hemispheric functioning which may serve as underlying biological mechanisms for the shared vulnerabilities between schizotypy and creativity.

The General Laterality Model

Chordates have a contralaterally organized nervous system culminating in laterally divided central nervous systems (Vallortigara & Bisazza, 2002), and research using both humans and animals consistently show asymmetry of the organization and function of the right and left cortical hemispheres. Theories of lateral function can be broadly categorized into specialization and interaction models (Kolb & Whishaw, 2009). In accordance with the specialization models, there is strong evidence throughout the neuropsychological literature for hemispheric specialization of some aspects of speech and language. Studies of brain-damaged patients have shown the importance of the left hemisphere in speech perception and production, while showing that the right hemisphere may specialize in music, prosody, and contextual interpretation of narrative. An extensive literature suggests that the left hemisphere organizes information by means of strong associations and narrow categorization; the left hemisphere shows a tendency to

exclude unclear categories or ambiguity. Conversely, the right hemisphere organizes semantic information loosely, retaining remote associations, categorizes broadly, and shows a tendency to form fuzzy categories (Atchley, Burgess, & Keeney, 1999; Beeman, 1993; Chiarello, Liu, Shears, Quan, & Kacinik, 2003; Hutchinson, Whitman, Abeare, & Raiter, 2003). Evidence from the studies of brain damaged patients supports these conclusions; right hemisphere damage is associated with difficulty drawing inferences from context and understanding humor or ambiguity (Brownell, Potter, Bihrle, & Gardiner, 1986; Gardner, Brownell, Wapner, & Michelow, 1983; Weylman, Brownell, Roman, & Gardner, 1989).

Alternatively, interaction models propose that the two hemispheres are both fully capable of multiple functions but operate dynamically and conjointly. The two hemispheres may act as parallel processors with preferred processing modes that excite or suppress the activity of the opposite side (Cook, 1986; Kinsbourne, 1974). Kinsbourne (1982), for example, writes:

> Lateralization provides neural distance, not between alternative mutually exclusive acts, but between complementary component processes that combine to program a unitary pattern, of behavior. By remaining separate until they are sufficiently elaborated to be combined, programs that contribute complementary elements maintain their differentiation and specificity. (p. 413)

Thus, our model previously outlined by Hutchinson et al. (2003) proposes a continuous interaction between the two hemispheres that occurs over time, contrasting and integrating the right-hemisphere broad organization and the left-hemisphere narrow organization. It appears that the hemispheres interact as two parallel processors. The right hemisphere processes the "ground"; meaning is a connotative process activated primarily through a bottom-up, stimulus driven process. The right hemisphere's vigilance for stimuli translates to higher-level maintenance for broad, weak, or remote semantic associations. Processing of the "figure" requires the left hemisphere, which maintains perceptual constancy, establishing denotative

meaning using a top-down cognitively driven process. The left hemisphere's mode of processing meaning translates to narrow, strong, close semantic associations.

Dichotic listening and semantic priming methodologies are useful for exposing hemispheric biases in processing and in exploring hemispheric interaction. Studies using dichotic listening require participants to attend to syllables, words or other stimuli when different stimuli are simultaneously presented to each ear. Under "free recall" conditions, most subjects show an advantage in recalling material presented to the right ear (left hemisphere). Even when directed to recall the left-ear (right hemisphere) first, subjects show greater interference from the right ear (Kimura, 1961a, 1961b). In semantic priming studies, participants make a lexical decision (identifying the stimulus as a word or non-word) about a stimulus (target) presented shortly after another word (prime). The prime may or may not be related to the target word. Theoretically, if a prime word relates to the target word, the lexical decision is faster as the semantic network is already activated. Thus, priming occurs when a previously introduced stimulus effects the response to a later stimulus. By presenting the words quickly to the right or left visual fields, researchers are able to examine lateralized differences and intra-hemispheric communication in language processing.

Findings in semantic priming studies depend on the relationship or association between the prime and the target. In general, findings support a model in which highly associated primes and targets effectively prime both hemispheres (Chiarello, Burgess, Richards, & Pollock, 1990; Walker & Ceci, 1985), while the right hemisphere shows greater priming for low associates when compared to the left hemisphere (Atchley et al., 1999; C. Burgess & Simpson, 1988; Chiarello & Richards, 1992; Nakagawa, 1991). Thus, priming the left hemisphere activates a

narrow, tightly associated group of words while activation of the right hemisphere results in a broader spread of activation that reaches remote or weak associates.

Previous work in our lab used semantic priming and dichotic listening methodology to test models of laterality. Hutchinson, et al. (2003) presented high and low associate primes to the right and left visual fields. Following a 50ms or 750ms stimulus onset asynchrony (SOA), participants performed a lexical decision task for targets presented in the right or left visual fields. In the 50ms SOA condition, high associates were primed in both hemispheres while low associates were only primed in the right hemisphere. At the 750ms condition, only high associates show priming effects in both hemispheres. Hutchinson et al. concluded:

> Under normal conditions, this interhemispheric interplay permits a continuous reconsideration of meaning and allows for creative consideration of alternative meanings. If the two hemispheres continuously send mirror-image arousal to the opposite hemisphere, then the right hemisphere has access to the left hemisphere's selected meaning while the left hemisphere can access the right hemisphere's broader array of activated associates should a change in the local semantic context require rapid reorganization around a different set of associates within the same cluster. Thus, each hemisphere can exploit the strength of the other trees (left hemisphere) without committing exclusively to one mode or the other to create a semantic system that can see both the forest (right hemisphere) and the other (p. 367).

Several other studies examined individual differences in the dynamic processes in which hemispheres interact to process semantic information. For example, Holcomb, Zuverza, Wang, and Whitman (2011) found that greater inter-hemispheric transfer of information was negatively related to characterological rigidity and positively related to political liberalism. They also found that openness to experience and performance on some measures of set shifting were associated with greater right hemisphere involvement.

The purpose of the current study is to examine lateralized processing of information in relationship to schizotypy and creativity. Creativity and schizotypy both appear to have an underlying element of loose cognitive boundaries, over-inclusive thought patterns, and broad

patterns of thinking. These characteristics are believed to be associated with right hemisphere activation and greater inter-hemispheric transfer of information (Leonhard & Brugger, 1998).

Schizotypy and Laterality

As in schizophrenia, those with schizotypy show abnormalities in language processing (Fisher et al., 2007). Research has found that schizotypy is generally associated with greater right hemisphere processing or a relative reduction in left hemisphere language processing (Fisher et al., 2007; Grimshaw, Bryson, Atchley, & Humphrey, 2010; Kostova, de Loye, & Blanchet, 2011; Overby, 1992; Richardson et al., 1997). Claridge and colleagues published several papers considering those who scored high on measures of schizotypia and found evidence for asymmetry (Broks, 1984; Broks, Claridge, Matheson, & Hargreaves, 1984; Claridge & Broks, 1984; Rawlings & Claridge, 1984).

Using a dichotic listening task, Poreh, Whitman and Ross (1993) found greater left ear advantage in students that scored high on a group of schizotypy questionnaires compared to controls. Ear preference was also associated with greater creativity. Using a lexical decision task, Leonhard and Brugger (1998), found that those who scored high on the Magical Ideation Scale showed no hemisphere preference compared to a group scoring low on the scale which showed the expected left hemisphere preference for tasks associated with language. Others have found similar findings of increased right hemisphere activity (or relative decrease in left hemispheric activity) in semantic processing, with those with high schizotypy scores priming both dominant and subordinate meanings of ambiguous words (Grimshaw et al., 2010; Johnston, Rossell, & Gleeson, 2008; Kravetz, Faust, & Edelman, 1998).

Rawlings and Claridge (1984) found an advantage for the right hemisphere in local processing in those that scored high on measures of schizotypy, whereas the left hemisphere

typically dominates local processing. This pattern of left hemisphere dysfunction may be particularly pronounced in those with positive symptoms (Richardson et al., 1997). Neuroimaging confirms greater relative right hemisphere activation during verbal tasks in those who score high on measures of schizotypy (Hori, Ozeki, Terada, & Kunugi, 2008). Schizotypy is also associated with general reduction of lateralization in semantic and emotional prosody tasks (Najt, Bayer, & Hausmann, 2012).

The literature specifically regarding the relationship between schizotypy and inter-hemispheric collaboration is unclear. There is some support for abnormalities in communication between the hemispheres (Suzuki & Usher, 2009). These findings are consistent with research showing similar disruption and alteration in connecting structures like the corpus callosum in patients with schizophrenia (Cowell, Denenberg, Boehm, Kertesz, & Nasrallah, 2003; P. Green, Hallett, & Hunter, 1983; Walker & Green, 1982).

Creativity and Laterality

Similarly, the broad, over-inclusive thinking found in highly creative individuals may also be explained by alterations in hemispheric processing. Meta-analysis has concluded that the preponderance of research evidence points to the greater right hemisphere activation in association with creativity, which may relate to a more global processing style (Mihov, Denzler, & Forster, 2010). Evidence for a relationship between creativity and the right hemisphere has been found in behavioral, neuropsychological, EEG, and neuroimaging studies (A. Kaufman, Kornilov, Bristol, Tan, & Grigorenko, 2010).

Mednick (1962) defined creativity as “the forming of associative elements into new combinations which either meet specified requirements or are in some way useful” (pg. 221). Mednick’s definition of creativity can be incorporated into our understanding of semantic

activation and the differences in between the hemispheres. Given the notion that those high in creativity form new and broad associates, we would expect a greater role of the right hemisphere in processing semantic information and greater inter-hemispheric communication (Rybakowski, Klonowska, Patrzała, et al., 2008). Abeare, Hill, Zuverza, Geenen, and Whitman (2005) tested this notion by completing a semantic priming study using participants with high and low levels of creativity. They found that high creativity was associated with greater right hemisphere involvement, and this involvement increased following tasks that required creativity and was most obvious at a 400ms stimulus onset asynchrony.

Researchers have also suggested that there is greater interplay between the hemispheres during creative tasks (Mihov et al., 2010). In a previous dissertation considering creativity and semantic priming within our lab, Abeare suggests "The connection between the two hemispheres is crucial, because asymmetric organization depends upon and likely originates from interhemispheric communication" (pg. 23). He found differing patterns of interhemispheric communication across varying SOAs in high and low creatives.

Whitman, Holcomb, and Zanes (2010) specifically considered the interaction between the hemispheres in creative subjects. They proposed:

> The creative process is akin to perception. When observing an ambiguous figure, or a cloud bank, the perception of a figure within the ground is sudden and compelling. Once the figure is identified, the confusing mosaic becomes figure and ground. Previously we proposed that the two hemispheres function as a dynamic, interacting system utilizing a left-hemisphere fine coding, or narrow w activation of semantic networks and right-hemisphere course coding, or broad semantic activation. We suggested that these two systems interact over time in a dynamic manner to provide a constant interplay between narrow and broad (or fine and coarse) perceptions, meanings and concepts. In this manner, for example, the left hemisphere defines words crisply while the right hemisphere maintains the background arousal necessary for changes in a semantic network (e.g. changes in meaning) (pg. 117).

Results from this study, which related examined lateralized priming differences in high and low creatives as determined by the Torrance Test of Creative Thinking, supported the hypothesis that creativity is associated with greater inter-hemispheric communication.

The Current Study

Few studies have examined both everyday creativity and schizotypy together in the context of laterality. Theorists suggest that both schizotypy and creativity are characterized by an overactive right hemisphere that takes on tasks typically dominated by the left hemisphere, such as those that requiring comprehension and processing of language (Brod, 1997). Poreh, Whitman, and Ross (1993) found a decrease in left hemisphere advantage in those that scored high on measures of schizotypy and also found that this group scored higher on some subtests of the Torrance Test of Creative Thinking. Weinstein and Graves (2002) considered the relationships between schizotypy (measured by the Chapman scales) and creativity (measured by a word fluency task and a remote associates task) using semantic priming lexical decision and dichotic listening methods and found both to be associated with increased right hemisphere processing. No studies were found that also directly examined the relationship between schizotypy, creativity, and inter-hemispheric communications.

As previously described, both schizotypy and creativity include an element of underlying flexible cognitive processing. This flexibility of thought is fundamentally characterized by over-inclusive thought or broad associations, which we have found in our work on lateralization and hemispheric differences to correlate with greater right hemisphere involvement and greater interhemispheric transfer of information. Therefore, we hypothesized that schizotypy and creativity would be positive predictors of a right hemisphere bias for activation and greater

interhemispheric collaboration in a lateralized semantic priming task. There is no evidence to support that these predictors would be associated with overall task accuracy.

Methods Part Three

Participants

This study utilized the same participants as study two. Due to an issue with the computer, data was dropped for the first nine participants. Data from all other participants was utilized for the accuracy analysis; however, only data from right-handed persons who achieved an accuracy greater than 70% were used for priming and cross-priming analyses resulting in a sample size of 82 participants.

Semantic Priming Task

Stimuli. The semantic priming task used is previously described by Hutchinson et al. (2003) Participants see words (e.g. bank) and non-words (e.g. crint) flashing on left or right side of the screens. Nonsense words were created by changing one phoneme in an actual English word. There were 287 trials. A trial consisted of a prime and a target. About half the trials use targets in which there were actual words, rather than nonsense words. Words were in black print on a white background. The words were presented on a desktop computer in the lab using SuperLab 4.5, which records accuracy and reaction time using a Cedrus response box. Participants are seated approximately 18 inches from the screen and place their chins on a rest to ensure proper distancing.

There were three types of word target trials: high associate (e.g. COFFEE-TEA), low associate (e.g. COFFEE-MILK), and unrelated (e.g. COFFEE-PERSON). Visual field presentation was counterbalanced and trail order was randomized, though due to programming error there were no non-word pairs presented in the RVF-RVF condition. D. Nelson, McEvoy,

and Schreibner word association norms were used to determine associate strength of the words. High associate targets included words that at least 30% of participants in Nelson's study reported immediately in a free association task. Low associates were those that were identified 1-5% of the time. Unrelated words were words that were not identified in Nelson's normative study.

Procedure. Each trial began with a mark displayed 1000ms to focus eyes to the center of the screen. Next, a prime appeared to the right or left visual field. The participant saw the target for 385ms followed by a 15ms interstimulus interval (total SOA = 400). Next, the target appeared for 185ms and is randomized to the left or right visual field. Following the presentation of the target, subjects made a lexical decision for the target word by pressing the appropriate button (i.e., 'WORD' or 'NONWORD') on a button box. This timing scheme was suggested to be most appropriate to show effects of creativity by Abeare et al. (2005).

Analysis

Laterality Indices and Composites. Data was cleaned according to suggestions made by Tabachnick and Fidell (2007), and univariate outliers found in the reaction time data were winsorized. To consider priming effects, we calculated the difference in reaction time across correctly identified related and unrelated trials to get results for both high and low associates. A graph showing the overall priming by visual field and type of prime can be found in figure 3. As suggested by Brugger (1993), we compute a laterality index to consider the relative contributions of each hemisphere for both accuracy, reaction time, and throughput scores. Scores fall between -1 (maximal left hemisphere) and +1 (maximal right hemisphere), with zero reflecting no asymmetry. The formula is computed: Laterality index = (LVF – RVF)/ (LVF + RVF). It is important to use such an index to consider relative performance of the right hemisphere in the context of the typical left hemisphere dominance for reading. With regard to cross-priming a

total composite for priming across the contralaterally presented word pairs was calculated to examine the degree of inter-hemispheric transfer of information.

For the analysis of part three, we used multiple regression with creativity (performance-based & two self-report measures) and level of schizotypy as predictors of accuracy, laterality, and inter-hemispheric transfer of information.

Results Part Three

As predicted, the overall model predicting task accuracy was not significant (R^2 = .036, F(4, 90) = .815, p = .519) and there were no significant individual predictors of accuracy. The overall regression model of the four predictors predicting the laterality index across all association strengths was not significant R^2 = .083, F(4, 77) = 1.75, p = .148), though performance-based creativity was significantly correlated with the laterality index (r(80) = .216, p = .026*)* suggesting a relationship with right hemisphere activation. The regression model for the four predictors predicting the laterality index of only highly associated pairs was not significant (R^2 = .051, F(4, 77) = 1.04, p = .390) and there were no significant correlations with predictor variables. With regard to the low-associate pairs, the regression model for the four predictors predicting the laterality index was also not significant (R^2 = .076, F(4, 77) = 1.57, p = .190), though the schizotypy composite showed a significant correlation with the laterality index (r(80) = .217, p = .025).

The model predicting overall cross priming was not significant (R^2 = .074, F(4, 77) = 1.53, p = .202), though scores on the IPIP creativity scale were significantly positively correlated with cross-priming, r(80) = .199, p = .037. The overall model predicting cross priming in the high associate condition was significant, (R^2 = .160, F(4, 77) = 3.68, p = .009), and the IPIP scores were a significant positive predictor whereas the schizotypy scores were a significant

negative predictor of cross priming (See table 8). The model predicting cross priming in the low associate condition was not significant (R^2 = .017, F(4, 77) = .341, p = .849), and no predictors were significantly related to cross priming in low associates.

Discussion Part Three

Overall, there were only trends supporting the proposed hypotheses. As predicted, accuracy was not related to constructs of interest. There was some evidence that performance-based creativity and schizotypy are related to right hemisphere activity, but only in specific conditions. These findings are in support of the study hypotheses and consistent with our prior findings (Abeare et al. 2005, Hutchinson et al., 2003 Poreh et al., 2003; Whitman et al., 2010) , but the stability of these findings is somewhat questionable as findings were inconsistent across predictors and conditions. With regard to cross priming, there was hypothesis-supporting evidence for self-reported creativity as a positive predictor of inter-hemispheric transfer of information. Contrary to the hypothesis, there was some evidence for a decrease in inter-hemispheric transfer of information in normal subjects scoring high on schizotypy. Again, these findings are condition specific and given the study limitations discussed below, there is concern that these findings may be spurious, especially given the number of analyses conducted in this study.

In addition to the limitations relating to the measurement of schizotypy and creativity previously described in part two, there are several limitations to this study relating to the use of the semantic priming methodology. There are several parameters that are set for a given priming study including specific word used and configurations set, stimulus onset asynchrony, timing of word presentation, degree of word association, location of visual field presentation, and how priming composites are calculated. Very few studies have been conducted systematically

considering how variations in these parameters affect results, even before considering potential individual differences. The parameters for this study were chosen based on review of prior similar studies conducted in our lab, and we cannot be certain that results would hold if parameters were to change. For example, Hutchinson et al. (2003) found differing patterns of results across various stimulus onset asynchronies. When considering individual differences, like creativity and schizotypy, information about various parameters is unknown.

Semantic priming data also requires considerable examination and decision making on the part of the researcher. Reaction time distributions for a particular word-target pair are often highly positively skewed, and often contain cases in which a decision is to made whether or not a data point is to be considered an outlier. Dealing with outliers is especially important in this kind of study because outliers may represent a different process (e.g. person became distracted during the task and later guessed the item correctly without even processing the words). In this study, outlier determination was largely made by considering gaps in the distribution and looking at absolute values (e.g. greater than 10s is likely an outlier), but very few studies publish their process for dealing with outliers in the data, so it is uncertain how this process of decision making influences final results. Furthermore, this study use a 70% overall accuracy cutoff to include data in analyses. This is used to help ensure that data included represents true priming data rather than random responding. It is assumed that those with 70% or more accurate responses are fully engaged in task for every item, which may not be the case and could affect final data analyses in unpredictable ways.

Additionally, there are specific limitations involving the semantic priming methodology unique to this study. There were significant difficulties in programing the study in SuperLab. Originally, there was supposed to be a 15ms pattern mask present during the inter-stimulus

interval. After considerable consultation with the Cedrus Superlab support staff, it was determined that the newly purchased desktop computer would not reliably present stimuli at that rate due to the video card refresh rate of the computer. In addition, Superlab could not guarantee that other stimuli would be present on the screen for the exact specified rate, and there was no way to measure the degree of error as the cycle of prime-interval-target would be consistently presented as reflected on response data print-out. It is generally assumed that this problem brought additional random error to the analysis, but its exact effects are unknown. It is also unpredictable how the lack of a distractor configuration presented in the RVF-RVF could have affected overall data.

Future studies may consider use of other methods for measuring laterality and inter-hemispheric transfer of information. Neuroimaging, despite having its own assumptions and limitations, may be useful for investigating individual differences.

Chapter 5: Final Conclusions

This dissertation sought to examine the relationship between everyday creativity and schizotypy measured continuously in a non-clinical sample. Special attention was given to this relationship in the context of neuropsychological similarities and differences, particular with executive functioning, laterality, and interhemispheric transfer of information. In general, there was support for a small relationship between creativity and schizotypy. This relationship was explained by openness to experience, a personality trait in which a person considers broad amounts of information and may have an over-inclusive pattern of thought. Creativity was related to all aspects of executive functioning, even when controlling for the effects of intelligence. Contrary to hypotheses, schizotypy showed a positive relationship to cognitive flexibility though this may be the result of a sample that showed very little schizotypal symptom endorsement and is better able to control broad associative thoughts to complete problem-solving tasks. Though inconsistent, there was a trend showing both schizotypy and creativity were associated with greater right hemisphere activation. Trends also showed increased hemispheric transfer of information in higher creativity and lower schizotypy.

The findings from these studies support Carson's (2011) model considering the relationship between creativity and psychopathology. Parts one and three focused on the shared vulnerabilities between creativity and schizotypy. Consistent with prior literature and theory (e.g. Acar & Sen, 2003; S. Kaufman and Paul, 2014; Miller and Tal, 2007; Gianotti, Mohr, Pizzagalli, Lehmann, & Brugger, 2001), this research showed that those high on schizotypy and creativity share an approach to processing information that is characterized by openness, broad associations, and overinclusive thinking. This style of thinking allows for the production of novel ideas and may result in increased production during divergent thinking tasks (Karimi et al., 2007;

Stoneham & Coughtrey, 2009). Based on trends in study three, our prior research findings, and our model of lateralization, (Abeare et al., 2005; Hutchinson et al., 2003; Whitman et al., 2010), we believe that this style of thinking is correlated with greater right hemisphere processing of language and greater interhemispheric transfer of information. As previously suggested (Leonhard and Brugger, 1998; Lindell, 2014), this pattern of lateralization may represent a biological vulnerability for both creativity and psychopathology.

Results from study two support Carson's (2011) model concerning the protective and risk factors that differentiate creativity and psychopathology. Consistent with prior literature (e.g. (Rybakowski et al., 2008), creativity was associated with multiple aspects of executive functioning. This increase in executive functioning, especially in the areas of monitoring and inhibition, is believed to help creatives control and harness broad and over-inclusive thoughts. Those high on schizotypy, however, may not have the adequate executive abilities to control this style of thought. As in Carson's model, it may be this reduction of control or executive function that puts them at risk for psychopathology.

This dissertation adds to the current literature, as very few studies described above use non-clinical populations or continuous measurement of schizotypy and creativity. Many prior studies consider special populations (e.g. artists, relatives of schizophrenics) and this study addresses a gap in the literature considering the constructs in the everyday population. This project integrates multiple research fields and the findings will help to contribute to our understanding of the neuropsychological underpinnings of individual differences in multiple domains of functioning. This project is meaningful and important because it points towards the converging and diverging biological bases of psychopathology and normal functioning, as

measured through neuropsychological methods. Findings from this study can contribute to our understanding, classification, and potential treatment of certain pathologies.

Future research can further these contributions by addressing specific limitations. Better measures of schizotypic traits in the general population are critical to future research. Items from the questionnaires utilized in this study reflect high degrees of pathology and are rarely endorsed in the non-clinical population. For example, even in the original study for the OLIFE short form (Mason et al., 2005), which is considered useful in non-clinical populations, items from the unusual experience scale were rarely endorsed. It may be difficult to develop such a questionnaire, and other types of data should be considered (e.g. interview, behavioral). In addition, replication and extension of results pertaining to laterality and inter-hemispheric transfer of information are necessary. Differing measurement techniques (e.g. neuroimaging, other behavioral laterality tests) may be helpful in furthering this line of research.

Table 1.

Pearson's R Correlations for Schizotypy, Openness, Creativity Scales, and Composites

	1.	2.	3.	4.	5.
Openness					
1. BFI Openness	-				
Creativity					
2. IPIP	.690***	-			
3. Gough	.464***	.416***	-		
4. Composite	.685***	-	-	-	
Schizotypy					
5. PAS	.144***	.109**	.062	.102**	.-
6. MIS	.188***	.141**	.082*	.133***	.609***
7. Composite	.188***	.139***	.078*	.129***	-

Note. BFI = Big Five Inventory, IPIP = Creativity Scale from the International Personality Item Pool, Gough = Creativity Personality Scale, PAS = Perceptual Aberration Scale, MIS = Magical Ideation Scale Schizotypy Composite was Log Transformed ***$p < .001$ **$p < .01$; *$p < .05$.

Table 2

Pearson Product Moment Correlations of Estimated Intelligence, Creativity, and Schizotypy

	1.	2.	3.	4.	5.	6.	7.
1. TOPF							
2. ATTA Creativity Index	.390***						
3. IPIP	.172	.197*					
4. Gough	.032	.136	.349***				
5. PAS	-.045	.028	--.066	.077			
6. MIS	.069	.059	.007	--.027	.605***		
7. OLIFE	-.032	.016	.244*	.174	.542***	.708***	
8. Schizotypy Composite	.023	.054	.108	.111	.760***	.881***	.896***

Note. TOPF = Test of Premorbid Functioning, IPIP = Creativity Scale from the International Personality Item Pool, Gough = Creativity Personality Scale, PAS = Perceptual Aberration Scale, MIS = Magical Ideation Scale , OLIFE = Oxford Liverpool Inventory of Feelings and Experiences Unusual Experiences Short Scale, PAS and MIS were Log Transformed ***p < .001 **p < .01; *p < .05.

Table 3

Component Loadings and communalities based on a principal components analysis with Oblimin rotation for 13 subtests of the Delis Kaplan Executive Function System

	Cognitive Flexibility	Inhibition	Monitoring
Card Sorting Correct	.881		
Card Sorting Description	.876		
Card Sorting Recognition	.877		
Twenty Questions Total	.508		
Twenty Questions Abstraction Score	.320		
Trails Condition 4 Time	.342	.380	
Design Fluency Total		.595	
Color Word Interference Time		.873	
Color Word Switching Time		.775	
Phonemic Fluency Total			.544
Semantic Fluency Total		.325	.504
Category Fluency Total			.970
Category Switching Total			.953

Note: Factor loadings <.3 are suppressed.

Table 4

Descriptive Statistics for Study 2

	M	SD
TOPF	98.53	13.11.
ATTA Creativity Index	73.84	10.34
IPIP	3.77	.52
Gough Creativity Scale	4.22	3.11
Schizotypy Composite	.27	.16
Latzman & Markon Monitoring	10.70	2.59
Latzman & Markon Inhibition	10.19	1.91
Latzman and Markon Flexibility	11.12	2.56
PCA Monitoring	10.70	2.59
PCA Inhibition	10.36	1.94
PCA Flexibility	10.66	1.85

Note: TOPF= Test of Premorbid Functioning Standard Score, ATTA = Abbreviated Torrance Test of Creativity, IPIP = Creativity Scale from the International Personality Item Pool. PCA = Composites created using principal component analysis Schizotypy Composite was log transformed

Table 5.

Prediction of the Monitoring Component of Executive Functioning

Monitoring according to Latzman and Markon and Principal Components Analysis

Variables	Zero Order Correlation	B	SE B	β	t	P
Constant		-.585	2.237		-.262	.794
TOPF SS	.442	.063	.018	.320	3.566	.001
IPIP	.086	-.546	.448	-.109	-1.221	.225
Gough	.223	.169	.073	.203	2.305	.023
ATTA Creativity Index	.475	.086	.023	.343	3.799	<.001
Schizotypy Composite	.051	.223	1.308	.014	.170	.865

Note: R^2 = .341, Adjusted R2 = .308, n = 104 p< .001. TOPF = Test of Premorbid Functioning Standard Score, IPIP = Creativity Scale from the International Personality Item Pool, Gough = Gough's Creative Personality Scale, ATTA = Abbreviated Torrance Test of Creativity Creativity Index Score. Schizotypy Composite was log transformed.

Table 6.

Prediction of the Inhibition Component of Executive Functioning

Inhibition according to Latzman and Markon

Variables	Zero Order Correlation	B	SE B	β	t	P
Constant		2.477	1.670		1.483	.141
TOPF SS	.513	.067	.013	.458	5.046	<.001
IPIP	.022	-.549	.334	-.149	-1.644	.103
Gough	.129	.081	.055	.131	1.472	.144
ATTA Creativity Index	.362	.035	.017	.191	2.086	.040
Schizotypy Composite	.103	.982	.976	.084	1.006	.317

Note: $R^2 = .326$, Adjusted $R^2 = .292$, n = 104, $p < .001$

Inhibition Determined by Principal Components Analysis

Variables	Zero Order Correlation	B	SE B	β	t	P
Constant		1.943	1.660		1.170	.245
TOPF SS	.516	.064	.013	.436	4.895	<.001
IPIP	.045	-.518	.332	-.139	-1.561	.122
Gough	.160	.097	.054	.155	1.772	.079
ATTA Creativity Index	.416	.047	.017	.249	2.779	.007
Schizotypy Composite	.079	.630	.971	.053	.649	.518

Note: $R^2 = .351$, Adjusted $R^2 = .318$, n = 104, $p < .001$. TOPF = Test of Premorbid Functioning Standard Score, IPIP = Creativity Scale from the International Personality Item Pool, Gough = Gough's Creative Personality Scale, ATTA = Abbreviated Torrance Test of Creativity Creativity Index Score. Schizotypy Composite was log transformed.

Table 7.

Prediction of the Cognitive Flexibility Component of Executive Functioning

Flexibility according to Latzman and Markon

Variables	Zero Order Correlation	B	SE B	β	t	P
Constant		-.100	2.197		-.045	.964
TOPF SS	.514	.086	.017	.441	4.943	<.001
IPIP	.017	-.565	.440	-.114	-1.286	.202
Gough	-.002	-.023	.072	-.028	-.315	.753
ATTA Creativity Index	.385	.057	.022	.229	2.553	.012
Schizotypy Composite	.192	2.882	1.285	.185	2.244	.027

Note: R^2 = .349, Adjusted R^2 = .315, n = 104, p < .001

Flexibility Determined by Principal Components Analysis

Variables	Zero Order Correlation	B	SE B	β	t	P
Constant		1.647	1.543		1.068	.288
TOPF SS	.551	.068	.012	.483	5.581	<.001
IPIP	.086	-.274	.309	-.077	-.886	.378
Gough	.092	.032	.051	.054	.632	.529
ATTA Creativity Index	.384	.034	.016	.192	2.204	.030
Schizotypy Composite	.230	2.388	.902	.211	2.647	.009

Note: R^2 = .387, Adjusted R^2 = .356, n = 104, p< .001. TOPF = Test of Premorbid Functioning Standard Score, , IPIP = Creativity Scale from the International Personality Item Pool, Gough = Gough's Creative Personality Scale, ATTA = Abbreviated Torrance Test of Creativity Creativity Index Score. Schizotypy Composite was log transformed.

Table 8

Prediction of Cross Priming (in Milliseconds) in the High Associate Condition

Variables	Zero Order Correlation	B	SE B	β	t	P
Constant		-178.243	118.590		-1.503	.137
IPIP	.269	77.701	26.339	.331	2.950	.004
Gough	.044	.366	4.112	.010	.089	.929
ATTA Creativity Index	-.004	-.196	1.180	-.018	-.166	.869
Schizotypy Composite	-.235	-227.902	82.201	-.302	-2.773	.007

Note: R^2 = .160 Adjusted R^2 = .117, n = 82, p = .009. IPIP = International Personality Item Pool Creativity Questionnaire, Gough = Gough's Creative Personality Scale, ATTA = Abbreviated Torrance Test of Creativity Creativity Index Score. Schizotypy Composite was log transformed.

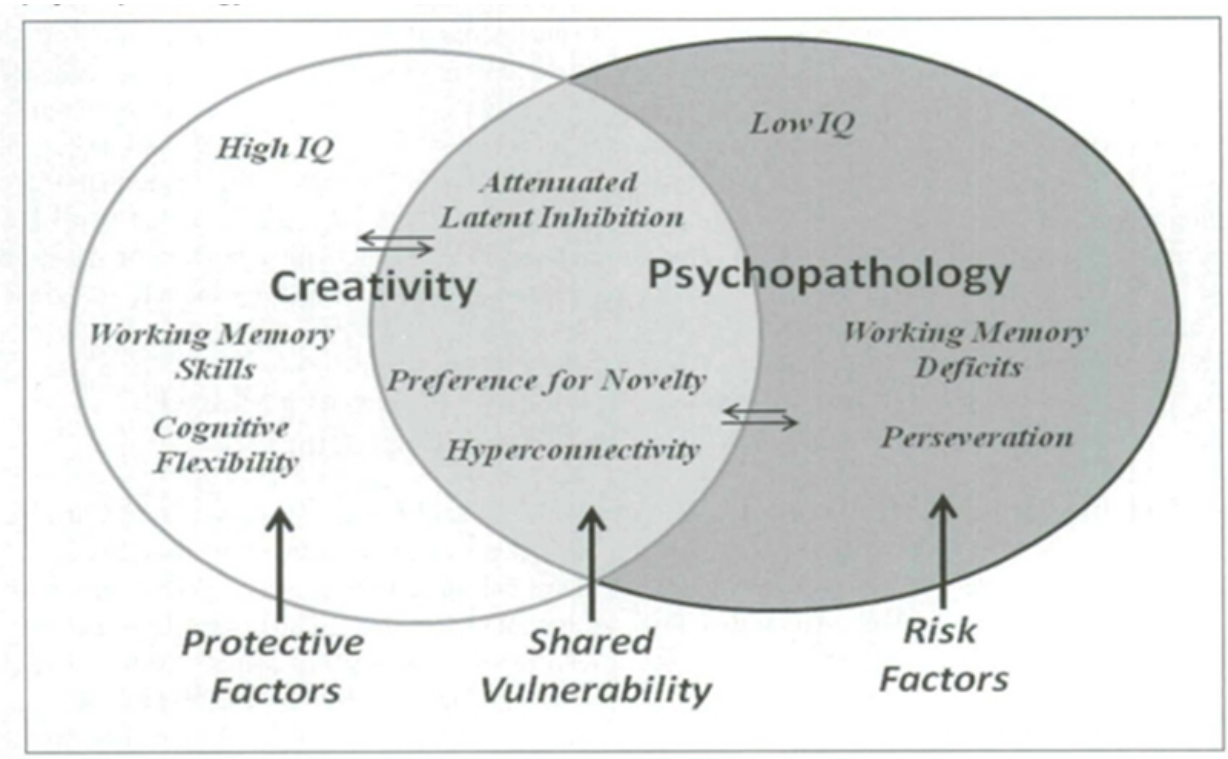

Figure 1: Model published in Carson (2011) showing her model for the relationship between creativity and general psychopathology.

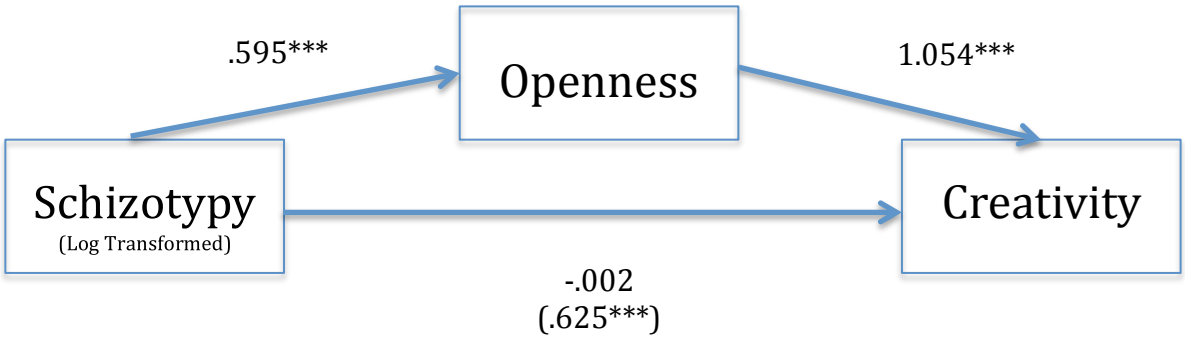

Figure 2: Openness fully explains the relationship between Schizotypy and Creativity. Note:*** $p < .001$.; numbers represent unstandardized coefficients.

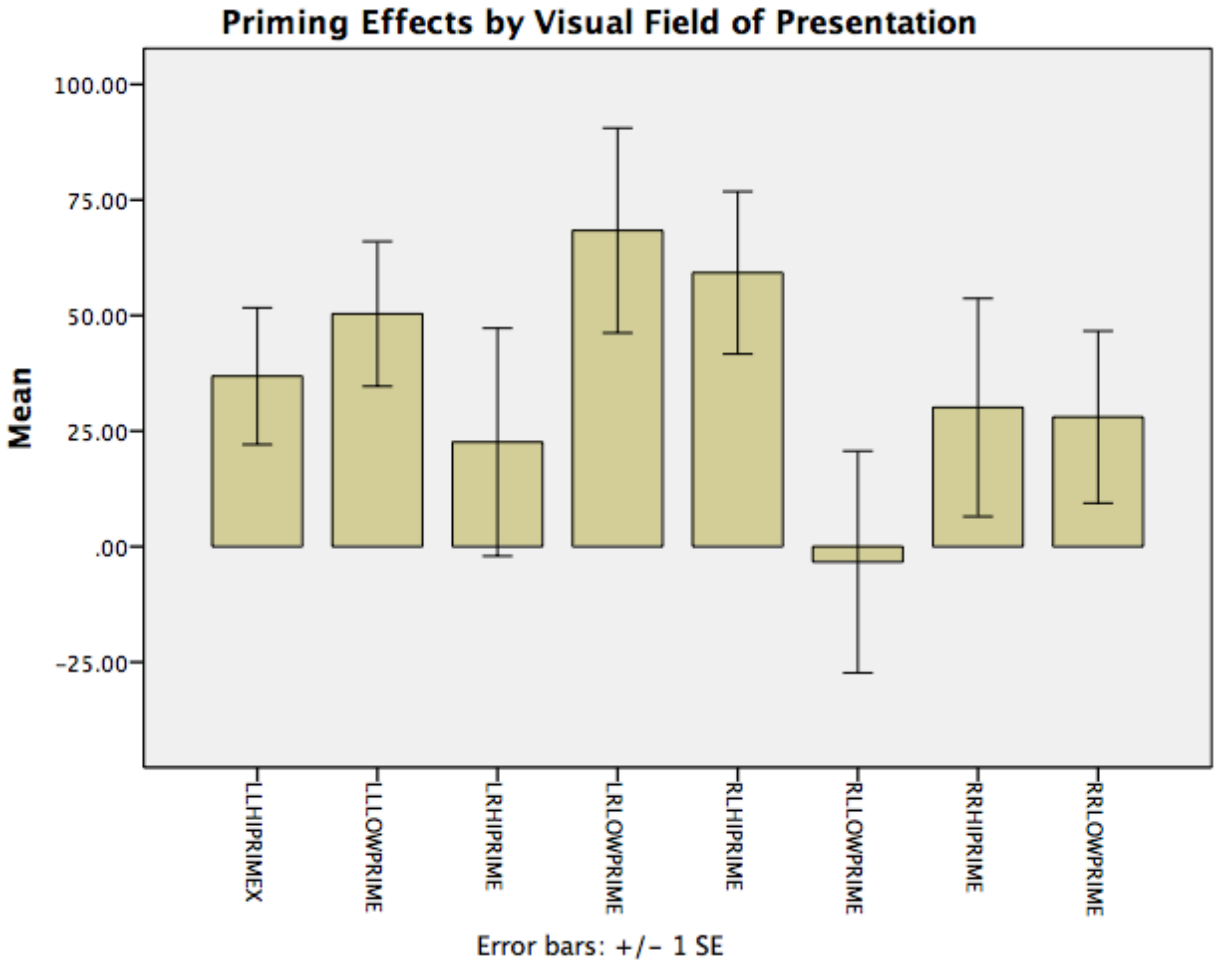

Figure 3. Mean priming in milliseconds according to visual field configuration and association strength.

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ABSTRACT

COGNITVE STYLE, LATERALITY, AND EXECUTIVE FUNCTION

by

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Advisor: Dr. R. Douglas Whitman

Major: Psychology (Clinical)

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Researchers have long linked creativity to psychopathology. In particular, everyday creativity is positively associated with schizotypy, a personality style with a possible relationship with schizophrenia that is associated with cognitive dysfunction. Genetic, biological, cognitive, and behavioral studies show connections between schizotypy and creativity, but the strength and mechanisms of these connections remain inconsistent or unclear. The purpose of this dissertation is to examine the relationship between these constructs from a neuropsychological perspective. In part one, a large non-clinical sample completed several questionnaires to consider the relationship between the constructs and related aspects of personality. A small indirect relationship was found between schizotypy and creativity, which explained by openness to experience. Part two examined the association between these constructs and performance on measures of executive functioning. A performance-based measure of creativity was also included. Creativity was positively associated with monitoring, inhibition, and cognitive flexibility aspects of executive functioning, whereas schizotypy only showed relationships with cognitive flexibility. Part three focused on patterns of hemispheric bias and inter-hemispheric interaction associated with schizotypy and creativity while concurrently testing a model

developed with the lab of lateralized brain functioning. This model proposes a continuous interaction between the two cerebral hemispheres that occurs over time, contrasting and integrating the right-hemisphere broad organization and the left-hemisphere narrow organization. Following this model, it was predicted that both constructs would be positively associated with greater right-hemisphere activity and greater interhemispheric communication. Hypotheses were tested using a lateralized semantic priming task. Analysis showed several trends supporting this model. These laterality patterns may underlie the shared vulnerabilities between schizotypy and creativity.

AUTOBIOGRAPHICAL STATEMENT

Leia Vos graduated from Calvin College in 2010 with a bachelor's degree in psychology with a minor in communication arts and sciences. She began a clinical psychology doctoral program at Wayne State University in August 2010 where she specialized in neuropsychology. She has worked with Dr. Whitman's neuropsychology laboratory since 2010 where she has completed five research studies related to laterality and individual differences. Many of these projects were presented at the International Neuropsychological Society meetings. She completed her master's thesis, *Lateralized differences in perceptual change blindness*, in 2011 and published it in *Laterality* in 2014. Leia was also active in research at her practicum placement at Rehabilitation Institute of Michigan from 2013-2015. This research focused on use of the Cog-Log in rehabilitation inpatients without brain injury. She presented these findings at the Div. 22 Rehabilitation Psychology conference in 2015. Leia is currently completing her pre-doctoral internship at the John D. Dingell VA medical center where she specializes in neuropsychology. Following graduation, she plans to pursue a postdoctoral residency in neuropsychology.