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Cone Of Gaze In Schizotypy: Potential Differences Among Positive, Negative, And Disorganized Subtypes

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CONE OF GAZE IN SCHIZOTYPY: POTENTIAL DIFFERENCES AMONG POSITIVE, NEGATIVE, AND DISORGANIZED SUBTYPES

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VITA

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ABSTRACT

Although not as prevalent as other disorders, the impact of schizophrenia is widespread and costly. Societal burden and individual suffering provide support for increased focus on the early identification of individuals at risk for developing schizophrenia spectrum disorders. Utilizing the construct of schizotypy is one method of studying the early onset of these disorders. Meehl (1962; 1990) introduced the concept of schizotypy as personality organization that results in increased vulnerability to develop schizophrenia spectrum disorders. Thus, individuals psychometrically identified to be schizotypes present a unique opportunity to study the factors that contribute to the development of schizophrenia spectrum disorders. In addition, endophenotypes, commonly described as intermediate phenotypes, provide a latent, yet measurable marker of the liability for schizophrenia. Wastler and Lenzenweger (2018) proposed that a self-referential bias in eye gaze perception could be a promising endophenotype and found support for positive schizotypes endorsing individuals in photos as looking at them over a wider range of eye gaze angles than a non-schizotypy control group. Although promising, this study did not include negative or disorganized schizotypes and no subsequent studies have been completed to examine self-referential eye gaze perception in these facets of schizotypy. This study sought to fill this gap in the literature. The final sample included 542 participants, ranging in age from 18 to 25. Positive (n = 66), negative (n = 64), and disorganized (n = 82) schizotypes were identified using the Multidimensional Schizotypy Scale. Self-referential eye gaze perception was measured using a cone of gaze task in which participants observed four series of

photos. In these photos, volunteer models continuously shifted their eyes from 25 degrees to the left to 25 degrees to the right, resulting in a range of eye gaze angles in photos. Participants then identified when individuals in the photo were looking toward them and looking away from them. T-tests were completed to determine if there were any significant differences between schizotypes and control groups on when they identified individuals in photos as looking toward them and looking away from them. Compared to a non-schizotypy control group, both negative and disorganized schizotypes identified individuals in photos as looking away from them significantly later. In contrast, when compared to a more loosely defined, non-deviant control group, positive schizotypes identified individuals in photos as looking toward them significantly earlier. These findings provide support for a self-referential gaze perception bias in all schizotypes; however, it presents an important distinction between groups. This difference could be explained by differences between groups in social cognitive and neurocognitive factors. Finally, this study provides additional support for establishing self-referential eye gaze perception as an endophenotype for schizophrenia spectrum disorders.

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CHAPTER 1

INTRODUCTION

Although schizophrenia is not as prevalent as many other psychological disorders, its impact is widespread and costly, both financially and psychologically. The overall economic burden of schizophrenia in the United States has been estimated to be approximately 155.7 billion dollars, with direct healthcare costs making up approximately 37.7 billion dollars and indirect costs, including unemployment and productivity lost due to caregiving, contributing 117.3 billion dollars (Cloutier et al., 2016). Societal burden and individual suffering provide significant support for the idea that early identification and subsequent treatment of schizophrenia spectrum disorders should be a primary focus of interventions with this population. However, in order to implement early intervention treatment, individuals in the beginning stages of developing a schizophrenia spectrum disorder must be readily identified, a task that has proved challenging.

In addition to difficulty with the identification of psychosis prone individuals, low prevalence rates contribute to difficulty in targeting these populations efficiently. The American Psychiatric Association (2013) cites that the prevalence of schizophrenia ranges from .3 to .7 percent, indicating that less than one person out of every one hundred people is diagnosed with schizophrenia. This low base rate makes schizophrenia an especially difficult disorder to target and study. Schizotypy offers a method of studying the vulnerability to develop schizophrenia

spectrum disorders which could prove helpful in remedying these issues. Because the construct of schizotypy is often conceptualized as the liability to develop schizophrenia and has been observed in approximately 10% of the population (Meehl, 1990), studying schizotypy opens the door to more rigorous studies that can be applied to both schizotypy subgroups and more widely to schizophrenia management and prevention efforts.

Meehl (1962; 1990) first introduced the concept of schizotypy and hypothesized that a single gene, the schizogene, was responsible for the deficits seen across schizotypy and schizophrenia. Although schizophrenia has been characterized as a genetically based disorder for decades, the search for a single schizophrenia gene has proved widely unsuccessful (Lenzenweger, 2010). Instead, it is generally accepted that a collection of genes contributes to the development of schizophrenia, and as a result, schizotypy. Meehl (1990) further theorized that neural transmission deficits lead to the presence of slippage at synapses, which results in the behavioral symptomology observed in schizophrenia. This concept is often referred to as "cognitive slippage" and is typically associated with associative loosening and cognitive abnormalities seen in schizophrenia (Lenzenweger, 2010). Stated similarly, a brain characterized by this slippage provides the foundation for the development of schizophrenia, or the genetic and biological predispositional vulnerability of a diathesis stress model. As such, the presence of these cognitive deficits does not mean that one will develop schizophrenia with certainty. Instead, these deficits interact with environmental factors, leading to the development of various schizophrenia spectrum disorders.

In contrast to the development of schizophrenia spectrum disorders, Meehl (1962; 1990) proposed that the schizotaxic brain, as discussed above, directly leads to the development of schizotypy, often without negative environmental factors. Consequently, schizotypy is defined as

the psychological and personality organization that results from the schizotaxic individual interacting with the world (Lenzenweger, 2006). In addition, although it is thought that the personality organization of schizotypy "harbors the liability for schizophrenia," it can develop into other schizotypic disorders, schizophrenia-related psychoses, or various endophenotypes (Lenzenweger, 2010). Endophenotypes are commonly the focus of schizotypy research and can be described as intermediate phenotypes, which are heritable and invisible to the naked eye. Cited examples of endophenotypes include deficits in sustained attention, eye tracking, and working memory (Lenzenweger, 2010). It has also been proposed that self-referential eye gaze perception as measured by a cone of gaze task, and more generally self-referential thinking, an aspect of social cognition, could be additional endophenotypes of schizotypy.

For example, Wastler and Lenzenweger (2018) demonstrated that individuals identified as positive schizotypes report feeling as though they are being "looked at" over a wider range of angles, or that they endorse direct gaze across a wider range of angles than a control group. Further, this has been suggested to be related to increased self-referential thinking and poor social functioning, both of which have been observed in individuals diagnosed with schizophrenia. These results prove promising; however, no subsequent studies have been completed to examine how different facets of schizotypy, including negative and disorganized schizotypy, affect the range of angles participants endorse as a direct gaze. This study will address this absence in the literature.

In addition to broadly adding to the literature of the early identification and treatment of schizophrenia spectrum disorders, the purpose of this study is to determine how facets of schizotypy, including positive, negative and disorganized types, are related to self-referential eye gaze perception. Finally, by considering self-referential eye gaze perception as a potential

endophenotype, literature contributing to the development of the theory of schizotypy will be expanded.

CHAPTER 2

REVIEW OF RELEVANT LITERATURE

Historical Views of Schizophrenia

Although distinct from schizophrenia, the first description of psychosis was documented in the Vedas of ancient Hindus in 1400 BC (Adityanjee et al., 1999) . Babylonian documents and other texts of the second millennium BC first described the origin of psychosis in the western world. In addition, during the fifth century, physicians Caelius Aurelianus and Alexander of Tralles, wrote of a disease resembling schizophrenia.

Although some suggest that schizophrenia dates back to the beginning of humanity, the first adequate recorded description of what appears to be schizophrenia came from John Haslam in 1809 (Gottesman, 1991). Haslam (1809) described a form of "insanity" that was characterized by hallucinations and delusions, blunted affect, and cognitive deficits. During the same year, a French physician, Phillippe Pinel, provided clear, cohesive descriptions of schizophrenia using the term *demence*, or loss of mind, to describe these individuals (Adityanjee et al., 1999; Gottesman, 1991). Benedict Morel utilized Pinel's idea of demence and coined the term *demence precoce*, meaning "loss of mind" and "early, premature," in 1852 to further characterize schizophrenia. Morel used these terms to describe what he saw as distinctive components of the disorder, such as cognitive decline and deterioration of the mind, in addition to the observation of the typical adolescent onset of this disease (Gottesman, 1991).

Emil Kraepelin, influenced by his predecessors Karl Kahlbaum and Ewald Hecker, expanded the view of the schizophrenia-like illness discussed before him to become more comparable to the construct known today. Through this conceptual expansion, Kraepelin was able to create a cohesive view of this illness, and named it dementia praecox (Gottesman, 1991), an anglicized version of Morel's term. He noted cognitive dysfunction in his patients, and assumed that this disorder was a form of dementia (Falkai et al., 2015). He also observed the presence of hallucinations and delusions, in addition to catatonia and hebephrenia, all of which became integrated into his conceptualization of dementia praecox (Gottesman, 1991). Kraepelin was also the first to focus on family history, age of onset, and hereditary factors and the role they played in this disorder (Adityanjee et al., 1999).

Finally, in 1908, Eugen Bleuler introduced the term schizophrenia, coming from Greek roots meaning splitting of the mind (Gottesman, 1991). This renaming of Kraepelin's dementia praecox could be viewed as a simple name change, or a reconceptualization of the underlying disorder, based on a dislike and rejection of Kraepelin's nosology (Maatz & Hoff, 2014). In his conception of schizophrenia, Bleuler noted the primary features as looseness of associations, affective flattening, autism, and ambivalence. Consequently, he viewed traditional positive symptoms, like hallucinations and delusions, as secondary (Adityanjee et al., 1999). In contrast to this view, Kurt Schneider described hallucinations and delusions as first rank symptoms beginning in 1939. Often known as Schneider first rank symptoms, this subset of hallucinations and delusions were thought to be of critical importance when diagnosing schizophrenia over other disorders (Cutting, 2015). This shift in thinking resulted in the predominance of importance placed on positive symptoms (e.g., delusions and hallucinations) over negative symptoms (e.g., social withdrawal, anhedonia, and avolition) still paramount today.

Overview of Schizophrenia

Although schizophrenia is not as prevalent as many other psychological disorders, its impact is widespread and costly, in both financial and emotional terms. The financial cost of schizophrenia in the United States has been estimated to range from 2 to 17.3 billion dollars, with hospitalization costs making up 68 percent of the total and medication contributing up to 2.3 percent of money spent nationwide (Knapp et al., 2004). Knapp and colleagues (2004) found that the value of the loss of productivity in the United States as a result of schizophrenia ranged from 9.1 to 12.0 billion dollars; additionally, the financial impact of schizophrenia on families ranged from 2.0 to 2.5 billion dollars, with the cost per patient per year ranging from 13 to 32 thousand dollars. Although these numbers seem extreme, more recent research has found the economic burden of schizophrenia in the United States to be even higher at 155.7 billion dollars, including direct and indirect health care costs, with direct healthcare costs accounting for approximately 37.7 billion dollars and indirect costs, including unemployment and productivity lost due to caregiving, accounting for an estimated 117.3 billion dollars (Cloutier et al., 2016). In addition to the financial cost to society, schizophrenia has a direct effect on those diagnosed with the disease and their loved ones. These increased burdens and debilitating deficits in day to day functioning as a result of schizophrenia shows that it is a mental illness that needs to be better understood to improve disease outcomes.

Description and Symptoms

Schizophrenia is a chronic, heterogeneous disorder; therefore, individuals diagnosed with schizophrenia will vary substantially in presentation and symptomology. Given its complex nature, symptoms of schizophrenia are typically divided into three broad categories: positive symptoms, negative symptoms, and disorganized symptoms. Positive symptoms can be

conceptualized as the addition of abnormal thoughts and experiences, such as delusions or hallucinations, whereas negative symptoms are characterized by the removal of normal thoughts and experiences, such as the inability to feel pleasure (Freedman, 2003). Disorganized symptoms may be observed through disorganized speech, inappropriate affect or disorganized behavior (Agrawal et al., 2016). Additionally, the emphasis placed on cognitive symptoms of schizophrenia, including difficulty with attention and memory has increased over time (Freedman, 2003).

Although disorganized and cognitive symptoms are important in the diagnosis and treatment of schizophrenia, positive and negative symptoms are traditionally viewed as the most prominent symptoms. Primary positive symptoms in schizophrenia include delusions and hallucinations (Agrawal et al., 2016). Delusions are often viewed as "miscalculations" that are rooted in neurocognitive abnormalities (Lysaker & Hamm, 2015). That is, delusions are false beliefs that one believes strongly even when confronted with evidence to the contrary (Parnas, 2015). Persecutory delusions are most commonly observed in schizophrenia, followed by delusions of reference and grandiose delusions (Turgut, 2017).

Although there are many definitions of hallucinations, they can, perhaps, be best described as sensory experiences that occur without the presence of matching external stimuli (Laroi et al., 2012). Hallucinations can be experienced in any sense modality, however auditory hallucinations are the most common type observed in schizophrenia, making up 60 to 80 percent of hallucinations (Kühn & Gallinat, 2012; Laroi et al., 2012). Individuals who experience hallucinations tend to describe a lack of control over the experience and feeling as though the experience is external. For example, individuals with schizophrenia who experience auditory

verbal hallucinations experience the sounds as distinct from their own internal voices (Laroi et al., 2012).

Although positive symptoms have traditionally been labeled as first rank symptoms of schizophrenia, negative symptoms are once again beginning to be reconceptualized as vital to the disorder's presentation. Negative symptoms of schizophrenia may include avolition, alogia, anhedonia, and flat affect (Agrawal et al., 2016). These types of symptoms have been found to be associated with social dysfunction and poor occupational functioning. Further, negative symptoms often persist even after treatment with antipsychotics, with approximately 25 to 30 percent of patients with schizophrenia continuing to exhibit these symptoms after treatment with antipsychotics; thus, these symptoms comprise a significant aspect of the disorder (Mitra et al., 2016).

Epidemiology

Prevalence

Although consistently lower than the prevalence rate of many other mental illnesses, the prevalence of schizophrenia has been subject to some disagreement. Global prevalence of schizophrenia has been found to be approximately 0.4 percent by Bhugra (2005). Additionally, in a study of schizophrenia prevalence using 188 studies from 46 countries, the point prevalence was determined to be 4.6 per 1,000 individuals, period prevalence was 3.3 per 1,000 individuals and lifetime prevalence was 4.0 per 1,000 individuals (Saha et al., 2005). Furthermore, the lifetime morbid risk, defined as the proportion of individuals who will develop schizophrenia at some point during their lifetime, was shown to be approximately 7.2 per 1000. Simeone and colleagues (2015) performed a more recent systematic review of prevalence rate research from 1990 to 2013 and found 12-month prevalence of schizophrenia to be approximately .33 percent

and lifetime prevalence of schizophrenia to be approximately .48 percent. Wu et al. (2006) found the 12-month prevalence of schizophrenia in the United States to be 5.1 per 1000 individuals. The American Psychiatric Association (2013) cites the prevalence of schizophrenia ranging from .3 to .7 percent.

Incidence

The annual incidence of schizophrenia ranges from 1.5 to 4.2 per 10,000 individuals aged 15-44 when schizophrenia is broadly defined (Kulhara & Chakrabarti, 2001). Abel and colleagues (2010) found the male to female incidence rate in schizophrenia to be 1.4:1. Cross-cultural studies have found that, when narrowly defined, schizophrenia rates do not differ between cultures, however, when schizophrenia is more broadly defined, differences emerge, such that rates are higher in cultures that define schizophrenia more broadly (Kulhara & Chakrabarti, 2001). Other research has suggested that there is no difference in the incidence of schizophrenia in developed and developing countries, citing the need for more research (Saha et al., 2006).

Additionally, studies have found that migrant groups tend to have a higher estimated rate of schizophrenia than native-born populations (Kulhara & Chakrabarti, 2001; Saha et al., 2005). The stress experienced from migration is a common explanation for these increased rates; however, others have cited living in an urban area or environmental causes, such as obstetric complications and prenatal infections, as alternative explanations (Kulhara & Chakrabarti, 2001; Myers, 2011). In addition, African Americans have been found to have three times the chance of being diagnosed with schizophrenia as European Americans (Bresnahan et al., 2007). It has been theorized that this discrepancy has developed through over-diagnosis of culturally bound symptoms and other methodology issues. However, some suggest that this is reflective of a true

difference, as a potential result of the interaction between the increased stress of being a minority and a genetic predisposition (Myers, 2011).

Finally, living in an urban area and a having low socioeconomic status has also been associated with a higher risk for schizophrenia, although these relationships are still unclear (Cooper, 2005; Kirkbride et al., 2008). More recent studies of income inequality have shown that countries with higher rates of income inequality have significantly higher rates of schizophrenia (Burns et al., 2014; Johnson et al., 2015). This finding may clarify the relationship between urban areas, socioeconomic status, and risk for the development of schizophrenia, though more research is needed.

Course

Symptoms of schizophrenia typically begin in late adolescence or early adulthood and persist throughout adulthood (Freedman, 2003). Specifically, age of onset typically ranges from 15 to 35, with very few cases developing outside of this age range (Gottesman, 1991). The peak age of onset seems to differ between males and females, with modal age of onset occurring in the early to mid-20s for males and late 20s for females (American Psychiatric Association, 2013). Additionally, approximately half of the men who develop schizophrenia experience onset by age 28, compared to half of the women who develop schizophrenia experiencing onset by age 33, demonstrating a later onset is more frequent in women (Gottesman, 1991).

Before the onset of clinical psychosis, prodromal symptoms of schizophrenia often occur. When studied retrospectively, prodromal symptoms that predicted the development of schizophrenia include delusional, disorganized and neurotic symptoms (Rofes et al., 2003). However, other research has suggested that prodromal symptoms are most commonly depressive

and anxiety symptoms (Shioiri et al., 2007). The identification of these prodromal symptoms is important in terms of early interventions for better disease outcomes.

Although outcome studies of schizophrenia have found outcomes ranging from full remission to severe, continuous illness, these studies consistently show that schizophrenia has a poorer outcome in comparison to other diagnoses (Lang et al., 2013). Male sex and increased negative symptoms are typically associated with poorer outcomes (Lang et al., 2013). Additionally, early onset of symptoms is also associated with a worse prognosis (American Psychiatric Association, 2013). In older adults, positive symptoms of schizophrenia tend to decrease in severity; however, considering the increased rate of aging in patients with schizophrenia, physical comorbidity becomes more prevalent (Jeste & Maglione, 2013).

Etiology of Schizophrenia

As previously stated, due to schizophrenia being such a complex, pervasive disease, affecting multiple domains of functioning, many theories of etiology have emerged. These etiologies range from environmental to genetic theories and have varying levels of empirical support. Over time, more comprehensive theories regarding the development of schizophrenia have been created, often emphasizing a genetic predisposition, or liability to schizophrenia, and environmental factors that contribute to the development of this illness. The theory of schizotypy, as later discussed, constitutes a comprehensive theory which integrates genetic and environmental factors in the development of schizophrenia spectrum disorders.

Biological Theories

Dopamine Hypothesis

Perhaps the most prominent of biological etiological theories has been the dopamine hypothesis. This theory originated from the discovery that neuroleptic drugs acted through

suppressing dopamine, leading to an assumption that dopamine was involved in the etiology of schizophrenia (Baumeister & Francis, 2002). This hypothesis has undergone various transformations over time in order to incorporate new research findings. The first version of the dopamine hypothesis for schizophrenia emphasized hyperdopaminergia (excess dopamine neurotransmission) throughout the brain. In the second version, the theory was reconceptualized to distinguish between hyperdopaminergia in subcortical brain areas and hypodopaminergia (lack of dopamine neurotransmission) in the prefrontal cortex (Howes & Kapur, 2009). Finally, a third version of the dopamine hypothesis was developed to account for various new findings in neurochemical imaging, genetic, and environmental research.

According to this most recent hypothesis, dopamine dysregulation is key to the development of schizophrenia. Howes and Kapur (2009) claim that the final common pathway to better understanding how dopamine affects the development of schizophrenia is the concept of presynaptic striatal hyperdopaminergia, that is, excessive dopamine in striatal brain regions. They argue that excessive dopamine in this brain area accounts for the psychotic aspects of schizophrenia, including hallucinations. Studies examining individuals at ultra-high risk for psychosis found evidence for hyperdopaminergia in the dorsal striatum, indicating that excessive dopamine in the striatum is associated with psychosis, or the positive symptoms of schizophrenia (Egerton et al., 2013). Additionally, this theory claims that genetic and environmental risk factors, along with the interaction between the two, lead to the development of schizophrenia; thus, the dysregulation of dopamine within a compromised brain as a result of environmental or genetic factors results in schizophrenia (Howes & Kapur, 2009). Although the dopamine theory presents a unified, empirically supported theory for the etiology of positive symptoms of

schizophrenia (i.e. psychosis), the theory behind the development of negative, disorganized and cognitive symptoms is less clear.

Additionally, although not as well established as the dopamine hypothesis, other neurotransmitters, including glutamate, gamma-aminobutyric acid (GABA), acetylcholine and serotonin have been theorized to affect the development and functioning of schizophrenia (Yang & Shih-Jen, 2017). Compared to the dopamine hypothesis, research on these neurotransmitters in relationship to the development of schizophrenia is in its infancy and must be further studied before definitive conclusions can be drawn.

Genetic Contribution

Schizophrenia has been characterized as a genetically based disorder for decades; however, the search for a schizophrenia gene, or group of genes, has proved widely unsuccessful (Lenzenweger, 2010). Twin studies have shown that heritability estimates for schizophrenia range from 83 to 87 percent (Cardno et al., 1999). Other studies have stated that genetic factors coupled with gene-environment interactions contribute 80 percent of the likelihood of developing schizophrenia (Kukshal et al., 2012). Although heritability estimates are high, finding specific genes that increase the risk for schizophrenia has been difficult. For example, Ripke et al. (2014) found 108 schizophrenia-associated genetic loci. The most promising outcome of this genetic study has been the finding that major histocompatibility complex (MHC) showed the most significant association to the risk for schizophrenia. Found at the MHC locus, the C4 gene, which is related to synaptic pruning, was found to be the strongest candidate in association to the development of schizophrenia (Essali, 2017). Although 108 schizophrenia associated genetic loci may seem significant, these genes, identified through a genome wide association study, were all of small effect and together accounted for only 4% of the variance in the diagnosis of

schizophrenia (Leo, 2016). For reasons similar to these, many have abandoned the search for "schizophrenia genes" and began to look in different directions.

Brain Differences

Brain differences seen between individuals with and without schizophrenia have been thought to be related to the development of this disorder. For example, larger volumes in left and right lateral ventricles, which are associated with a corresponding decrease in gray matter, have been found in individuals with schizophrenia when compared to a healthy control group (Rosa et al., 2010). Furthermore, increased ventricle size is significantly correlated with both obstetrical complications and increased delivery time, both of which have been associated with the risk of developing schizophrenia. For example, hypoxia during birth, which affects grey matter mass, has been shown to be related to the development of schizophrenia (Opler et al., 2013). These findings support the theory that early brain insults contribute to the neurodevelopment of schizophrenia. However, it is often difficult to determine if brain differences have been caused by the disorder itself or have led to the development of it.

Environmental Theories

Preconceptual, Prenatal, and Perinatal Risk Factors

Various risk factors that occur before conception have been linked to the development of schizophrenia, including advanced paternal age, the amount of time taken to conceive, and time between pregnancies. Additionally, during pregnancy, low maternal levels of folate, an important micronutrient for cell division, may act as a risk factor for schizophrenia through the formation of neural tube defects. Low maternal folate, in addition to other nutritional deficiencies (potentially essential fatty acids, retinoids, vitamin D, and iron), are suspected to be the reason

behind the increased rates of schizophrenia seen in populations following famines, specifically the Dutch Hunger Winter and the Chinese famine (Opler et al., 2013).

Abnormal neurodevelopment, specifically the disruption of brain development, has been linked to prenatal exposure to viruses through the maternal placenta (Khandaker et al., 2013; Opler et al., 2013; Wright & Murray, 1993). Researchers have demonstrated that various viruses are positively correlated to the development of schizophrenia, including herpes simplex virus type-2, polio, rubella, influenza, and Toxoplasma gondii (Opler et al., 2013). These infections and others are associated with a two to five-fold increase in risk for developing schizophrenia (Khandaker et al., 2013). Interestingly, Vuillermot and colleagues (2010) were able to link prenatal exposure to infections to abnormalities in the dopaminergic system. In an animal study, these researchers concluded that prenatal immune activation results in maldevelopment in the dopaminergic system, starting in fetal development and continuing postnatally. Some suspect that fetal brain development is impacted by these viruses through exposure to proinflammatory cytokine production, as opposed to the virus directly (Khandaker et al., 2013; Opler et al., 2013). Inflammatory responses, and the possibility of schizophrenia being an autoimmune disease are also frequently noted (Khandaker et al., 2013).

Although, logically, the best course of action for the treatment of an infection during pregnancy is the use of anti-infective agents, a recent study has found that infections during pregnancy treated with an anti-infective agent resulted in a 37% higher risk for the development of schizophrenia. Furthermore, antibiotics were shown to be especially hazardous, as antibiotic use, rather than the use of another anti-infective agents such as antivirals, antimycotics, or antiparasitics, accounted for the majority of risk. This finding may purely be the result of bacterial infections being a greater risk factor for development of mental health issues (Köhler et

al., 2017); however, given that antibiotic use has been shown to disrupt the gut microbiome, which communicates with the central nervous system, and effects behavior and mood, the gut microbiome may play a bigger role than previously expected (Chrobak et al., 2016; Köhler et al., 2017). Simply stated, fetal exposure to maternal viruses is associated with an increased risk for schizophrenia, however, this risk increases when the fetus is exposed to antibiotics through maternal treatment of a bacterial infection. It is possible that, given the relationship between antibiotic use and damage to the gut microbiome, the microbiome could be implemented as a mechanism for increased risk to schizophrenia, however, further research is needed. Finally, cited as being related to many disorders and illnesses, high levels of maternal stress, which result in increased permeability of the placenta to cortisol, have been shown to affect the dopaminergic system and are associated with an increased risk for the development of schizophrenia (Opler et al., 2013).

Postnatal Risk Factors

Postnatal risk factors, including psychosocial factors, also contribute to the development of schizophrenia. One meta-analysis showed robust evidence for childhood adversities, cannabis use, and stressful events during childhood being risk factors for the development of schizophrenia (Belbasis et al., 2018). In addition to these well-established risk factors, emigration and living in an urban environment have also been consistently linked to the development of schizophrenia (Laba-Stefanek et al., 2016). Importantly, it can be theorized that the connection between each of these factors is increased stress, which likely interacts with a genetic predisposition to result in a range of outcomes, including the development of schizophrenia spectrum disorders. Further, various stressors, including childhood trauma and adult exposure to stressors like war, are also considered to be postnatal risk factors in the

development of schizophrenia (Laba-Stefanek et al., 2016). Cumulative lifetime trauma has also been connected to the development of schizophrenia spectrum disorders, indicating that exposure to trauma and stress may have a dose-dependent effect. Interestingly, adulthood trauma has been linked to significantly more severe positive symptoms, whereas childhood trauma has been linked to significantly more severe anxiety and depression symptoms (Liu et al., 2021).

Implications

Schizophrenia is a severe, chronic mental illness that often captures the attention of both researchers and clinicians. It is well known that schizophrenia has a debilitating effect in various aspects of functioning in those experiencing the disorder, however, a lack of cohesion in research has potentially led to missed opportunities for a greater understanding of schizophrenia and improvements in treatment recommendations.

Although schizophrenia is a heterogeneous disorder in presentation, the research backing it is also widely heterogenous. Schizophrenia lacks a widely accepted, unified framework from which researchers and clinicians can work. Without a framework or interactional theory guiding research, studies can appear to be disjointed and lack a bigger-picture point of view. It is only a matter of time before a universal, interconnected theory of schizophrenia is proposed. However, until this time, it is recommended that research focused on schizophrenia attempt to “connect the dots” between various well-supported theories. The theory of schizotypy, as discussed below, is one method of connecting these dots into a primarily unified theory of schizophrenia spectrum disorders, including their development and the potential for effective treatments.

Overview of Schizotypy

Both Kraepelin and Bleuler, known to many as the fathers of schizophrenia, discussed “latent schizophrenia” as a personality dysfunction which manifested as a less severe expression

of schizophrenia, especially in first degree relatives of individuals diagnosed with schizophrenia (Bleuler, 1911; Kraepelin, 1919). The concept of schizotypy was introduced some 50 years later when Rado (1960) suggested that schizotypy is a construct which harbors the latent liability for schizophrenia, while Meehl (1962; 1990) essentially created a diathesis stressor model to explain the interaction between the genetic etiology and environmental factors in the creation of the schizotype. Because schizotypy is often conceptualized as the liability to develop schizophrenia and has been theorized to be present in approximately 10% of the population (Meehl, 1990), studying schizotypy opens the door to more rigorous research studies that can be applied to both specific schizotypy subgroups and more widely as a platform for schizophrenia management and prevention efforts.

Theory of Schizotypy

In order to understand the theoretical framework behind the proposed study, one must first understand the concept of schizotypy. Meehl (1962; 1990) expanded the concept of schizotypy and hypothesized that a single gene, the schizogene, was responsible for the deficits seen across schizotypy and schizophrenia. Although schizophrenia has been characterized as a genetically based disorder for decades, the search for a single schizophrenia gene has proven largely unsuccessful (Lenzenweger, 2010). Instead, it is generally accepted that a collection of many genes each contribute a small amount to the development of schizophrenia, and as a result, schizotypy.

Meehl (1962; 1990) theorized that neural transmission deficits lead to the presence of slippage at synapses, or “cognitive slippage,” which results schizotaxia. Meehl posited that cells exhibiting hypokrisia, or a deviation in synaptic signal selectivity, was related to this slippage, which is typically associated with associative loosening and cognitive abnormalities

(Lenzenweger, 2010; Meehl, 1989). Meehl further theorized that schizotaxia was a "neural integrative defect" and the only component of schizotypy which can be inherited. He believed that the resulting personality type that arises from the interaction between schizotaxia and an individual's social learning history is schizotypy. In addition, unfavorable polygenic potentiators, such as anxiety and introversion, and adverse experiences, such as childhood trauma, contribute to the development of schizophrenia in those with this susceptibility (Meehl, 1989). Stated similarly, a brain characterized by this slippage provides the foundation for the development of schizotypy, or the genetic and biological predispositional vulnerability of a diathesis stress model. As such, the presence of these cognitive deficits and the personality organization of schizotypy does not mean that one will develop a schizophrenia-like disorder with certainty. Instead, schizotypy interacts with psychosocial stressors and polygenic potentiators, as stated above, leading to a variety of outcomes ranging from mild deficits to schizophrenia (Lenzenweger, 2015).

Consequently, schizotypy is defined as the psychological and personality organization that results from the schizotaxic individual interacting with the world (Lenzenweger, 2006). In addition, although it is thought that the personality organization of schizotypy "harbors the liability for schizophrenia," it can develop into other schizotypic disorders, schizophrenia related psychoses, and result in the display of endophenotypes (Lenzenweger, 2010). Overall, this suggests that the concept of schizotypy can be utilized as the much needed organizing framework of schizophrenia spectrum and related disorders, including schizophrenia, delusional disorder, psychosis-not otherwise specified, and schizotypal and paranoid personality disorders (Lenzenweger, 2010; 2015).

The theory of schizotypy purposes that schizotaxia and resulting schizotypy are necessary requirements for developing schizophrenia, however, if one's environment is favorable, it is most likely that this individual will not develop mental illness and instead remain a "healthy schizotype" (Meehl, 1962). Meehl (1990) proposed that approximately 10% of the population is schizotypic and approximately 10% of schizotypes decompensate into schizophrenia after an interaction between schizotypy and negative environmental factors occurs, resulting in the approximate 1% prevalence rate of schizophrenia. Although Meehl (1962) discussed the main environmental factor contributing to the development of schizophrenia being the "schizophrenogenic mother," various other environment factors have been hypothesized to be related to this pathway.

Schizotypy and Schizophrenia

It has been found that, on average, 50% of schizotypy variance is explained by genetics (Linney et al., 2003). For example, various dopamine-related genes (e.g. DRD2) show a relationship to schizotypy (Barrantes-Vidal et al., 2015; Taurisano et al., 2014). However, given that only 50% of the variance is genetically related, a large portion of the remaining variance in schizotypy must be related to other factors, including environmental factors, biological factors, and psychosocial factors. For instance, pre- and perinatal complications and maternal exposure to influenza have been associated with an increased risk of schizotypy (Barrantes-Vidal et al., 2015; Machón et al., 2002). Psychosocial factors, such as urbanicity, poverty, and migrant status have also shown relationships to schizotypy (Barrantes-Vidal et al., 2015). Notably, many of these factors have also been associated with an increased risk for developing schizophrenia.

Although there have been many proposed environmental factors that interact with schizotypy to contribute to the development of schizophrenia (e.g. stressful events during

adulthood, handedness, cannabis use, traumatic brain injury, advanced maternal age, childhood adversities, urbanicity, obstetric complications, tobacco smoking, general academic achievement, viral infection, etc.), in a recent metanalysis, only history of obstetric complications, childhood adversities, stressful events during adulthood, and cannabis use showed robust evidence for a relationship to the development of schizophrenia (Belbasis et al., 2018). However, in response to Belbasis and colleagues, Suetani et al. (2018) suggest that the accumulation of risk factors may be more important in the likelihood of developing schizophrenia than the specific types of risks one is exposed to. In addition, it was purported that the effect of exposure to risk factors depends on underlying vulnerabilities (Suetani et al., 2018).

Assessing Schizotypy

Schizotypy can be assessed in a variety of ways, however, at risk individuals are most often assessed clinically or psychometrically. In the clinical assessment of schizotypy, hypothetically psychosis prone individuals would be identified based on their display of specific symptoms, such as odd or magical thinking. By definition, these symptoms do not reach criteria for full psychosis, however, deficits in various domains of functioning can be observed clinically and used to identify high-risk individuals. These individuals are often deemed “high risk” based on a family history of psychosis, or other risk factors.

When using psychometric assessment, identifying schizotypes can be achieved using various measures. These measures are often self-report personality measures and include broad measures of psychopathology and personality functioning, such as the Minnesota Multiphasic Personality Inventory-2 (MMPI-2; e.g., Bolinskey & Gottesman, 2010). Meehl and Dahlstrom (1960) began the process of identifying those at risk for psychosis by creating a set of guidelines to distinguish between MMPI profiles of neurotic and psychotic individuals. Gilberstadt and

Duker (1960) took this a step further by analyzing profiles and determining that individuals with a specific profile (2-7-8 codetype) were more likely to endorse schizoid tendencies, difficulties with concentration, and higher rates of rumination and feelings of inadequacy than the general patient pool. This profile also tended to fit the profile of "psuedoneurotic schizophrenics" and was found to predict the later development of schizophrenia in individuals without current psychosis (Peterson, 1954). The effort to distinguish individuals at risk for developing schizophrenia spectrum disorders continues with both the MMPI-2 (Bolinskey & Gottesman, 2010) and the MMPI-2-RF (Hunter et al., 2014).

In addition to broad measures of personality, more specific measures of psychosis proneness and schizotypy have been developed, such as the Chapman Psychosis Proneness Scales (CPPS). More specifically, the CPPS were designed to reflect the heterogeneity in schizophrenia spectrum disorders and include five scales that measure different domains associated with the liability to psychosis as opposed to a unidimensional approach that attempts to measure the liability to schizophrenia spectrum disorders as a whole (Chapman et al., 1980). The CPPS include the Perceptual Aberration Scale, the Magical Ideation Scale, the Revised Physical Anhedonia Scale, the Revised Social Anhedonia Scale, and the Impulsive Nonconformity Scale. In a longitudinal study which followed undergraduate students, Chapman et al. (1994) found that students who scored high on the Perceptual Aberration Scale and Magical Ideation Scale were significantly more likely to have psychotic-like experiences, schizotypal symptoms, and psychotic relatives at a 10-year follow up. This supports the idea that psychometric measures of schizotypy demonstrate predictive validity and can be useful in identifying potential schizotypes.

More recently, the Multidimensional Schizotypy Scale (MSS) has been developed for the assessment of schizotypy and includes subscales designed to measure positive, negative, and disorganized schizotypy. The MSS is relatively new, and thus, faces a dearth of research in its ability to identify schizotypes in comparison to the more established measures discussed above.

Factors of Schizotypy

In their development of a new assessment measure of schizotypy, the Multidimensional Schizotypy Scale, Kwapil et al. (2018) reported that positive schizotypy is best assessed by measuring magical beliefs, referential thinking, mind reading and thought transmission, supernatural experiences, unusual perceptual and somatic experiences, paranoia and suspiciousness and special powers. Cicero and Kerns (2010) proposed a model of positive schizotypy which included three factors, including paranoia, referential thinking and cognitive perceptual deficits. The paranoia factor includes suspicions of other people, while the cognitive-perceptual factors include magical beliefs and perceptual aberrations, thought to be similar to delusions and hallucinations, respectively. Finally, the referential thinking factor was defined as the tendency to interpret innocuous stimuli as self-relevant.

In contrast, negative schizotypy is assessed by items that measure social disinterest, flat affect, anhedonia, alogia, anergia, and avolition (Kwapil et al., 2018). Finally, the disorganized schizotypy factor was assessed by items designed to measure disorganized thought and behavior, confusion, racing thoughts, loose associations, disrupted speech, difficulty following conversation, and slowness of thought (Kwapil et al., 2018). These domains overlap with Mason (2015) who reported that the negative factor of schizotypy usually includes traits related to anhedonia and social anxiety, while the disorganized factor is conceptualized as cognitive disorganization and includes difficulties in attention, confusion, and impulse control.

Although conceptually related to the symptom domains of schizophrenia, few studies have empirically examined whether factors of schizotypy directly map onto the symptoms of schizophrenia. However, Thomas et al. (2019) recently found that positive and negative facets of schizotypy are highly correlated with positive and negative symptom domains of schizophrenia, providing support for the use of schizotypy as a model for investigating schizophrenia.

Endophenotypes in Schizophrenia and Schizotypy

Meehl called for the development of "high validity indicators" for schizotypy some sixty years ago, resulting in an influx of research examining potential indicators and further development of his theory of schizotaxia, schizotypy and schizophrenia. Endophenotypes have played a major role in this expansion of research. Gottesman and Gould (2003) stated that endophenotypes are "measurable components unseen by the unaided eye along the pathway between disease and distal genotype" and provide a method of studying genetic underpinnings of disease. Endophenotypes are commonly the focus of schizotypy research and can also be described as intermediate phenotypes, which are heritable and not visible to the naked eye (Lenzenweger, 2010). Cited examples of endophenotypes in schizotypy include deficits in sustained attention, eye tracking and working memory (Lenzenweger, 2010). It is proposed that self-referential eye gaze perception, as measured by a cone of eye gaze task, discussed below, could be an additional endophenotype of schizotypy.

Social Cognition

Social cognition refers to a range of mental activities, including the perception and interpretation of the intentions and behaviors of others that underlie social functioning and interactions (Green et al., 2008). Traditionally, social cognition includes five domains, including theory of mind, social perception, social knowledge, attribution bias, and emotion processing.

Theory of mind refers to the ability to make inferences about the beliefs and intentions of others. Social perception includes the ability to identify socially bound roles and rules. Similarly, social knowledge is defined as awareness of the roles, rules, and goals that describe social situations and guide interaction with others. Attribution bias refers to how people infer the causes of events, or how they think about what made something occur. Finally, emotion processing includes perceiving and using emotions, which includes the ability to identity emotions in others (Green et al., 2008).

Individuals with schizophrenia show deficits across all of these domains (Savla et al., 2013). Importantly, these deficits have been connected to functional outcomes, including community integration, social skills, and independent living skills in schizophrenia (Couture et al., 2006, Fett et al., 2011). Deficits in social cognition across facial emotion recognition, theory of mind, and emotion management have been found in schizotypy, supporting the idea that social cognitive deficits may be an endophenotype for the liability to develop schizophrenia spectrum disorders (Morrison et al., 2013). In addition to social cognitive deficits broadly being a potential endophenotype, it is possible that more specific components of social cognition, such as self-referential gaze perception, as discussed below, could also be an endophenotype.

Cone of Gaze

Gaze cues and the perception of being "looked at" have important implications for social interactions. This perception typically signals that another individual would like to communicate in some way (Hamilton, 2016; Senju & Johnson, 2009). In addition, gaze cues regulate social interaction, express intimacy, provide information, and facilitate goal setting (Baron-Cohen, 1995; Kleinke, 1986; Patterson, 1982). Evaluating gaze direction seems to be somewhat inherent,

such that when judging a videotaped gaze, individuals tend to be largely accurate in determining gaze direction, with small estimation errors, especially for direct gaze (Cline, 1967).

Furthermore, most individuals display a preference for direct gaze, which develops in infancy (Farroni et al., 2002). Balsdon and Clifford (2018) found that at higher levels of uncertainty, devised by using individuals in photos wearing dark sunglasses, participants reported gaze as more direct over a wider range of eye gaze angles. This finding suggests that when visual information is reduced, individuals tend to assume direct gaze. Gamer and Hecht (2007) first developed the cone of gaze metaphor to better explain these eye gaze phenomena. This metaphor describes a range of gaze angles, ranging from eye positions being to the far left to far right. In a wider cone of gaze, individuals identify eyes as "looking at them" over a wider range of eye gaze angles. In comparison, a narrow cone of gaze requires individuals identifying eyes as looking at them over a small range of angles closest to direct eye gaze.

The widening of cone gaze has been found in individuals with both social anxiety and social phobia (Gamer et al., 2011; Harbort et al., 2013). In addition, it has been demonstrated that ostracized individuals endorse a greater degree of averted gazes as being direct when compared to included individuals (Lyyra et al., 2017). It was theorized that ostracized individuals display an increased need for belonging, which results in a search for signals of inclusion (i.e. being looked at over a wider range of eye gaze angles). These findings suggest equifinality of a wider cone of gaze, such that there can be multiple explanations for endorsing direct gaze over a wider range of ambiguous eye gaze angles. In addition to observing deficits in cone of gaze tasks across multiple disorders, Harbort et al. (2013) demonstrated that with treatment, this widening of cone of gaze can be normalized. Importantly, this suggests that cone of gaze deficits are a valuable and changeable target of intervention.

Cone of Gaze Deficits in Schizophrenia

Hooker and Park (2005) found that individuals with schizophrenia were as able to accurately identify direct eye contact as controls, however, individuals with schizophrenia were found to be significantly more likely to misinterpret averted gaze as a direct gaze when compared to a control group. Further, Hooker and Park (2005) attributed this finding to the idea that individuals with schizophrenia experience higher rates of self-referential bias in judging eye gaze, which likely results in misinterpreting the intentions of others during social interactions. In contrast to the above results, a study which examined the ability to discriminate between different angels of eye gaze found that individuals with schizophrenia did not demonstrate deficits in detecting averted gaze and orientating to gazed-at orientation (Seymour et al., 2017). In other words, individuals diagnosed with schizophrenia were able to accurately detect averted eye gazes and orient to where averted gazes seemed to be focusing as well as controls. This suggests that individuals with schizophrenia show deficits at the level of interpretation as opposed to lower-level processes. Researchers proposed that these findings indicate deficits in higher-level cognitive processing, such as interpreting what eye gazes mean (both direct and averted), as opposed to deficits in lower-level processes, like the simple identification of whether an eye gaze is directed toward you or averted.

Cone of Gaze Deficits in Schizotypy

Using a cone of gaze task, Wastler and Lenzenweger (2018) demonstrated that individuals identified as positive schizotypes report feeling as though they are being “looked at” over a wider range of angles, such that they endorse direct gaze across a wider range of angles than a control group. They found differences between the schizotypy and control group only in their cone of gaze width, indicating that the groups differ in regard to ambiguous gaze angles,

rather than direct eye gaze. Similar to schizophrenia findings in cone of gaze tasks, this finding was associated with increased self-referential thinking and poor social functioning, both of which have been observed in individuals diagnosed with schizophrenia (Wastler & Lenzenweger, 2018). Specifically, in this study self-referential thinking was defined as "a form of subtle reality distortion in which one experiences otherwise neutral events, objects, and/or interactions with other people as having special, significant, self-relevant meaning" (Lenzenweger et al., 1997; Wastler & Lenzenweger, 2018, p. 3). Interestingly, though a widening of cone gaze has also been found in individuals with social anxiety, self-referential thinking, as measured by the Referential Thinking Scale, has been observed as significantly higher in positive schizotypy groups in comparison to social anxiety and healthy control groups (Meyer & Lenzenweger, 2009).

Wider implications suggest that gaze perception, and more broadly social cognition, may serve as an endophenotype for schizophrenia liability. These results prove promising; however, no subsequent studies have been completed to examine how different facets of schizotypy, including negative and disorganized schizotypy, affect the range of angles participants endorse as a direct gaze. Because each facet of schizotypy is theorized to be the conceptual pair to symptom domains in schizophrenia (positive, negative, disorganized), examining each facet of schizotypy and its connection to deficits in identifying averted and direct eye gaze could provide a theoretical base for studying these deficits in schizophrenia and tailoring treatment based on the primary display of symptoms. The proposed study will address this absence in the literature.

Current Study

In addition to broadly adding to the literature about early identification and treatment of schizophrenia spectrum disorders, the purpose of this study is to determine how facets of schizotypy, including positive, negative and disorganized types, are related to self-referential eye

gaze perception, measured within this experiment using a cone of gaze task and when participants identify individuals in photos as looking toward them and subsequently looking away from them. It is predicted that all individuals identified as schizotypes, (i.e. individuals identified as positive, negative, and disorganized schizotypes) using the Multidimensional Schizotypy Scale (MSS) will identify that individuals in photos are both looking toward them and looking away from them at a wider gaze angle in comparison to controls

CHAPTER 3

METHODOLOGY

Overview and Design

This study is part of a larger, ongoing study of schizotypy. In addition to broadly adding to the literature about the early identification and treatment of schizophrenia spectrum disorders, the purpose of this study is to determine how facets of schizotypy, including positive, negative and disorganized types, are related to self-referential eye gaze perception, measured within this experiment using a cone of gaze task, as described below, and the range of ambiguous gaze angles that individuals identify as looking at them.

Group membership will be determined using the Multidimensional Schizotypy Scale (MSS). Participants who score two standard deviations above the mean or higher on an MSS dimension (i.e., positive, negative, or disorganized) will be classified as a high schizotypy (HS) participant for that dimension. These individuals will be compared to a control group of low schizotypy (LS) individuals, defined as scoring less than one standard deviation above the mean on each MSS dimension. Low schizotypy participants must fall below one standard deviation above the mean on positive, negative and disorganized dimensions, as measured by the MSS. Each participant, regardless of group membership, will complete a cone of gaze task. Results will be compared between groups.

Power Analysis

Statistical power was determined using a commonly available power analysis program (GPower; Erdfelder et al., 1997) to detect a medium effect size (d = 0.4). This value was selected based on earlier studies of schizotypy that have found similar effect sizes. Given the allocation ratio of approximately 4 times as many non-hits as hits, 62 participants would be needed in each hit group (positive, negative, and disorganized), and 248 participants would be needed in non-hit control groups for a total of 434 participants.

Participants

The initial participant pool consisted of undergraduates from Indiana State University recruited from introductory psychology classes. These participants received course credit in exchange for their participation in the study. Participants were required to be 18 to 25 years old to participate in this study, based on the desire to capture participants during the period of greatest risk for developing a schizophrenia spectrum disorder. To be included in the final sample, participants must have completed the Multidimensional Schizotypy Scale (MSS) and completed the cone of gaze task.

The final sample included data from 542 participants. These participants ranged in age from 18 to 25 years old. Individuals who self-identified as female made up 75.5% of the final sample. Individuals who self-identified as male made up 24.5% of the final sample. It was expected that there would be an overrepresentation of individuals who identified as female due to participant recruitment from introductory psychology courses. Of participants who chose to identify their race/ethnicity, 66.3% self-identified as White/Caucasian, 21.2% as African American, 5.7% as Hispanic, 2.4% as Asian, and 4.5% as Other, which included individuals who identified as more than one race/ethnicity.

In regard to the high schizotypy or hit groups, participants that scored two standard deviations above the mean or higher on an MSS dimension (i.e., positive, negative, disorganized) were classified as a hit or high schizotypy participant for that dimension. There were 66 individuals in the high positive schizotypy group, 64 individuals in the high negative schizotypy group, and 82 individuals in the high disorganized schizotypy group. Importantly, high schizotypy groups were not mutually exclusive. That is to say, a participant could meet criteria to be in multiple groups (e.g., positive schizotypy and disorganized schizotypy) and as a result was placed in hit groups for all the domains that they scored two deviations or higher than the mean on. In order to be placed in the low schizotypy control group, individuals had to have scored less than one standard deviation above the mean on each MSS dimension. Stated another way, these individuals did not meet "hit" criteria on any MSS dimension and represented a non-schizotypy control group, allowing for a clean comparison between hits and non-hits. There were 300 individuals in the low schizotypy control group.

Measures

Multidimensional Schizotypy Scale (MSS)

As previously discussed, the Multidimensional Schizotypy Scale (MSS; Kwapil et al., 2018) was used to determine group membership. The MSS is a self-report measure of schizotypy and includes subscales of positive, negative, and disorganized dimensions of schizotypy. The positive and negative subscales include 26 items each, while the disorganized subscale contains 25 items resulting in a measure of 77 total items. Each of these scales has been found to demonstrate good to excellent internal consistency reliability. Kwapil et al. (2018) produced coefficient alpha levels of .89 for the positive schizotypy subscale, .87 for the negative schizotypy scale, and .94 for the disorganized schizotypy scale in a sample of 1000 participants.

Given the recent development of this measure, there is a considerable shortage of independent research. This study seeks to contribute to the growing literature on the MSS as a reliable and valid measure of schizotypy.

Cone of Gaze (CoG) Task

A version of a Cone of Gaze (CoG) task, originally created by Gamer and Hecht (2007) was utilized as a measure of gaze perception and consequently, self-referential eye gaze perception. The CoG task used in this study was adapted from Wastler and Lenzenweger (2018). The CoG task was developed using sequential photographs of models moving their eyes from left to right. Of note, the heads of models remained forward facing and only their eyes moved. Images were taken using the burst mode on an iPhone as models tracked a moving target with their eyes from 25 degrees to the left to 25 degrees to the right over 5 seconds. This resulted in approximately 10 photos per second. Photos from each model were selected isochronally, such that an equal time interval occurred between each selected photo to ensure that eye gaze angles were consistent across models. Models included an African American male, African American female, Caucasian male and Caucasian female, resulting in four sets of photographs. Eleven photos of each model were used, with varying eye gaze angles, from a direct gaze looking straight ahead to a fully averted gaze in both the right and left direction (see Appendix). Each photo was numbered sequentially, ranging from 1 to 11, with photos 1 and 11 representing the most averted eye gazes to both the right and left and photo 6 representing direct, or straight forward, eye gaze.

Procedures

Participants were provided information about the study and provided written consent before beginning testing. Anonymity was ensured through the use of identification numbers,

which were assigned to participants at the start of data collection. The use of identification numbers serves to ensure that participants' names would not be utilized for data identification purposes. Relevant to this study, participants completed both the MSS self-report measure and Cone of Gaze task on the same occasion. In addition, although not directly pertinent to this study, participants also completed additional self-report measures, as part of a larger, ongoing study during this data collection session.

Participants first completed the MSS in a group setting on the Indiana State University campus. The vast majority of participants were given the MSS questionnaire in paper and pencil format in a room with approximately 30 other participants and encouraged to work at their own pace. No personally identifying information was requested at this time. As previously discussed, scores from the MSS were used to identify high schizotypy individuals and low schizotypy individuals.

After completion of the MSS, the CoG task was completed by each participant. Participants completed this task individually with a trained research assistant in a private room. For this task, each participant was presented with a series of photos of four models (one African American male, one African American female, one Caucasian male, and one Caucasian female). These photos began with the model's gaze averted 25 degrees right of the camera, with subsequent photos having the model's gaze move 5 degrees to the left, resulting in pictures of various eye gaze angles. Eye gaze angles included 25 degrees, 20 degrees, 15 degrees, 10 degrees, and 5 degrees to the right and left of center. In addition, there was one photo with the model's eyes directly oriented toward the camera for a total of 11 photos. Participants viewed a total of 44 photos. Each range of photos was presented sequentially (i.e., left to right) and as

previously stated, each of the photos was assigned a number in order of presentation, ranging from 1 to 11.

Photos were presented such that participants could control the transition between photos with the computer keyboard. The participant was instructed to click the right arrow key on a keyboard until they believed that the model's eyes in the photo were looking toward them. The image number was recorded by a research assistant who was monitoring the task on a separate screen. The participant was then instructed to continue to click the arrow until they believed that the model's eyes were no longer directed toward them or looking away from them. Again, the image number was recorded by a research assistant who was monitoring on a separate screen. This procedure was followed for all four models with each participant.

Of note, data collection continued during the COVID-19 pandemic. Additional precautions were taken during this time to minimize risk of contracting COVID-19 to both researchers and participants. Participants continued to complete data collection in person for test security purposes and to ensure that research assistants were able to observe participants completing measures and be available to answer any questions. During this time, the MSS questionnaire was completed online on personal laptops to minimize contact of materials (e.g., pencils, scantrons, MSS questionnaires) between participants and research assistants. In addition, data collection rooms were limited to 15 participants (as opposed to 30 participants) per data collection session to ensure adequate social distancing. Mask wearing was required, materials and common areas were sanitized between participants, and a plastic shield was erected between participants and research assistants during the cone of gaze computer task to further minimize risk. The Indiana State University Institutional Review Board reviewed and approved all changes in procedures.

Statistical Analysis

All data was analyzed using the IBM SPSS Statistics Package 27. Analyses were conducted to examine each proposed hypothesis. The main proposed hypotheses include the prediction that individuals identified as positive, negative, and disorganized schizotypes will identify individuals in photos as looking at them over a wider range of eye gaze angles in comparison to controls, meaning that positive, negative, and disorganized schizotypes would identity the individuals in the photo as looking toward them earlier or looking away from them later than controls. To test these hypotheses, each schizotype group (positive, negative, and disorganized) was compared to a control group using an independent means *t*-test to determine whether knowing which dimension of schizotypy one exhibits increases the ability to predict performance on a CoG task. Scores for which participants identified individuals in photos as looking toward and looking away from them (i.e., 1-11) were averaged across the four different sets of photographs to obtain participants' mean toward and away scores, which were then utilized during analyses. Missing data was replaced with the overall group average for toward or away. Cohen's *d* was used for effect sizes. In the first set of analyses, high schizotypy groups and a low schizotypy control group, as earlier defined, were compared using independent sample *t*-tests to determine if any differences existed in identification of eye gaze as looking toward or looking away from them. In the second set, as further described below, independent sample *t*-tests were completed with the same high schizotypy hit groups and a more broadly defined control to observe any potential differences in when participants identify individuals in photos as looking toward and away from them.

CHAPTER 4

RESULTS

Comparisons Between High and Low Schizotypy Groups

In the first set of analyses, high schizotypy individuals were defined as individuals who scored two standard deviations above the mean on the corresponding MSS dimension. For example, a high positive schizotypy participant must have scored two standard deviations above the mean on the positive schizotypy scale of the MSS. This resulted in high schizotypy groups for positive, negative, and disorganized dimensions. Each of these groups were compared to a low schizotypy control group for both toward and away eye gaze scores. The low schizotypy group included participants that scored lower than one standard deviation above the mean on all MSS dimensions, such that these individuals did not fall into any high schizotypy category. Refer to Table 1 for a full summary of descriptive statistics and results of the first set of analyses.

Positive Schizotypy

Although trending toward significance, no significant difference was found between high positive schizotypes (M = 5.14, SD = .90) and low schizotypy controls (M = 5.35, SD = .74) in identifying when individuals in photos were looking toward them, $t(364) = -1.944$, $p = .053$; $d = .26$. Similarly, there were no significant differences between positive schizotypes (M = 8.19, SD = 1.39) and low schizotypy controls (M = 7.93, SD = 1.15) in identifying when individuals in

Table 1

Descriptive statistics and results of independent samples t-tests for comparisons between high schizotypy and low schizotypy groups

	Group	N	Mean	SD	t	*p*	*d*
Positive Toward	High	66	5.14	.90	-1.944	.053	.26
	Low	300	5.35	.74			
Positive Away	High	66	8.19	1.39	1.639	.102	.22
	Low	300	7.93	1.15			
Negative Toward	High	64	5.24	.78	-1.067	.287	.15
	Low	300	5.35	.74			
Negative Away	High	64	8.26	1.14	2.089	**.037***	.29
	Low	300	7.93	1.15			
Disorganized Toward	High	82	5.27	.83	-.836	.404	.10
	Low	300	5.35	.74			
Disorganized Away	High	82	8.28	1.30	2.416	**.016***	.30
	Low	300	7.93	1.15			

Note. High = high schizotypy hit group. Low = low schizotypy control group.
* $p < .05$

photos were looking away from them, $t(364) = 1.639$, $p = .102$; $d = .22$. See Figure 1 for an illustration of these findings.

Negative Schizotypy

There was also no significant difference in identifying individuals in photos as looking toward them between high negative schizotypes ($M = 5.24$, $SD = .78$) and the low schizotypy control group ($M = 5.35$, $SD = .74$), $t(362) = -1.067$, $p = .287$; $d = .15$. In contrast, a significant difference was found between high negative schizotypes and the low schizotypy control group with high negative schizotypes ($M = 8.26$, $SD = 1.14$) identifying individuals in photos as looking away from them significantly later than the low schizotypy control group ($M = 7.93$, $SD = 1.15$) with a small to medium effect size, $t(362) = 2.089$, $p = .037$; $d = .29$. See Figure 2 for an illustration of these findings.

Disorganized Schizotypy

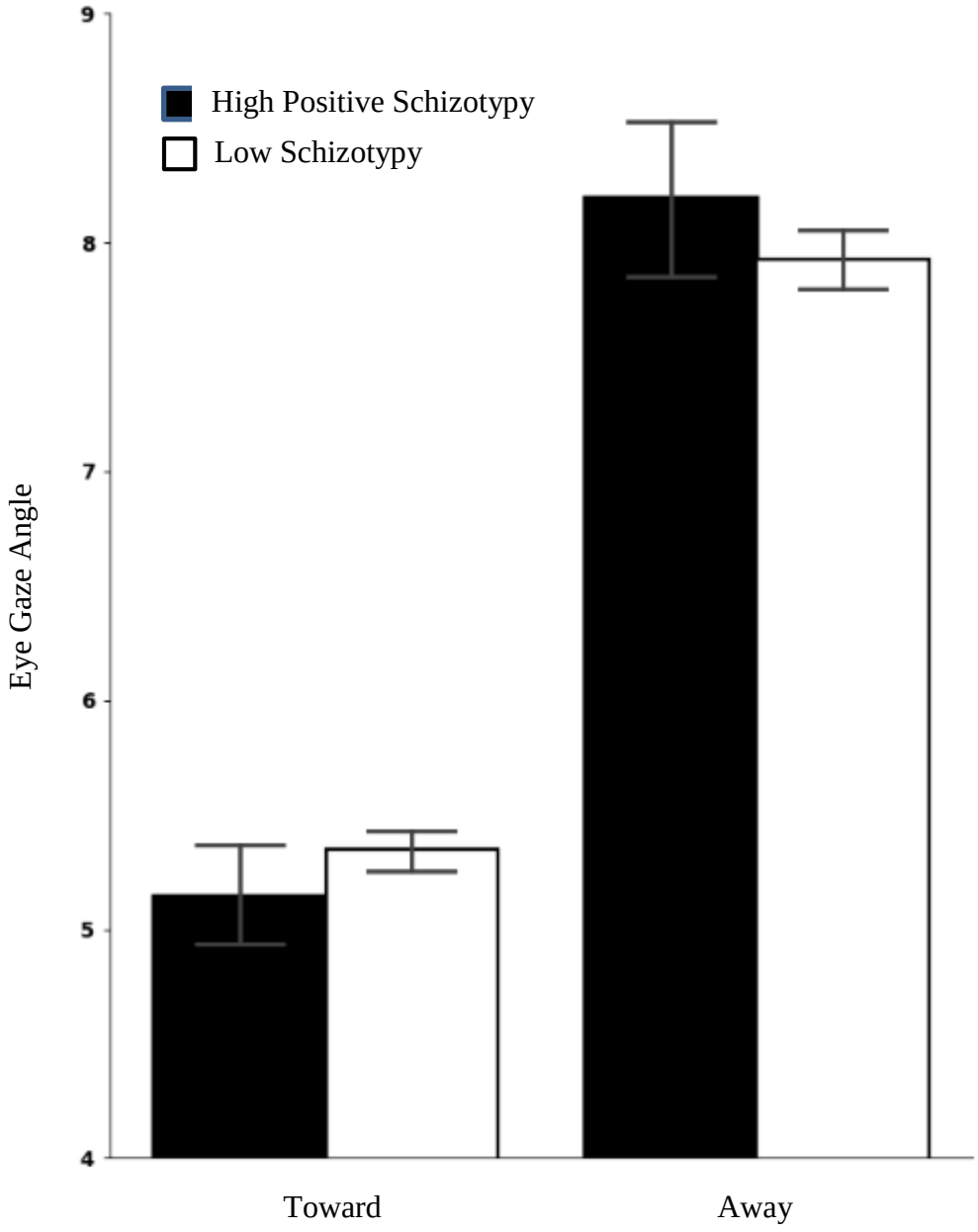
Finally, there was no significant difference found between high disorganized schizotypy ($M = 5.27$, $SD = .83$) and the low schizotypy control group ($M = 5.35$, $SD = .74$) in terms of identifying when individuals in photos were looking toward them, $t(380) = -.836$, $p = .404$; $d = .10$. However, there was a significant difference between high disorganized schizotypes ($M = 8.28$, $SD = 1.30$) and the low schizotypy group ($M = 7.93$, $SD = 1.15$) with disorganized schizotypes identifying individuals in photos as looking away from them significantly later, $t(380) = 2.416$, $p = .016$. The effect size of this finding fell in the small to medium range, $d = .30$. See Figure 3 for an illustration of these findings.

Comparisons Between High Schizotypy and Non-Deviant Groups

Previous research has suggested that positive schizotypes report feeling as though they are being looked at over a wider range of eye gaze angles than controls (Wastler &

Figure 1

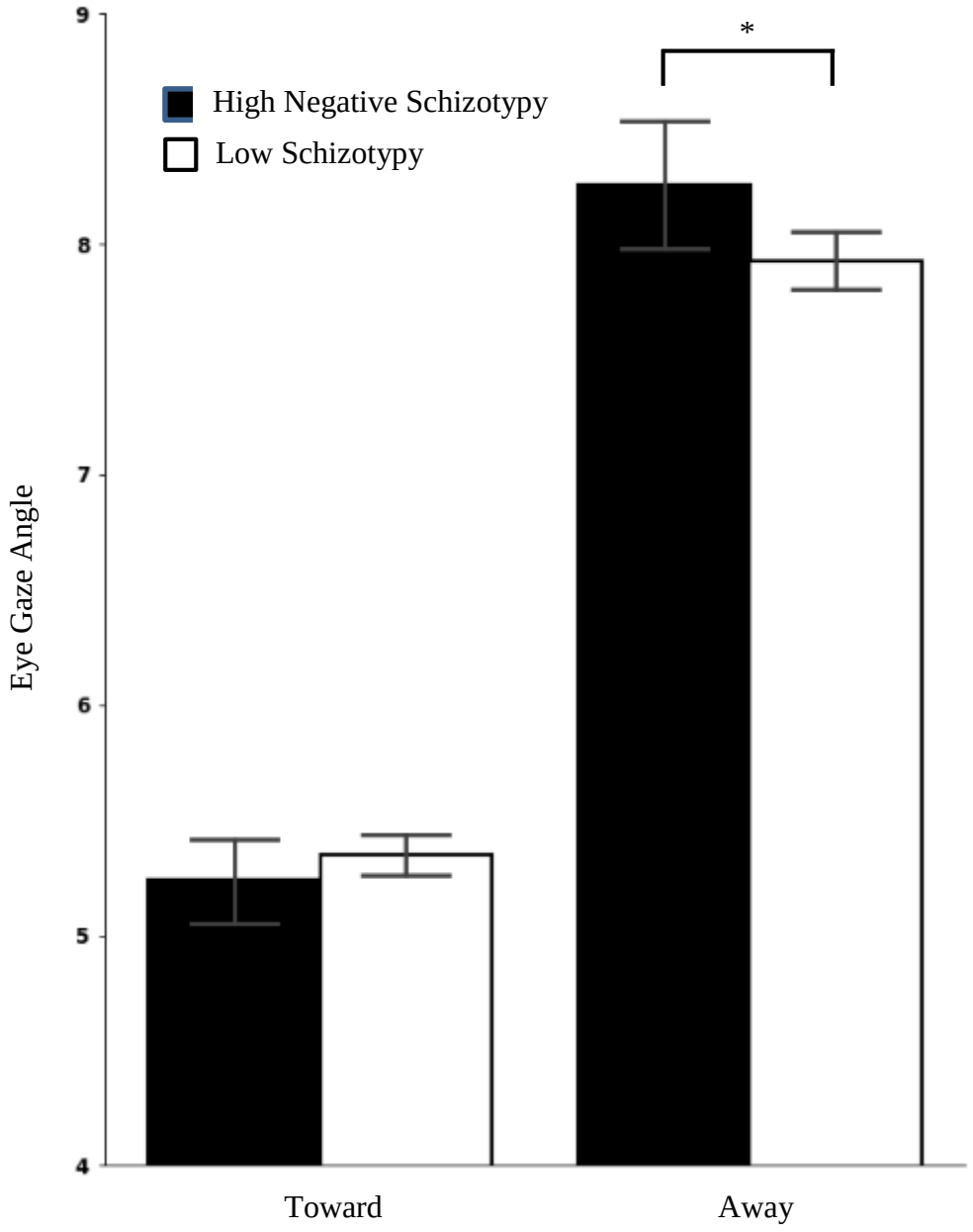
Comparison between looking toward and looking away eye gaze in high positive schizotypes and a low schizotypy control group



Note. N = 66 for high positive schizotypy group. N = 300 for low schizotypy control group. No significant differences were found between groups.

Figure 2

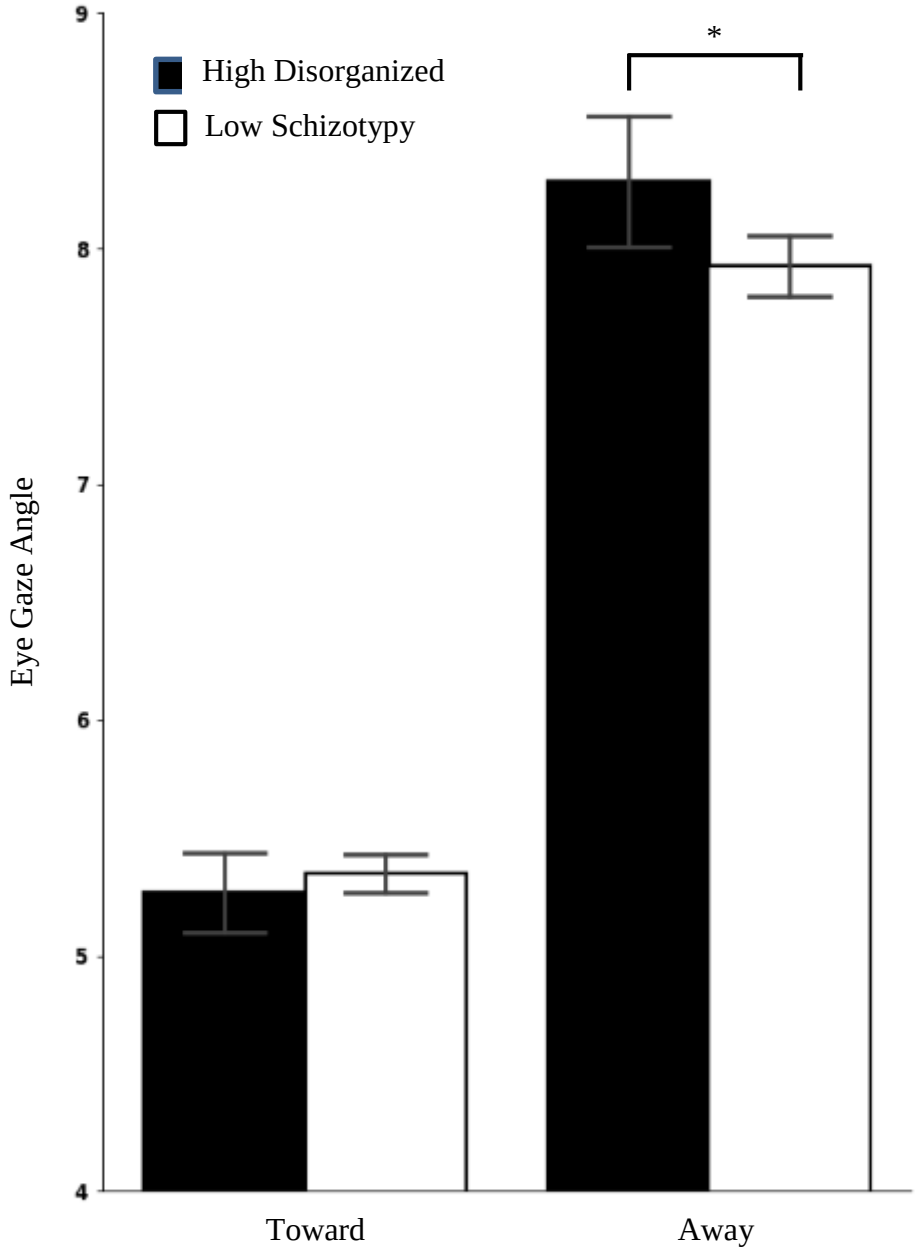
Comparison between looking toward and looking away eye gaze in high negative schizotypes and a low schizotypy control group



Note. N = 64 for high negative schizotypy group. N = 300 for low schizotypy control group.
* A significant difference was found between groups at $p < .05$

Figure 3

Comparison between looking toward and looking away eye gaze in high disorganized schizotypes and a low schizotypy control group



Note. N = 82 for high disorganized schizotypy group. N = 300 for low schizotypy control group.
* A significant difference was found between groups at $p < .05$

Lenzenweger, 2018), however, the above analyses revealed non-significant findings in the comparisons between the high positive schizotypy group and low schizotypy control group in the identification of individuals in photos looking toward and looking away from them. Based on these findings and previous conflicting research, additional analyses were completed. In this set of analyses, high schizotypy groups were defined in the same way as in the first set of analyses, however the control group was defined differently. Individuals were assigned to the non-deviant control group if they were not defined as a "hit" (i.e., if they did not score two standard deviations above the mean on any MSS dimension. This resulted in a larger number of individuals in a less stringent, more broadly defined control group (n = 460). Refer to Table 2 for a full summary of descriptive statistics and results of the second set of analyses.

Positive Schizotypy

Using these groups, a significant difference was found between the high positive schizotypy group (M = 5.14, SD = .90) and then non-deviant schizotypy control group (M = 5.36, SD = .73) on identifying when individuals began to look toward them, with the positive schizotypy group identifying individuals in photos as looking toward them significantly earlier than the non-deviant control group, $t(524) = -2.150$, $p = .032$. This finding had a small to medium effect size, $d = .28$. In contrast, no significant difference was found between the high positive schizotypy group (M = 8.19, SD = 1.39) and non-deviant control group (M = 7.99, SD = 1.20) on identifying individuals in the photos as looking away from them, $t(524) = 1.236$, $p = .217$; $d = .16$. See Figure 4 for an illustration of these findings.

Negative Schizotypy

No significant difference was found between high negative schizotypes (M = 5.24, SD = .78) and the non-deviant control group (M = 5.36, SD = .73) on identification of individuals in

Table 2

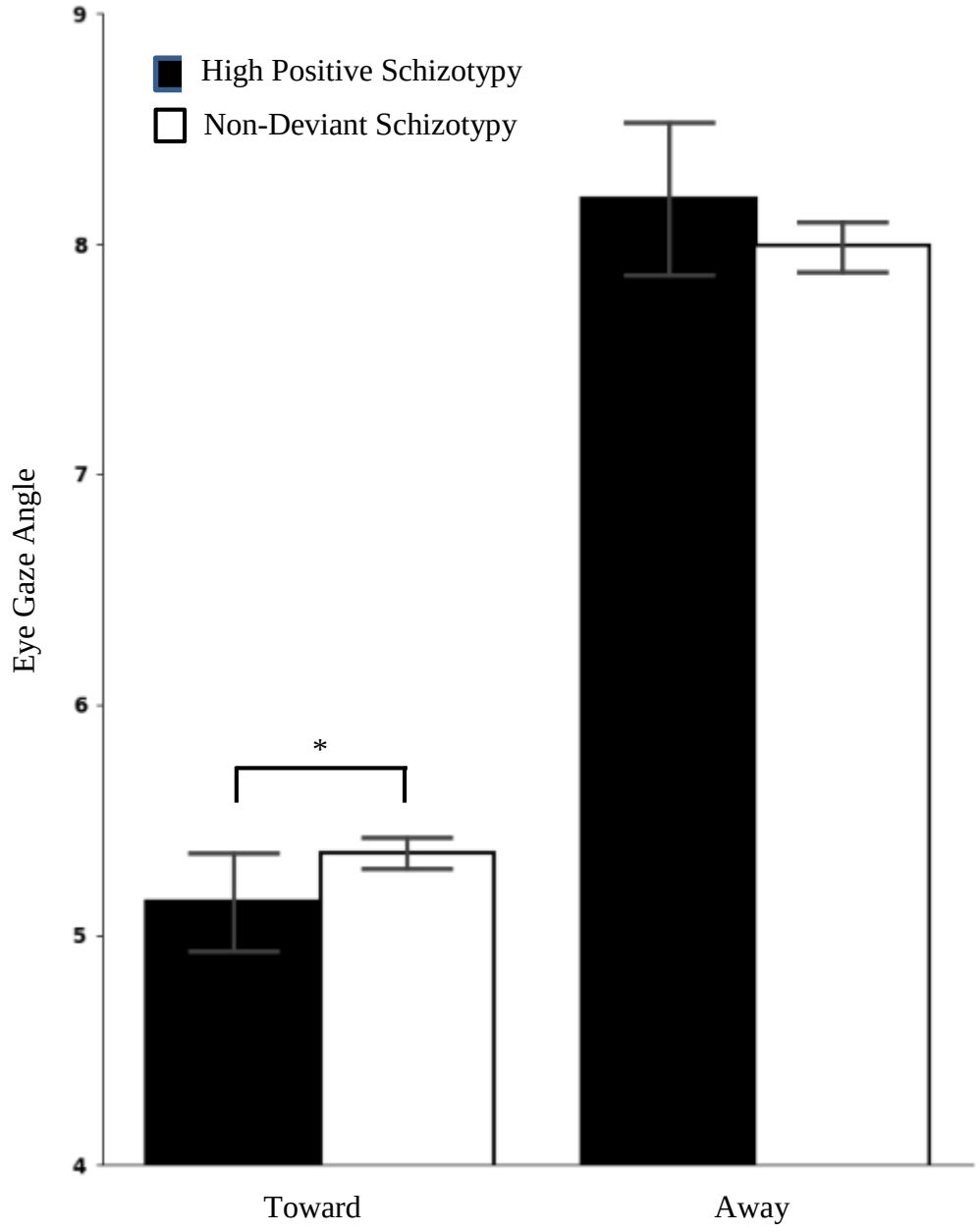
Descriptive Statistics and Results of Independent Samples t-Tests for Comparisons Between High Schizotypy and Non-Deviant Schizotypy Groups

	Group	N	Mean	SD	t	*p*	*d*
Positive Toward	High	66	5.14	.90	-2.150	**.032***	.28
	Non-Deviant	460	5.36	.73			
Positive Away	High	66	8.19	1.39	1.236	.217	.16
	Non-Deviant	460	7.99	1.20			
Negative Toward	High	64	5.24	.78	-1.209	.227	.16
	Non-Deviant	460	5.36	.73			
Negative Away	High	64	8.26	1.14	1.652	.099	.22
	Non-Deviant	460	7.99	1.20			
Disorganized Toward	High	82	5.27	.83	-.983	.326	.12
	Non-Deviant	460	5.36	.73			
Disorganized Away	High	82	8.28	1.30	1.983	**.048***	.24
	Non-Deviant	460	7.99	1.20			

Note. High = high schizotypy hit group. Non-Deviant = non-deviant control group
* $p < .05$

Figure 4

Comparison between looking toward and looking away eye gaze in high positive schizotypes and a non-deviant schizotypy control group



Note. N = 66 for high positive schizotypy group. N = 460 for non-deviant schizotypy control group.
* A significant difference was found between groups at $p < .05$

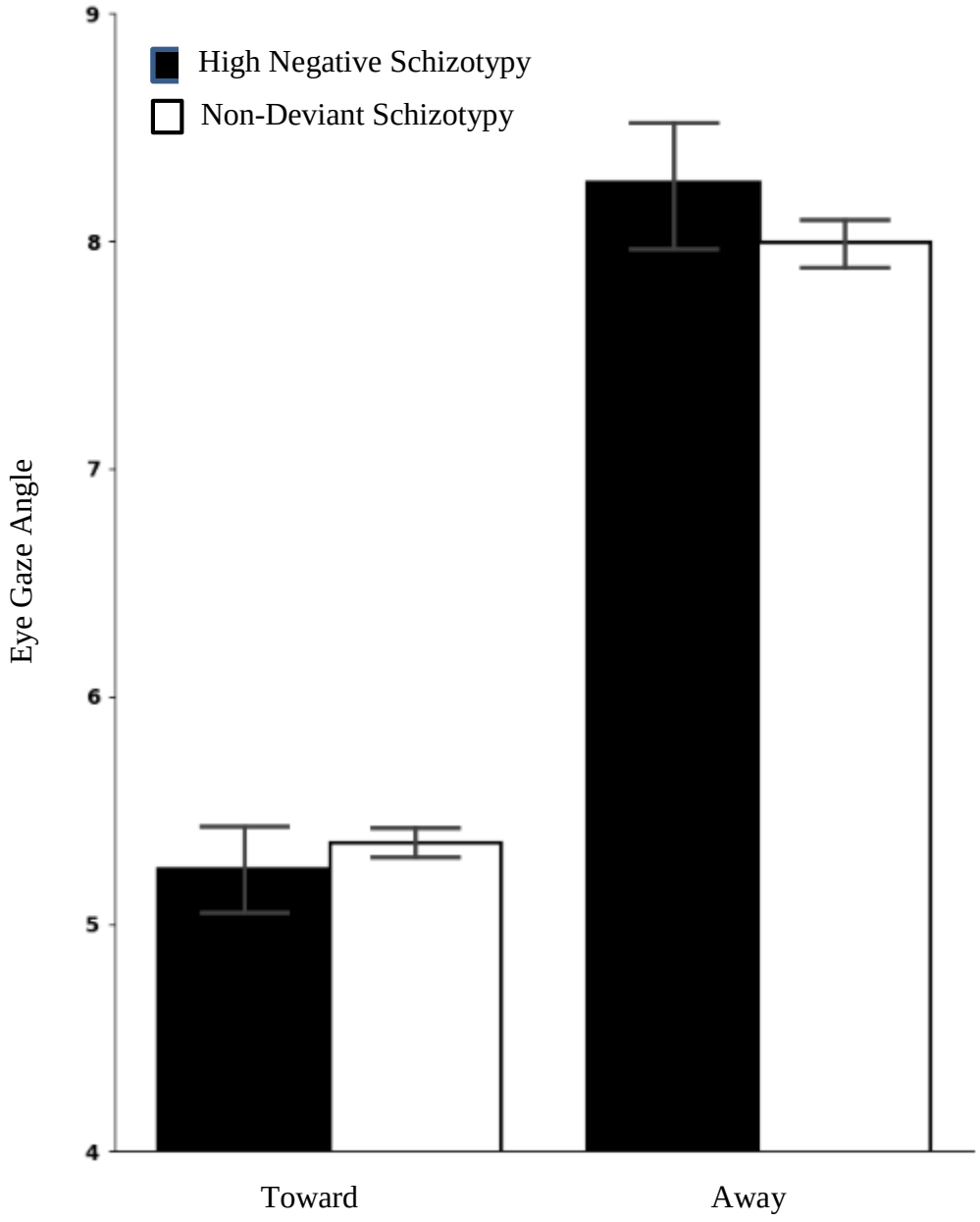
photos beginning to look toward them, $t(522) = -1.209$, $p = .227$; $d = .16$. Interestingly, though a significant difference was found in the first set of analyses, no significant difference was found between high negative schizotypes ($M = 8.26$, $SD = 1.14$) and the non-deviant control group ($M = 7.99$, $SD = 1.20$) in identifying individuals in photos as looking away from them, $t(522) = 1.652$, $p = .099$; $d = .22$. Refer to Figure 5 for an illustration of these findings.

Disorganized Schizotypy

Finally, results for the high disorganized schizotypy group remained the most consistent. No significant difference was found between high disorganized schizotypy ($M = 5.27$, $SD = .83$) and the non-deviant control group ($M = 5.36$, $SD = .73$) on identification of individuals in photos looking toward them, $t(540) = -.983$, $p = .326$; $d = .12$. Similar to the first set of analyses, a significant difference between the high disorganized schizotypy ($M = 8.28$, $SD = 1.30$) and non-deviant control group ($M = 7.99$, $SD = 1.20$) was found in regards to identification of individuals in photos looking away from them, with the disorganized group identifying these individuals as looking away from them significantly later than the control group, $t(540) = 1.983$, $p = .048$. The effect size of this finding fell in the small to medium range, $d = .24$. See Figure 6 for an illustration of these findings.

Figure 5

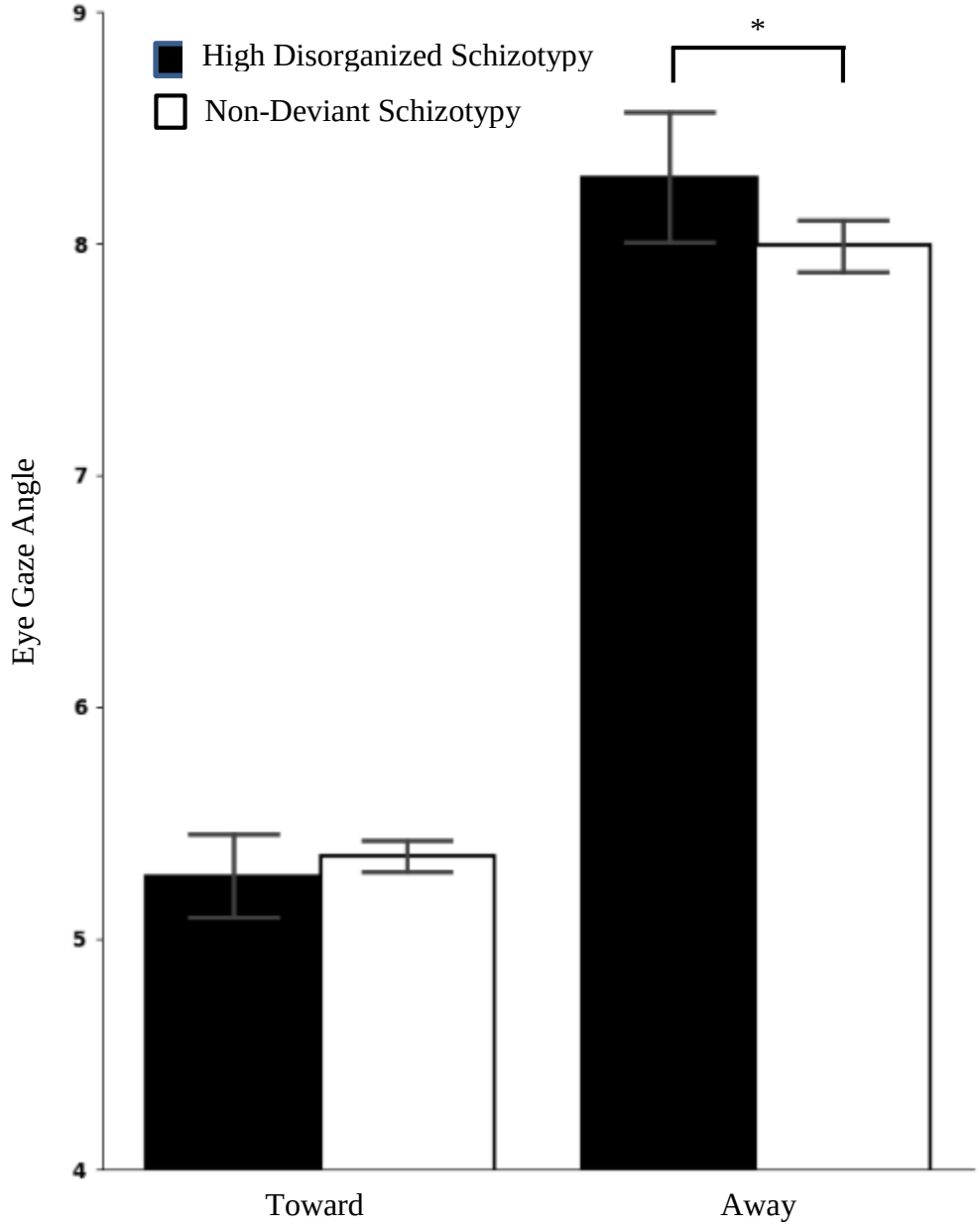
Comparison between looking toward and looking away eye gaze in high negative schizotypes and a non-deviant schizotypy control group



Note. N = 64 for high negative schizotypy group. N = 460 for non-deviant schizotypy control group. No significant differences were found between groups.

Figure 6

Comparison between looking toward and looking away eye gaze in high disorganized schizotypes and a non-deviant schizotypy control group



Note. N = 82 for high disorganized schizotypy group. N = 460 for non-deviant schizotypy control group.
* A significant difference was found between groups at $p < .05$

CHAPTER 5

DISCUSSION

This study found that positive schizotypes identify individuals in photos as looking toward them significantly earlier than a broadly defined control group, however, there were no significant differences found in identifying individuals as looking away from them between the high positive schizotypy group and control groups. Both the high negative schizotypy and high disorganized schizotypy groups identified individuals in photos as looking away from them significantly later than a control group that was more stringently defined. Again, neither the positive nor disorganized group displayed any differences in identifying individuals as looking toward them when compared to the control group. Simply stated, this study supports the idea that positive schizotypes are more likely to identify persons as looking toward them earlier whereas negative and disorganized schizotypes are more likely to identify individuals as looking away from them later. Although this implies that all schizotypes view persons as looking at them over a wider range of eye gaze angles, providing support for the main hypothesis, there are important differences between groups, especially positive versus negative and disorganized schizotypes. These differences could be due to increased self-referential thinking in schizotypy, however, other factors, including different facets of social cognition and neurocognitive factors, may also play a role in the more subtle differences between these groups.

Self-Referential Thinking

Individuals with schizotypy have been shown to display higher levels of self-referential thinking than individuals with social anxiety and healthy controls, indicating that high levels of self-referential thinking may be specific to schizotypy (Meyer & Lenzenweger, 2009). The Referential Thinking Scale, a well validated measure of self-referential thinking, has a high factor loading on the positive schizotypy factor, but does not load onto negative schizotypy or negative affect factors (Meyer & Lenzenweger, 2009). This may further indicate that self-referential thinking and positive schizotypy are uniquely associated with one another, as opposed to self-referential thinking being associated with each domain of schizotypy, including the negative and disorganized dimensions.

Generally, research that targets self-referential thinking and schizotypy seems to find stronger connections between positive schizotypy and self-referential thinking. For example, Mason and Budge (2011) found that both self-referential thinking and positive schizotypy predicted the amount of agreement participants reported with statements that measure the Barnum effect, indicating that individuals with high levels of positive schizotypy and self-referential thinking endorsed generic messages (e.g., horoscopes) as being more accurate statements about themselves. It was proposed that positive schizotypes that display self-referential thinking were more likely to take generic information and apply it to themselves as relevant or accurate to their lives.

More relevant to this study, Wastler and Lenzenweger (2018) used positive schizotypes in their study on gaze perception and found that positive schizotypes were more likely to endorse individuals as looking at them over a wider range of angles than a control group. They also found an association between endorsing a wider range of eye gaze angles as direct gaze and a measure

of self-referential thinking. In an attempt to clarify somewhat mixed findings about self-referential gaze perception in schizophrenia, Chan et al. (2021) compared gaze perception in individuals with high levels of reference delusions, low levels of reference delusions, individuals in clinical remission, and matched controls. It was found that individuals with schizophrenia (i.e., high and low levels of reference delusions) were more likely to identify averted gaze as self-directed gaze, however, individuals with high levels of reference delusions displayed this deficit across a wider range of ambiguous and unambiguous eye gaze angles, indicating that reference delusions are associated with a stronger self-referential gaze bias. Both of these studies provide support for the idea that a self-referential bias in gaze perception is associated with positive symptoms in both schizotypy and schizophrenia groups. Though in the schizophrenia group, low levels of reference delusions were also associated with identifying ambiguous averted eye gaze as direct, this effect was stronger in the high reference delusion groups, with these individuals endorsing direct gaze across ambiguous and unambiguous gazes.

None of the studies discussed thus far have examined the tendency to identify persons as looking toward them versus looking away from them. Because of this, it is unclear if participants with high positive schizotypy or schizophrenia were identifying individuals in photos as looking toward them earlier, looking away from them later, or some combination of both. The current study indicates that a high positive schizotypy group only identifies individuals in photos as looking toward them earlier and do not identify those individuals as looking away from them later. It is possible that high self-referential thinking, commonly found to be related to positive symptoms, results in individuals believing that people are looking toward them before a control group but does not affect identification of when individuals look away from them. Thus, it is proposed that the high self-referential thinking frequently observed in positive schizotypy may

be the driving force behind this group identifying persons as looking toward them earlier than a control group. Presumably, this indicates that different factors, such as other social cognitive deficits or neurocognitive factors, are resulting in negative and disorganized schizotypes identifying persons in photos as looking away from them later.

Social Cognitive Factors

A wide range of social cognitive deficits have been observed in individuals with schizophrenia across domains of theory of mind, social perception, social knowledge, attribution bias, and emotion processing (Salva et al., 2013). Further, these deficits have been connected to various aspects of social functioning (Couture et al., 2006; Fett et al., 2011). Although the literature on social cognitive deficits in schizophrenia is clear, deficits in schizotypy have been less consistent. In an attempt to address these inconsistent findings regarding social cognitive deficits in schizotypy, Morrison et al. (2013) measured traditional domains of social cognition, including facial emotion recognition, theory of mind, and emotion management in a high schizotypy and control group. They found that the schizotypy group preformed significantly worse on all of these domains, providing support for overarching social cognitive deficits in a schizotypy population.

Self-referential thinking has been proposed as a component of social cognition, indicating that there is an existing connection between social cognition and self-referential eye gaze perception. However, due to the widespread nature of social cognition, it is likely that other components of social cognition may also be related to the widening cone of gaze found in schizotypy. Although not a comprehensive list, interpersonal sensitivity and aspects of empathy are presented as potential factors that contribute to self-referential gaze perception.

Interpersonal Sensitivity

A more specific aspect of social cognition that may affect self-referential gaze perception is the concept of interpersonal sensitivity. It is thought that in order to function successfully within social interactions, one must display interpersonal sensitivity, or a sensitivity to emotions, thoughts and behavior of others and the ability to understand and communicate social cues (Miller & Lenzenweger, 2012). Further, individuals with good interpersonal sensitivity display better interpersonal skills and are better socially adjusted (Hall et al., 2009) while those that have poor interpersonal sensitivity, namely those with schizophrenia, display deficits in interpersonal and social functioning (Toomey et al., 2002). In addition, individuals with high levels of schizotypy display interpersonal sensitivity deficits in comparison to control groups which presumably affects social functioning (Miller & Lenzenweger, 2012).

Although self-referential gaze perception does not cleanly fit into any one social cognition domain, it broadly shares features with decrements in interpersonal sensitivity as it represents a deficit in the ability to understand social cues from others. Due to this overlap, deficits in interpersonal sensitivity may have affected the identification of individuals looking toward and looking away from participants that fell in positive, negative, and disorganized schizotypy subgroups. Although this represents a potential explanation, interpersonal sensitivity does not explain the more subtle differences observed between schizotypy dimensions in gaze perception.

Affective and Cognitive Empathy

The concept of empathy, which is commonly thought to be associated with theory of mind may provide a clearer explanation for differences observed between groups. Both positive and negative schizotypy have been shown to be associated with poorer cognitive empathy, or the

ability to understand another's mental state (Henry et al., 2008). However, interestingly, positive schizotypy is also associated with increased perceived capacity for cognitive empathy (i.e., individuals with high positive schizotypy rate their own cognitive empathy as higher than other schizotypy groups even though they do not display increased cognitive empathy). Researchers attributed this to increased ideas of reference and an overinterpretation of environmental cues, such that these individuals tend to consider themselves as uniquely in tune or sensitive to others (Henry et al., 2008). This hypersensitivity to and overinterpretation of environmental cues found in positive schizotypy may contribute to the finding in this study that positive schizotypes identify individuals in photos as looking toward them earlier than a control group. For example, if one believes they have a unique ability to understand another's mental state and overinterpret environmental cues, they may be more likely to identify others as looking towards them.

Research has also demonstrated that individuals with high levels of schizotypy, particularly negative schizotypy, display reduced affective empathy, increased negative affect, and poor social functioning (Henry et al., 2008). It has been shown that deficits in social functioning in negative schizotypy can be partially attributed to deficits in affective empathy, or one's own emotional response to the emotional state of another individual. Further, disorganized schizotypy is not associated with reduced cognitive empathy but is associated with reduced affective empathy (Henry et al., 2008). Although this study purposefully utilized neutral faces as stimuli, high schizotypy individuals, especially those with disorganized symptoms, tend to perceive neutral faces as displaying negative emotions (Brown & Cohen, 2010). Taken together, the interplay between deficits in affective empathy and facial emotion recognition may play a role in negative and disorganized schizotypes identifying individuals in photos as looking away from them later than a control group. For example, if one experiences reduced affective empathy

and interprets neutral faces as negative or frightening, they may be more likely to identify individuals as looking at them for a longer period of time, as seen in negative and disorganized schizotypes identifying individuals in photos as looking away from them later than a control group.

Neurocognitive Factors

Broad neurocognitive impairment across various cognitive domains, ranging from memory to attention, are often viewed as a core feature of schizophrenia (Heinrichs & Zakzanis, 1998) and are strongly associated with poorer functioning (Green, 1996). Although less well established, cognitive disturbances have also been widely observed in schizotypy populations (Flückiger et al., 2019). Deficits in neurocognitive domains, like sustained attention, working memory, response inhibition, and cognitive flexibility, as discussed below, may provide an explanation for differences between schizotypy groups in gaze perception that social cognitive factors fall short answering.

Sustained Attention and Working Memory

Deficits in attention have been widely reported in persons diagnosed with schizophrenia and have been proposed to be heritable, display distinct patterns in persons with schizophrenia, and predict later functioning (Cornblatt & Keilp, 1994). Sustained attention deficits have also been observed in both positive and negative schizotypy and have been proposed as a potential endophenotype of vulnerability to schizophrenia spectrum disorders (Gooding et al., 2006). Gooding et al. (2006) further proposed that there are differences in the mechanisms that cause deficits in sustained attention with positive schizotypes showing deficits in sustained attention due to difficulty with stimulus evaluation and target detection and negative schizotypes displaying less efficient monitoring and updating, leading to deficits in sustained attention.

Impairment in working memory has also been proposed as relevant to sustained attention deficits (Gooding et al., 2006). Further, in a recent meta-analysis on the neuropsychological correlates of schizotypy, evidence of deficits in verbal and visual-spatial working memory were found in schizotypes in comparison to control groups (Siddi et al., 2017). Thus, it is well established that deficits in working memory and sustained attention are found in schizotypy.

In a study of self-referential gaze perception in schizophrenia, it was found that cognitive function, especially attention and processing speed were associated with lower self-referential gaze perception (Chan et al., 2021). This finding provides support for the idea that deficits in sustained attention may contribute to increased self-referential gaze perception in schizotypy. Because it has been proposed that the underlying mechanisms of sustained attention deficits differ between positive and negative schizotypy, this could partially explain the differences in gaze perception between these groups. Specifically, because negative schizotypes demonstrate less efficient monitoring and updating in attention, it is possible that their identification of individuals in photos looking away from them later than controls could be caused by a delay in updating of attention or insufficient monitoring of environment stimuli (i.e., eye gaze in this study). Although disorganized schizotypy was not specifically addressed in the reviewed literature, it is possible that a similar deficit in sustained attention could have resulted in the similar findings in disorganized schizotypes.

Cognitive Flexibility and Inhibition

In a longitudinal study of cognitive functioning in schizotypy, it was found that high negative schizotypy predicted worse response inhibition and semantic switching (e.g., the ability to shift semantic categories) at a four-year follow-up (Karamaouna et al., 2021). Somewhat similarly, high disorganized schizotypy predicted poorer semantic processing and complex

processing speed/set shifting at the four-year follow up. Moreover, negative schizotypes displayed worse response inhibition, set-shifting, and complex processing/set-shifting when compared to controls (Karamaouna et al., 2021). Unfortunately, comparisons between disorganized schizotypes and controls could not be made due to limited sample size.

Importantly, within this study, negative and disorganized schizotypes both displayed some type of deficit in complex processing/set-shifting (Karamaouna et al., 2021). Generally, set shifting is defined as the ability to shift attention between tasks (Kolb & Whishaw, 2006), however, set-shifting ability was incorporated within a task that required more complex processing in this study. Complex processing/set-shifting was measured by the portion of the Trail-Making Test which requires individuals to connect alternating, yet consecutive numbers and letters. Relatedly, a previous meta-analysis also demonstrated deficits in set-shifting ability in schizotypy (Chun et al., 2013). In addition to these findings, another meta-analysis found that cognitive flexibility (the mental ability to switch between thinking about different concepts) was associated with more negative and disorganized schizotypy traits (Siddi et al., 2017). If both negative and disorganized schizotypes display deficits in complex set-shifting, but positive schizotypes do not, this may indicate that deficits in set-shifting could be related to negative and disorganized schizotypes interpreting eye gaze and looking away from them later than controls in this study. For example, if an individual has trouble shifting their attention from one task to another, it may cause delays in that individual reporting that someone is looking away from them after they have reported that the person is looking toward them.

As reported above, negative schizotypes have demonstrated worse response inhibition compared to controls (Karamaouna et al., 2021). Disorganized schizotypy has also been shown to be related to cognitive disinhibition (Vollema & Postma, 2002). In contrast, at least one study

has provided evidence for positive schizotypy predicting enhanced inhibition control (Cochrane et al., 2012). Similar to complex set-shifting, deficits in response inhibition in negative and disorganized schizotypes may be related to identifying individuals in photos as looking away from them later than controls. Without the ability to inhibit responses to distractions or other external environmental stimuli, these individuals may display a lapse in attention, as previously discussed, and report individuals as looking away from them later.

Implications

As previously stated, this study is a part of a larger, ongoing project. Broadly, one of the primary goals of this study was to contribute to the literature of potential endophenotypes in schizophrenia spectrum disorders. Gaze perception deficits, and more broadly social cognitive deficits, have previously been proposed as a potential endophenotype for schizotypy (Wastler & Lenzenweger, 2018). This study provides further support for self-referential gaze perception as an endophenotype of schizotypy.

It is proposed that the differences observed between schizotypy dimensions in identification of individuals in photos as looking toward them versus looking away from them may be explained by differences in self-referential thinking, differences in other social cognitive functions, or differential neurocognitive functioning between positive, negative, and disorganized schizotypes. Although the literature is somewhat mixed, it is possible that increased self-referential thinking contributes to positive schizotypes identifying individuals in photos as looking toward them earlier than a control group, whereas deficits in neurocognitive domains, like sustained attention and set shifting, contributes to negative and disorganized schizotypes identifying individuals in photos as looking away from them significantly later than a control group. These findings and proposed mechanisms could provide new directions in exploring the

more subtle differences between schizotypy dimensions in gaze perception and other potential endophenotypes.

In addition to contributing to the broader literature on endophenotypes in schizotypy, findings from this study provide support for targeting gaze perception deficits within social cognitive interventions for schizophrenia spectrum disorders and potentially individuals at high risk of developing a schizophrenia spectrum disorder. Self-referential gaze perception could prove a valuable treatment target within the field of social cognition, given its similarity to multiple social cognitive domains. Because social cognitive interventions tend to be skill based and train individuals on "right" versus "wrong" responses, accurate gaze perception could be easily incorporated into existing social cognitive approaches, including group based and computerized treatments.

Strengths of the Current Study

There are numerous strengths of this study. Perhaps one of the most important strengths is that this study distinguished between positive, negative, and disorganized schizotypes. This allowed for differences between groups to be observed. Similarly, this study included a method to observe differences in gaze perception of individuals in photos as looking toward and away from a participant. Without this design, the finding that positive schizotypes tend to interpret individuals as looking at them earlier while negative and disorganized schizotypes tend to interpret individuals as looking away from them later would have been missed. In addition, using a task-based method to measure eye gaze perception can be viewed as a strength in this study because it is less susceptible to some biases that occur in self-report measures, including impression management, social desirability bias, random responding and others.

Limitations of the Current Study

The primary limitation of this study is likely the use of convenience sampling. Because this study took place at a mid-sized Midwestern university, all participants were college students and fell between the ages of 18-25. In addition, because participants were recruited from introductory psychology courses, female participants were overrepresented. These factors could result in a lack of generalizability of findings, especially to males and individuals not attending college. Presumably, because all participants were actively enrolled in college courses, it is likely that participants were relatively high functioning and not experiencing many, if any, clinically meaningful symptoms of schizophrenia spectrum disorders. Other at-risk groups, including first degree relatives of those with schizophrenia and ultra-high-risk groups, may experience a different pattern of gaze perception deficits, which could be more severe than the ones observed in this study.

In addition, although the study was adequately powered, a larger sample size of positive, negative, and disorganized schizotypes could have resulted in stronger results and negated the need to define the control group two distinct ways. A self-report measure was utilized to define positive, negative, and disorganized schizotypy groups, which could have resulted in random responding or an impression management response style and ultimately affected group membership. Finally, previous research has demonstrated that individuals are more likely to perceive direct eye gaze in attractive faces (Kloth et al., 2011). This potential confounding factor was not accounted for in the current study and may represent a limitation.

Future Directions

This study served to lay the foundation for the idea that different dimensions of schizotypy may display differences in eye gaze perception. Indeed, it was found that positive

schizotypes identify individuals in photos as looking at them earlier whereas negative and disorganized schizotypes identify individuals in photos as looking away from them later. Though this implies that all schizotypes display a bias that individuals are looking at them over a wider range of eye gaze angles than controls, the subtle underlying pattern is different between groups. Although this study provides evidence that there are differences between schizotypes in eye gaze perception, it is still unknown what contributes to these differences. Though self-referential thinking, social cognition, and neurocognitive factors were proposed as potential mechanisms, future studies are needed to determine the correlates of identifying individuals as looking toward positive schizotypes earlier versus looking away from negative and disorganized schizotypes later to begin to determine underlying mechanisms of these differences.

In addition, future research could focus on potential race and gender differences, or interactions may arise in the identification of eye gaze. Although previous research has suggested that individuals display increased sensitivity to direct eye gaze in own-race faces in comparison to other-race faces (Collova et al., 2017), differences in identifying individuals as looking toward someone earlier or looking away from them later has not been explored. It is possible that individuals may differentially attribute ambiguous eye gaze angles as looking at them earlier or looking away from them later if the individuals in the photo are in of the opposite gender or race due to hypervigilance, stereotyping, or bias. For example, female participants may identify male individuals in photos as looking at them over a wider range of angles compared to other female individuals. In addition, Caucasian participants may identify African American individuals in photos as looking at them over a wider range of angles compare to other Caucasian individuals.

As previously mentioned, these findings provide support for targeting self-referential gaze perception in social cognitive interventions and treatment. In general, treatment designed to

improve social cognitive skills have shown promise in their impact on social cognition domains (e.g., improvements on measures of emotion processing), however, study results have been mixed in demonstrating the generalization of these benefits to in vivo social functioning (e.g., Vidarsdottir et al., 2019). These findings have led to concerns that improvements in social cognition domains do not generalize to long-term or in-vivo social functioning. Although some have attempted to address this by incorporating interventions designed to practice social skills, this has generally not improved durability of in vivo social functioning (Horan et al., 2018). Based on these findings, it may be unlikely that "teaching" individuals when someone is looking at them versus not looking at them would result in meaningful change in functional outcomes in individuals with schizotypy or schizophrenia.

In addition, although seemingly promising, it is also important to consider the limitations of an endophenotypic model of schizotypy and schizophrenia spectrum disorders. As the literature on potential endophenotypes expands, it is unclear if these discoveries are leading to the early identification of those at risk for schizophrenia spectrum disorders or if targeting these deficits (e.g., sustained attention, gaze perception) makes a clinically meaningful difference in the progression to more severe disorders, such as schizophrenia. Based on this and the uncertainty of the benefit of social cognitive interventions, it may be most useful to utilize findings such as these to inform treatment options that are more integrated and holistic in nature which may help individuals to integrate information and perceptions of those they engage with in social interactions in a more complete way.

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APPENDIX: CONE OF GAZE EXAMPLE STIMULI