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2015

Influence of Emotional Stimuli on Working Memory in Schizotypy

Docia L. Demmin
College of William & Mary - Arts & Sciences

Influence of Emotional Stimuli on Working Memory in Schizotypy

Docia L. Demmin

Penn Yan, NY

Bachelor of Arts, Binghamton University, State University of New York, 2012

A Thesis presented to the Graduate Faculty
of the College of William and Mary in Candidacy for the Degree of
Master of Arts

Department of Psychology
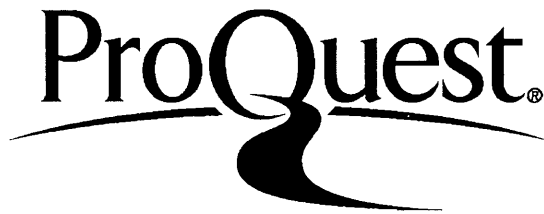
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This Thesis is submitted in partial fulfillment of
the requirements for the degree of

Master of Arts

_____
Docia L. Demmin

Approved by the Committee, May, 2015

_____
Committee Chair
Professor Glenn Shean, Psychology
The College of William and Mary

_____
Assistant Professor Paul Kieffaber, Psychology
The College of William and Mary

_____
Assistant Professor Matthew Hilimire, Psychology
The College of William and Mary

COMPLIANCE PAGE

Research approved by

<u>W&M Protection of Human Subjects Committee</u>

Protocol number(s): PHSC-2014-09-11-9791-dldemmin

Date(s) of approval: 09/15/2015

ABSTRACT

Previous literature has demonstrated impairments in emotion processing and working memory in individuals with psychometrically-defined schizotypy. The interaction of emotion and cognition has also been examined, but to a lesser extent. Results of these studies indicate greater distractibility by task-irrelevant stimuli in association with schizotypal traits. The aim of the current study is to examine the relationship between emotion and cognition by evaluating working memory performance during an n-back task incorporating task-relevant emotional stimuli, in a psychometrically-defined schizotypy sample. Both emotional salience of the stimuli as well as cognitive-load were varied by including both facial and postural displays of emotion in 2-back and 3-back conditions. Results revealed a significant interaction between stimuli type, emotion, and group, where the schizotypy group performed significantly worse on the n-back during the presentation of angry facial stimuli, however, there were no significant group differences for postural displays of emotion. Reaction time data indicated a significantly slower response time, overall, for the schizotypy group. Based on these results it can be concluded that individuals with psychometrically-defined schizotypy experience aberrant processing of task-relevant emotional stimuli, in particular during the presentation of angry facial stimuli. The slower reaction time evidenced by the schizotypy group may provide support for a greater influence of emotion on cognition, in individuals with schizotypal traits. These findings underscore a need for additional research in order to determine the effect of relevant emotional stimuli on working memory in schizotypy. Efforts to better understand emotion-cognition interactions in populations with lower symptom levels may provide insight into related impairments within the broader illness.

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1. Introduction

1.1 Schizophrenia

Schizophrenia is a chronic and debilitating disease marked by both

positive and negative symptoms as well as impairments in cognitive function

(Velligan et al.,1997). The current prevalence rate for the disorder is estimated at

four to seven per 1000 persons worldwide (McGrath, Saha, Chant, & Welham,

2008), and is associated with a substantial societal economic burden (Chong,

Chaiyakunapruk, DBC, KKC, & Chiou, 2014). While recovery after first-episode is

likely, rates of relapse, co-morbidities, and residual symptoms remain high

(Zipursky, Menezes, & Streiner, 2014; Buckley, Miller, Lehrer, & Castle, 2009;

Karow, Naber, Lambert, & Moritz, 2011). The trajectory and course of the illness

may be influenced by numerous factors including age of onset, duration of

untreated illness, gender, and degree of familial and social support (Jobe &

Harrow, 2010; Schennach-Wolff et al., 2011; Abel, Drake, & Goldstein, 2010;

Demjaha, MacCabe, & Murray, 2011). While findings regarding the influence of

symptom severity and dimension on disease prognosis are somewhat mixed,

negative symptom severity appears to be associated with greater impairments in

psychosocial functioning, and poorer quality of life (Ventura, Hellemann, Thames,

Koellner, & Nuechterlein, 2009; Ho, Nopoulos, Flaum, Arndt, & Andreasen, 2014;

Rabinowitz et al., 2012).

1.1.1 Symptoms of Schizophrenia

Symptoms of schizophrenia are classified along positive, negative, and

disorganized dimensions (Peralta & Cuesta, 1994; Grube, Bilder, & Goldman,

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1998). Positive symptoms encompass features characteristic of general psychosis, such as delusions and hallucinations, and reflect atypical behaviors absent in non-disordered individuals. Positive symptoms are most transient and show the greatest responsiveness to antipsychotic medication (Martyns-Yellowe, 1993). Negative symptoms include flat or blunted affect, avolition, anhedonia, and alogia. These symptoms are more difficult to target psychopharmacologically, resulting in greater persistency over time (Buchanan, 2007). Disorganized symptoms share some overlap with cognitive functioning impairments, and can be characterized by disorganized speech, disorganized or bizarre behaviors, and inappropriate affect (Mindham, 1986). These symptoms may be associated with the greatest impairments in executive functioning and social cognition (Basso, Nasrallah, Olson, & Bornstein, 1998; Shean, Murphy, & Meyer, 2005).

Previous studies have suggested relationships between symptom dimensions and distinct neurocognitive correlates (Basso, Nasrallah, Olson, & Bornstein, 1998; O'Leary et al., 2000; Brekke, Raine, & Thomson, 1995). However, the symptoms of schizophrenia are extremely heterogeneous in both symptom severity and presentation. Some individuals may exhibit greater negative, positive or disorganized symptomology, while others display relatively comparable levels of all symptoms. Similarly, within a single individual's course of illness there may be great variability, with episodes of acute psychosis and other periods characterized by flat affect or amotivation (Buchanan & Carpenter, 1994; Kirkbride et al., 2006). Schizophrenia symptomology is made further

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complex by nonspecificity of symptoms, which has led to the development of a broader spectrum view of the illness (Marenco & Weinberger, 2000).

1.2 Schizotypy

The current view of schizophrenia is that of a continuum, where individuals with an underlying genetic vulnerability may experience symptoms at subclinical levels. This schizophrenia phenotype was first termed 'schizoptype' by Rado. According to this perspective, schizophrenia symptoms are expressed along a range of severity and are present to a lesser extent in some individuals (Rado, 1953). Meehl further developed this initial understanding, and described a 'schizogene' that was responsible for changes in brain development in individuals with schziotypy. 'Schizotaxia' was described as the ensuing neural abnormalities, which, in combination with environmental influences, led to the development of a schizotypal personality. According to Meehl, a schizotype concludes with schizotypy, a schizophrenia spectrum disorder, or schizophrenia. Meehl hypothesized that 10 percent of the general population might carry this genetic vulnerability, and about five percent would result in schizophrenia, indicating a much greater risk than that of the general population (Meehl, 1962; Lenzenweger, 1994; 2006). An important research implication from Meehl's revolutionary model is the notion that individuals who do not go on to develop schizophrenia will, nevertheless, exhibit abnormalities in psychological and neurocognitive processes indicative of this vulnerability. This understanding has led to a plethora of studies aimed at identifying specific schizophrenia endophenotypes. Taxometric studies have confirmed a subset of the population

exhibits schizotypal personality organization, and that these traits are associated with an increased risk for developing schizophrenia (Raine, 1991; Lenzenweger, 2006; Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994).

1.2.1 Schizotypal Traits

The current view of schizotypy recognizes symptoms as multidimensional, and comprising of three factors (positive, negative, and disorganized), just as posited with full-blown schizophrenia (Reynolds, Raine, Mellingen, Venables, & Mednick, 2000; Fossati, Raine, Carretta, Leonardi, & Maffei, 2003; Kerns, 2006). In this way, schizotypy symptoms are reflective of schizophrenia symptoms, but at milder, subclinical levels (Raine et al., 1994). The positive symptom dimension of schizotypy includes ideas of reference, odd beliefs or magical thinking, perceptual abnormalities, and suspiciousness. The negative dimension denotes few or no close friends, excessive social anxiety, and constricted or blunted affect. Lastly, the disorganized facet encompasses traits such as odd behavior and unusual speech, for example vague, circumstantial or stereotyped (Raine, 1991). Individuals with schizotypy exhibit these traits in varying levels of severity and functional impairment.

1.2.2 Measurement of Schizotypy

There are several current methods used to study schizotypy. Some studies recruit first- or second-degree biological relatives of schizophrenia patients in order to capture a shared, underlying genetic vulnerability. Support for this method is found in existing literature that has identified an increased risk for developing schizophrenia in relatives of diagnosed patients (Edvardsen, Psychol,

& Kringlen, 1993; Linney et al., 2003; Calkins, Curtis, Grove, & Iacono, 2004). A second method identifies individuals who are in the prodromal phase of illness, and likely experience psychotic symptoms at attenuated levels. This population also includes individuals with brief, intermittent psychosis, though below clinical threshold for schizophrenia (Miller et al., 2002; Cornblatt et al., 2003). A third approach is sampling from individuals who meet schizotypal personality disorder criteria (Nuechterlein et al., 2002). While the aforementioned methods have contributed valuable insights to the pathogenesis of schizophrenia, these samples may not be representative of the lower range of the schizotypy continuum and may overlook this larger portion of individuals. Because a great majority of individuals identified as schizotypes will not go on to develop schizophrenia, or related disorders, additional utility may lie in examining individuals with lower levels of symptomotology (Lenzenweger & Korfine, 1992). For this reason, many researchers employ a psychometric risk approach, where schizotypy samples are psychometrically-defined based on validated measures of schizotypy symptomotology (Lenzenweger & Loranger, 1989; Lenzenweger, 1994; Dinn, Harris, Aycicegi, Greene, & Andover, 2002; Gooding, Matts, & Rollmann, 2006).

The Schizotypal Personality Questionnaire (SPQ) is the most widely used inventory of schizotypy traits, and is most frequently used in the identification of psychometrically-defined schizotypy samples. The SPQ is a 74-item, self-report questionnaire that includes the full range of schizotypal symptomology. The SPQ measures nine schizotypal traits; ideas of reference, excessive social anxiety,

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magical ideation, perceptual abnormalities, odd or eccentric behavior, asociality, odd speech, blunted affect, and suspiciousness. These nine traits can further be grouped into the three broader domains; positive, negative, and disorganized symptoms. Though it is named the "Schizotypal Personality Questionnaire", the SPQ is often used in assessing mild to moderate traits of schizotypy, rather than strictly identifying schizotypal personality disorder (Raine, 1991; Raine et al.1994).

Taken together, these findings suggest schizotypy can be viewed similarly to schizophrenia, multidimensionally and along of continuum of symptom severity. Schizotypy is indicative of an underlying vulnerability to schizophrenia, and can be identified using validated instruments, such as the SPQ. Research with psychometrically-defined schizotypy samples provides insight into the broader illness, without confounds such as medication and institutionalization. Examining individuals at the lower end of the schizotypy continuum might further elucidate our understanding of the development of schizophrenia spectrum disorders, and uncover potential risk and protective factors (Lenzenweger, 1994).

1.3 Neurocognition

Neurocognitive impairments in schizophrenia include deficits in processing speed, attention, executive functioning, verbal memory and language processing (Brébion et al., 2000; Braff, 1993; Minzenberg, Laird, Thelen, Carter, & Glahn, 2009; Cirillo & Seidman, 2003; Sommer, Ramsey, & Kahn, 2001). Previous research identifies cognitive deficits as a unique predictor of functional outcome in individuals with schizophrenia (Green, Kern, Braff, & Mintz, 2000; Green, Kern,

& Heaton, 2004; Milev, Ho, Arndt, & Andreasen, 2005). Research with schizotypy samples has also evidenced impairments in neurocognitive functioning, though much less severe than those observed in schizophrenia. These deficits exist within similar domains to those impaired in schizophrenia samples, including attention and executive function (Lenzenweger, Cornblatt, & Putnick, 1991; Gooding, Kwapil, & Tallent, 1999; Jahshan, & Sergi, 2007; Meyer & Shean, 2006).

1.3.1 Working Memory

Neuroimaging studies suggest that working memory is executed by the prefrontal cortex (PFC), particularly within the dorsolateral prefrontal cortex (DLPFC; Sawaguchi & Goldman-Rakic, 1991; Braver et al., 1997; Levy & Goldman-Rakic, 2000). Abnormalities in the PFC in patients with schizophrenia have long been recognized, and associated working memory deficits are a central feature of neurocognitive impairments in schizophrenia (Manoach et al., 1999; Manoach at al., 2000; Perlstein, Carter, Noll, & Cohen, 2001). Working memory is generally described as the system that provides temporary storage of task-relevant information (Baddeley, 1992). Meta-analyses consistently confirm the existence of working memory deficits in schizophrenia samples (Lee & Park, 2005; Forbes, Carrick, McIntosh, & Lawrie, 2009). In addition, working memory deficits have been established in biological relatives of schizophrenia patients (Conklin, Curtis, Calkins, & Iacono, 2005; Egan et al., 2001), individuals with diagnosed schizotypal personality disorder (Roitman et al., 2000; Farmer, Niznikiewicz, Voglmaier, McCarley, & Shenton, 2014; Saperstein et al., 2006),

and psychometrically-defined schizotypy samples (Tallent & Gooding, 1999; Gooding & Tallent, 2003). Taken together, the results of these studies suggest that working memory deficits may be an endophenotypic marker of schizophrenia liability.

Some studies have attributed observed working memory impairments to an inability to successfully encode stimuli (Hartman, Steketee, Silva, Lanning, K., & McCann, 2003; Meda, Stevens, Folley, Calhoun, & Pearlson, 2009; Mayer, Kim, & Park, 2014). Mathes et al. (2005) demonstrated that impaired early perceptual processing in schizophrenia patients resulted in subsequent working memory deficits. Similarly, one study discovered that when the attentional salience of stimuli was increased, working memory was enhanced in individuals with schizophrenia (Lee & Park, 2006). Researchers Lee and Park (2005) determined that maintaining mental representations active above threshold and under the focus of attention, especially during distractions, may be necessary for successful working memory.

A variety of tasks are currently used to assess working memory performance in schizophrenia samples. These measures include the N-back Task (e.g., Perlstein, Dixit, Carter, Noll, & Cohen, 2003), working memory subscales of the Wechsler Adult Intelligence Scale (e.g., Dickinson, Iannone, Wilk, & Gold, 2004), the Wisconsin Card Sorting Task (e.g., Gold, Carpenter, Randolph, Goldberg, & Weinberger, 1997), and several subtests of the MATRICS battery such as the Letter-Number Span and the WMS-III Spatial Span (e.g., Perry et al., 2001). While each of these measures have proved useful

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in assessing working memory performance, the N-back Task might be particularly advantageous in evaluating working memory processes.

The N-back Task was first introduced in 1958 by Wayne Kirchner as a method of assessing age differences in memory tasks of "rapidly changing information". During the task, the participant is presented a series of stimuli and instructed to determine whether or not the currently displayed stimulus matches the one from N-steps earlier in the sequence (Kirchner, 1958). In this way, the N-back task is able to measure a number of key processes within working memory. To meet the demands of task, the participant must maintain, update, and manipulate information in working memory. An advantage to the N-back Task paradigm is the ability to vary cognitive load. Low working memory load designs might involve recalling whether a stimulus matched or differed from stimuli presented more recently in the sequence (1 position back, or 2 positions back), while high working memory load designs might require the participant to recall stimuli that were presented even earlier in the sequence (3 positions back, etc.). For this additional utility we have elected to use the N-back Task in this experimental design.

Previous literature has demonstrated that patients with schizophrenia make significantly more errors on versions of the N-back task, than healthy controls (Perlstein, Carter, Noll, & Cohen, 2001; Kerns & Berenbaum, 2003; Schneider et al., 2007). Several of these studies have demonstrated a decrease in performance coinciding with increases in task difficulty (Carter et al., 2014). Consistent with other established similarities, individuals with schizotypy have

demonstrated working memory impairments when compared with healthy controls (Park, Holzman, & Goldman-Rakic, 1995). Yet few previous studies have assessed working memory performance in psychometrically-defined schizotypy samples using the N-back Task (Smyrnis et al., 2007). Kerns and Becker (2008) assessed N-back working memory task performance in a group of individuals rating high on a measure of disorganized symptoms. Results revealed poorer performance in the N-back Task by individuals with disorganized schizotypy when compared with a control group, while no differences were found in performance on a psychometrically matched verbal intelligence task (Kerns & Becker, 2008). Conversely, in a study by Schmidt-Hansen and Honey (2009) reduced working memory performance during an N-back task was associated with positive schizotypy, and to a lesser degree with lower levels of negative schizotypy. Irrespective of associations with symptom dimensions, results are indicative of a clear deficit in working memory performance assessed using the N-back task, in individuals with psychometrically-defined schizotypy.

1.4 Social Cognition

Social cognition refers to the processing of social information, and includes the ability to perceive, interpret, and process this type of information. Impairments in social cognition have been evidenced in schizophrenia samples, and to a lesser extent in schizotypy samples (Penn, Sanna, & Roberts, 2008; Savla, Vella, Armstrong, Penn, & Twamley, 2012). Individuals with schizotypy display impairments in making social inferences, theory of mind, and interpreting non-verbal social cues (Phillips & Seidman, 2008; Shean, Bell, & Cameron,

2007). However, research in this domain has been somewhat inconsistent, and results are varied (Kelemen, Kéri, Must, Benedek, & Janka, 2004; Pickup, 2006; Jahshan & Sergi, 2007; Gooding & Pflum, 2011).

This may be partially attributed to the difficulty in detangling the contribution of general cognitive functioning to social cognitive ability. Several theories exist to describe the relationship between social and nonsocial cognition. While processing social information may inherently rely on neurocognitive ability, previous research has established social cognition and non-social cognition as separate domains (Van Hooren et al., 2008; Allen, Strauss, Donohue, & van Kammen, 2007). Other researchers have suggested social cognition may mediate the relationship between neurocognition and functional outcome (Addington, Saeedi, & Addington, 2006; Vaskinn et al., 2008; Vauth, Rüsch, Wirtz, & Corrigan, 2004). However, some findings indicate that measures of social cognition account for additional variance in outcome that is not explained by measures of nonsocial cognition alone (Brüne, 2005; Pinkham & Penn, 2006; Pijnenborg et al., 2009). Thus, it may be the interaction of neurocognitive and social cognitive impairments that are most predictive of overall functioning and quality of life (Fett, Viechtbauer, Penn, van Os, & Krabbendam, 2011).

1.4.1 Emotion Processing

An abundance of research exists on emotion processing deficits in individuals with schizophrenia. These impairments reflect abnormalities in experiencing, expressing, and recognizing emotions, and are associated with

impairments in functional outcome (Feinberg, Rifkin, Schaffer, & Walker, 1986; Heimberg, Gur, Erwin, Shtasel, & Gur, 1992; Mandal, Pandey, & Prasad, 1998; Kee, Green, Mintz, & Brekke, 2003; Sergi, Rassovsky, Nuechterlein, & Green, 2006). Prior research suggests that individuals with schizophrenia may experience a disconnect between the expression of emotion, and the immediate, subjective experience of emotion (Kring & Moran, 2008). This is supported by studies showing schizophrenia samples rate emotional stimuli similarly to controls in terms of arousal (Heerey, & Gold, 2007; Hempel, Tulen, van Beveren, Mulder, & Hengeveld, 2007; Hempel et al., 2005; Herbener, Song, Khine, & Sweeney, 2008). However, individuals with higher levels of anhedonia have demonstrated diminished subjective responses to emotional stimuli (Dowd & Barch, 2010).

It is somewhat unclear whether emotion processing impairments in schizophrenia are elicited by negative or positive emotions. Several studies have indicated individuals with schizophrenia report less positive responses to positive emotional stimuli (Paradiso et al., 2003; Taylor, Phan, Britton, & Liberzon, 2005) and experience greater difficulty in recognizing positive emotions (Sachs, Steger-Wuchse, Kryspin-Exner, Gur, & Katschnig, 2004; Tseng et al., 2013). Yet, a number of other studies have found patients with schizophrenia display a differential deficit in processing negative affect, particularly fear (Schneider, Gur, Gur, & Shtasel, 1995; Kohler et al., 2003; Phillips at al., 1999; Bediou et al., 2005).

Further adding to the complexity are results from studies with schizotypy

samples. Individuals with schizotypy have also exhibited deficits in emotion processing, though these impairments are less pronounced than those observed in schizophrenia patients (Kerns, 2005; Kerns & Becker, 2008; Phillips & Seidman, 2008). Brown and Cohen (2010) found that when compared with controls, individuals with psychometrically-defined schizotypy were less accurate in identifying facial affect for all emotions, but showed particular difficulty in correctly identifying neutral faces. Other research examining emotion processing in a psychometrically-defined positive schizotypy sample identified an increased memory response bias for negative words, resembling the negative bias observed in some schizophrenia samples (Kerns, 2005). Lastly, using a sample of individuals meeting criteria for schizotypal personality disorder, Waldeck and Miller (2000) discovered an impaired ability to label positive emotions, when compared with other emotions. Given these mixed results, it is currently uncertain whether individuals with schizotypy are susceptible to emotion processing deficits when processing negative or positive emotions.

1.5. Impact of Emotion on Cognition

Cognition researchers have long recognized that impact of emotion on cognitive processing. In healthy individuals, emotional stimuli attract more attention than non-emotional stimuli and therefore facilitate processing (Anderson & Phelps, 2001; Öhman, Flykt, & Esteves, 2001; Anderson, 2005). However, if the emotional salience of the stimuli is unrelated to the task, the presentation of emotional stimuli may instead worsen performance, requiring an increase in the need for cognitive control (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002;

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Van Dillen & Koole, 2009). Thus, depending on task relevance the emotional content of the stimuli may either enhance or detract from cognitive processing (Uher, Brooks, Bartholdy, Tchanturia, & Campbell, 2014).

As previously described, evidence suggests that individuals with schizophrenia display deficits in emotion processing. Therefore, it might be inferred that individuals with schizophrenia would be less influenced by task-relevant emotional stimuli (Becerril & Barch, 2011). However, individuals with schizophrenia also demonstrate a decreased working memory capacity (Lee & Park, 2005; Forbes, Carrick, McIntosh, & Lawrie, 2009), and therefore may experience more influence of emotion on cognition, especially when emotional salience is irrelevant to the demands of the task. Pauly et al. (2008) found that when compared with controls, individuals with schizophrenia displayed more errors when presented with negative odors, than with neutral odors, during a verbal N-back Task. Similarly, Anticevic, Repovs, Corlett, and Barch (2011) presented irrelevant negative, neutral and task-related interference to schizophrenia patients and matched controls during a delayed-response visual working memory task, using fMRI. The schizophrenia group showed increased distractibility and failed to recruit regions associated with distractor filtering, in all distractor conditions, while the control group only evidenced distractibility during negative interference (Anticevic, Repovs, Corlett, & Barch, 2011).

In contrast to these findings are the results from Becerril and Barch's (2011) study investigating the impact of relevant emotional stimuli on cognition. Researchers administered a 2-back version of an N-back working memory task

to 38 individuals with schizophrenia and 32 healthy controls, during an fMRI scan. The N-back task consisted of faces displaying happy, fearful, or neutral expressions. Results indicated normal amygdala activity during the presentation of the task-relevant emotional stimuli, suggesting the schizophrenia sample had intact responses to the emotionally evocative stimuli. However, results also revealed altered DLPFC and hippocampal activity during the presentation of negative and neutral stimuli in individuals with schizophrenia. Specifically, while the control group exhibited the expected decrease in DLPFC and hippocampal activity for negative as compared with neutral conditions, the schizophrenia group showed the opposite pattern. Blocked analyses of this activity showed activity associated with item processes and working memory maintenance that spans items. Because previous studies have identified reduced maintenance-related activity in schizophrenia (Driesen et al., 2008; Goldberg, Patterson, Taqqu, & Wilder, 1998; Johnson et al., 2006), researchers suggested the increased activity demonstrated by the schizophrenia group during the negative condition was perhaps indicative of better active maintenance of negatively valenced items, due to enhanced encoding. Conversely, this alteration in activity could have been attributed to an inefficient use of cognitive resources (i.e., with a more vulnerable cognitive system, the schizophrenia sample may have employed additional mental resources). Importantly, researchers discovered no significant group differences in behavioral performance during the emotionally-loaded working memory task, though the schizophrenia group did perform worse overall. While the unusual findings from this study provide valuable insights into the

interplay of emotion and cognition in schizophrenia, additional research is needed to further elucidate this relationship (Becerril & Barch, 2011).

Few existing studies have investigated the effect of emotion on cognitive performance in schizotypy samples. Mohanty et al. examined the influence of negative and neutral words on Stroop task performance in positive schizotypy raters and controls, using fMRI. Positive schizotypy raters showed increased right and decreased left activity in dorsolateral prefrontal cortex, reflective of a deficit in attentional set maintenance, during the presence of negative emotional distractors. Additionally, schizotypy raters showed abnormal activity in ventral limbic areas, including nucleus accumbens and hippocampus and amygdala activity, a circuit that is implicated in the integration of cognitive and affective processes. These results indicate that similar neural abnormalities in emotion-cognition processes may be impaired in schizotypy, as in schizophrenia (Mohanty et al., 2005).

Kerns has also explored the relationship between positive schizotypy symptoms, emotion processing, and cognitive performance, by using an affective priming task and a word recognition task. The affective priming task presented an emotionally valenced prime word, followed by an emotionally valenced target word where participants indicated whether the word was positive or negative. At a short stimulus onset asynchrony, healthy individuals performing this task have been shown to exhibit a congruence effect, where reaction times are faster if the prime and target word have the same valence (Klauer & Musch, 2003). However, at a long stimulus onset asynchrony contrast effects have been demonstrated,

where reaction times are faster if the prime and target word are of different valences. This contrast effect has been attributed to a compensatory process aimed at countering the interference produced by the prime word on the rating of the target words (Klauer, Rossnagel, and Musch, 1997). Kerns discovered that individuals with high levels of positive schizotypy did not demonstrate an affective priming reaction time effect, and they exhibited a smaller shift in affective priming from a short to a long stimulus onset asynchrony when compared with controls, suggesting they were not benefiting from congruence or contrast effects experienced by healthy participants. Furthermore, there was no indication of enhanced memory for negative words during the word recognition task in the schizotypy group, though this effect has been well-established in healthy participants. Overall, the results of this study provide evidence of impaired emotion-cognition interactions, in positive schizotypy (Kerns, 2005).

1.6. Goals and Hypotheses of the Current Study

The current study aims to further investigate the relationship between cognition and emotional processing in schizotypy, using a sample of psychometrically-defined schizotypes. Strikingly few studies have examined the influence of task-relevant emotional stimuli on cognitive performance, and instead focus on the impact of unrelated emotional stimuli. In this study, we will use emotionally valenced, task relevant stimuli in an N-back working memory task administered to a schizotypy and normal control group. The cognitive load of the task will be varied, by administering both a 2-back and 3-back version of the N-back task. Additional variation will be present in stimuli type, incorporating both

facial and postural stimuli to examine the extent to which emotional explicitness of the stimuli influences working memory. No study, to date, has utilized emotionally valenced postural stimuli to assess working memory performance, in either schizophrenia or schizotypy samples. However, in a study using DANVA2 facial, paralinguistic, and postural stimuli to evaluate emotion recognition in schizotypy, specific schizotypal traits were associated with impairments in identifying postural and paralinguistic cues, but not facial stimuli (Shean, Bell, & Cameron, 2007). These results suggest individuals with high levels of schizotypy might experience particular difficulty in processing less overt displays of emotion.

Based on previous findings from episodic memory literature demonstrating enhanced memory for salient emotional events, we hypothesize the emotionally valenced stimuli will enhance attention to, and encoding of, such stimuli in healthy controls. However, in accordance with results from Kern's (2005) study examining emotion-cognition interactions in schizotypy, we speculate the schizotypy group will not experience this same facilitation effect for the task-relevant emotional stimuli. The less explicit postural stimuli will require additional processing yet, resulting in poorer working memory performance, when compared with controls.

Support for our second hypothesis comes from a recent study examining the effects of cognitive load in a psychometrically-defined schizotypy sample. Results revealed an interaction of group by cognitive load, where the schizotypy group displayed a greater decline in performance on a series of neurocognitive tests as the information processing load was increased, than did controls (Xavier,

Best, Schorr, & Bowie, 2015). Therefore, we expect additional group differences in working memory performance to coincide with increases in cognitive load, denoted by 2-back and 3-back versions of the N-back tasks.

2. Method

2.1 Participants

Participants (N = 869) were comprised of undergraduate students enrolled in Introductory Psychology courses at The College of William and Mary. Students completed a battery of assessments administered online from September 2014 to April 2015. The online questionnaire included a consent form, demographic questions, and the full-scale SPQ. First, participants were excluded from the sample if they endorsed three or more responses in the unexpected direction on the Chapman Infrequency Scale (Chapman & Chapman, 1983) (N = 53). Participants were then selected based on total SPQ scores. The schizotypy group corresponded to scores at or above the 85th percentile ($\geq$ 33) and the control group corresponded to scores at or below the 15th percentile ($\leq$ 4). These criteria were derived from criterion validity established by Raine (1991) in the original development of the SPQ, where 55% of subjects scoring in the top 10% had a diagnosis of schizotypal personality disorder. However, because the objective of this research is to examine the effect of emotion on cognition in individuals with lower levels of schizotypal traits, and not schizotypal personality disorder, per se, slightly more relaxed criteria was used (top 15% of scores). Participants were selected from this mass-testing sample at the start of each semester. Participants recruited at the second time-point were selected based on

the original criteria (≥ 33 for the schizotypy group, ≤ 4 for the control group).

Selected participants were invited via e-mail to participate in the study, and offered either $15 cash compensation or one credit towards course required research participation. The final sample included 31 participants in the schizotypy group and 34 participants in the control group. Of the 65 total participants included in the sample, 44 (67.69%) were female and 21 (32.31%) were male. The mean (*SD*) age of the sample was 19.77 (2.63) years. Most participants were white, n=50 (76.9%), with the remaining sample composed of Asians (n=8; 12.3%), African Americans (n=9; 13.8%), Latinos (n=2; 3.1%) and respondents identifying as multiracial or other (n=2; 3%).

This study was approved by the College of William and Mary Human Subjects Review Board and informed consent was obtained for each subject prior to completing the experiment. Trained research assistants prepared study tasks and monitored execution of the experiment.

2.2 Materials

All instruments are listed below and are included in the appendix section.

2.2.1 Schizotypal Personality Questionnaire (SPQ)

Participants were selected based on Schizotypal Personality Questionnaire (SPQ) scores. The SPQ is a 74-item, self report questionnaire that assesses the full range of schizotypal personality disorder symptomotology (DSM V; Raine, 1991) It has demonstrated good psychometric properties as well as convergent and discriminant validity between scales measuring similar and dissimilar constructs. For these reasons the SPQ has been used in a large

number of studies and is frequently preferred over other similar instruments

(Raine, 1991; Raine et al.,1994). Participants responded to each item with 'yes'

or 'no'.

2.2.2 Schizotypal Personality Questionnaire - B (SPQ-B)

The SPQ- is a brief, self-report screening instrument intended to measure

schizotypal traits. The SPQ-B is based on the full-scale SPQ and includes

corresponding subscales: cognitive/perceptual (positive), interpersonal difficulties

(negative), and disorganization. Participants responded to each of 22 items with

'yes' or 'no' (Raine & Benishay, 1995).

2.2.3 Chapman Infrequency Scale

The infrequency scale contains 13 items designed to screen out

participants who respond in a random or "fake-bad" manner. Participants who

endorsed more than three of these items were omitted from further study

(Chapman & Chapman, 1983).

2.2.4 N-back Task

The N-back paradigm is frequently used to assess visual working memory.

The N-back Task was administered in both 2-back, and 3-back versions. The 2-

back test required participants to recall stimuli two positions back in the

sequence. The 3-back version required participants to remember what was

presented three positions back in the sequence. Participants were presented with

a forced choice where they were required to respond on the keyboard with the

left arrow if they were viewing a target (i.e., a match in consecutive stimuli) and

the right arrow if they were viewing a nontarget (a lack of match in consecutive

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stimuli). Participants performed three runs of each version, presented in four separate blocks. Each stimulus appeared on the screen for 2.5 seconds with a 500 ms interstimulus delay. At the start of the task, participants underwent a 2-back practice block using child facial stimuli.

2.2.5 Emotional Stimuli

The Diagnostic Analysis of Nonverbal Accurary-2 (DANVA-2) measures individual differences in ability to accurately produce and interpret affect communicated through facial expressions, body postures, gestures, and paralanguage (Nowicki & Duke, 1994) The DANVA-2 stimuli were selected based on a predetermined level of rater agreement. The current study involves facial and postural subtests of the DANVA-2. The DANVA-2 Adult Facial expressions (DANVA-2-AF) consists of 24 color photographs of an equal number of happy, sad, angry and fearful facial expressions of high and low intensities (Nowicki and Carton, 1993). During stimuli presentation, participants were required to identify the facial or postural emotion expressed. Keys 1-4 corresponded to happy, sad, angry, and fearful emotions, respectively. The DANVA-2, Adult Postural (DANVA-2-POS) component consists of color, full-body shots of actors expressing one of the four specified emotions. Postural cues are portrayed by actors dressed in black, with the face of each actor concealed by a black oval, to restrict focus to the posture. There are 24 presentations of an equal number of happy, sad, angry and fearful postures, of high and low intensities. The DANVA-2 AF and POS have good test-retest reliability and sufficient construct validity (Nowicki & Duke, 1994). Both the faces and voice stimuli were

presented using a computer program and the order of presentation was randomized.

2.3 Procedure

Upon arrival, participants read and signed informed consent. All testing was administered on a computer. Participants were provided with instructions, followed by a practice trial of the N-back task, using child facial stimuli. Participants performed a block of three runs of a 2-back version of the N-back task, and a block of three runs of a 3-back version, using faces expressing happy sad angry or fearful emotions. After each image participants were presented with instructions on how to respond. They were instructed to press '1' if they thought the person in the photograph was happy, '2' if they thought the person in the photograph was sad, '3' if they thought the person in the photograph was angry, and '4' if they thought the person in the photograph was fearful. After the third stimulus (for the 2-back condition) and fourth stimulus (for the 3-back condition) a follow-up question was presented. It stated: Does the emotion displayed in this photograph match the emotion displayed in the photograph two (or three) positions back? Participants were given instructions to press the left arrow key if the photograph displayed the same and the right arrow key if the current photograph displayed a different emotion. The 2-back and 3-back N-back Task using facial stimuli was followed by a 2-back block and 3-back block using postural stimuli, in which all the methods were the same. Upon completion of the task, participants completed the abbreviated version of the SPQ to ensure group

reliability. The experiment lasted about one hour and was administered, primarily, by trained undergraduate research assistants.

2.4 Statistical Analyses

To examine emotion recognition accuracy, working memory accuracy and working memory reaction time (RT), we conducted three separate 2 x 2 x 4 x 2 repeated measures mixed-design analyses of variance (ANOVAs), with block type (2-back, 3-back), stimuli type (facial, postural), and stimulus valence (happy, sad, angry, fearful) as within-subjects factors and group (schizotypy, control) as a between-subjects factor. Emotion recognition accuracy and working memory accuracy were calculated using total scores, while working memory reaction time represented the mean, for the various conditions.

3. Results

Statistical analyses were conducted using SPSS version 22 (SPSS, 2013).

3. 1 Descriptive Statistics

Prior to data analysis participants were examined for group reliability by comparing SPQ scores obtained prior to recruitment with SPQ-B scores obtained during study participation. Two participants in the schizotypy group were removed from the analysis due to inconsistent SPQ-B scores (SPQ-B scores equaling 0). Table 1 presents descriptive data for the schizotypy and control group. There were no significant differences between the final schizotypy and control samples (n = 31, n = 34) in terms of descriptive statistics. Table 2 presents the mean, median, standard deviation, range, skew, and kurtosis for the

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SPQ, SPQ-B (and associated subscales), and the conditions of the N-back task.

3. 2 Emotion Recognition Accuracy

A four-way mixed between-within analysis of variance (2 N-back loads x 2 stimulus types x 4 stimuli valences x 2 groups) was conducted on the data for emotion recognition accuracy. Mauchly's test indicated that the assumption of sphericity had been violated for emotion ($\chi^2(5) = 13.47$, $p < .05$), and the interaction of emotion and stimuli type ($\chi^2(5) = 12.23$, $p < .05$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.87$; $\varepsilon = 0.89$). There was a significant main effect of N-back load ($F(1,63) = 9.91$, $p = .003$, $\eta^2_p = .136$), stimuli type ($F(1,63) = 8.33$, $p = .005$, $\eta^2_p = .117$), and emotion ($F(2.61,164.43) = 17.64$, $p < .001$, $\eta^2_p = .219$), that was qualified by a significant interaction between stimuli type and emotion ($F(2.70,169.85) = 9.36$, $p < .001$, $\eta^2_p = .129$) and succeeded by a interaction between N-back load, stimuli type, and emotion ($F(3,189) = 4.77$, $p = .003$, $\eta^2_p = .070$). Levene's test of equality of error variances indicated error variances were fairly homogenous for each condition ($p > .05$). There was no significant main effect of group ($F(1,63) = .077$, $p = .783$) for emotion recognition accuracy.

The interaction between N-back load, stimuli type, and emotion was further explored with a two-way repeated measures ANOVA (2 stimuli types x 4 stimuli valences) examining 2-back emotion recognition accuracy, and collapsing across groups. Mauchly's test indicated that the assumption of sphericity had been violated for emotion ($\chi^2(5) = 12.84$, $p < .05$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.89$).

Again, there was a significant main effect of stimuli type ($F(1,64) = 120.36$, $p <$ .001, η^2_p=.653), and emotion ($F(2.66,170.12) = 17.65$, $p <$.001, η^2_p=.216), that was qualified by a significant interaction between stimuli type and emotion ($F(3,192) = 8.50$, $p <$.001, η^2_p=.117).

The interaction between stimuli type and emotion suggests that, for all groups, 2-back emotion recognition accuracy for the various stimuli valences was dependent upon the stimuli type (facial or postural). That is, recognition accuracy for each emotion varied according to the distinctiveness of the stimuli. The significant interaction between stimuli type and emotion for 2-back emotion recognition accuracy was therefore followed by a series of repeated-measures t-tests, using a False Discover Rate correction (α = .05) for multiple comparisons.

3. 2.1 False Discovery Rate

The False Discovery Rate (FDR) is a more recently developed correction for multiple comparisons that affords greater power and is more appropriate when the variables of interest are dependent, as in this analysis. Benjamin and Hochberg (1995) defined the FDR as the expected proportion of errors among the rejected hypotheses, or the proportion of falsely declared pairwise tests among all pairwise tests declared significant. It has been shown that the FDR performs comparably to other methods with few comparisons, and has increased power with increasing number of comparisons (Benjamin & Hochberg,1995).

Three of the four repeated-measures t-tests were significant according to the computed FDR cutoff (.0375). There was a significant difference in 2-back emotion recognition scores for fearful faces (M = 13.37, SD = 1.81) and postures

(M = 10.10, SD = 3.10; $t(64)$ = 8.20, p < .001), happy faces (M = 15.05 , SD = 2.75) and postures (M = 13.02 , SD = 3.36; $t(64)$ = 4.80, p < .001), and sad faces (M = 15.15 , SD = 3.25) and postures (M = 13.74 , SD = 2.41; $t(64)$ = 3.37, p = .001), but not for angry faces (M = 13.48 , SD = 2.94) and postures (M = 13.28 , SD = 3.39; $t(64)$ = -.50, p = .662). Results are displayed in figure 1.

A two-way repeated measures ANOVA (2 stimuli types x 4 stimuli valences) was also conducted to examine 3-back emotion recognition accuracy, collapsing across groups. Mauchly's test indicated that the assumption of sphericity had been violated for emotion ($\chi^2(5)$ = 18.12, p < .05), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ϵ = 0.83). Again, there was a significant main effect of stimulus type ($F(1,64)$ = 17.94, p < .001, η^2_p=.219), and emotion ($F(2.50,159.74)$ = 16.12, p <.001, η^2_p=.201), that was qualified by a significant interaction between stimulus type and emotion ($F(3,192)$ = 4.05, p =.008, η^2_p=.059).

The interaction between stimuli type and emotion suggests that, for all groups, emotion recognition accuracy for the various stimuli valences was dependent upon the stimuli type (facial or postural). The significant interaction between stimulus type and emotion for 3-back emotion recognition accuracy for both groups was followed by a series of repeated-measures t-tests, using a False Discover Rate correction (α = .05) for multiple comparisons. Only one of the four repeated-measures t-tests were significant according to the computed FDR cutoff (.0375). There was a significant difference in 3-back emotion recognition scores for happy faces (M = 12.94, SD = 4.14) and postures (M = 15.40, SD = 2.97;

t(64) = -4.79, *p* < .001), but not for angry faces (M = 12.80 , SD = 3.20) and

postures (M = 13.25 , SD = 3.21; *t*(64) = -1.02, *p* = .314), fearful faces (M = 11.19

, SD = 3.25) and postures (M = 11.68 , SD = 2.97; *t*(64) = -.938, *p* = .352), or sad

faces (M = 13.32 , SD = 2.94) and postures (M = 14.14 , SD = 3.09; *t*(64) = -1.89,

p = .064). Results are displayed in figure 2.

3.3 N-back Accuracy

A four-way mixed between-within analysis of variance (2 n-back loads x 2

stimuli types x 4 stimuli valences x 2 groups) was conducted on the data for N-

back accuracy. Mauchly's test indicated that the assumption of sphericity had

been met for all included variables (*p* < .05). There was a significant main effect

of N-back load (*F*(1,63) = 63.34, *p* < .001, η^2_p=.501) and emotion (*F*(3,189) =

16.52, *p* <.001, η^2_p=.208), that was modified by significant interactions between

N-back load and stimuli type (*F*(1,63) = 4.05, *p* =.048, η^2_p=.060), N-back load and

emotion (*F*(3,189) = 6.79, *p* <.001, η^2_p=.097), and stimuli type and emotion

(*F*(3,189) = 4.74, *p* =.003, η^2_p=.070). Of most importance was a significant

interaction between stimuli type, emotion, and group (*F*(3,189) = 14.92, *p* =.008,

η^2_p=.061). Levene's test of equality of error variances indicated error variances

were fairly homogenous for each condition (*p* > .05).

The interaction between stimuli type, emotion and group was further

explored by a two-way mixed between-within ANOVA (4 stimuli valences x 2

groups) examining N-back accuracy for facial stimuli, averaging across N-back

load. Mauchly's test indicated that the assumption of sphericity had not been

violated (*p* > .05). Results indicated a significant main effect of emotion (*F*(3,189)

= 7.87, p <.001, η^2_p=.111), that was qualified by a significant interaction between emotion and group (F(3,189) = 3.78, p =.011, η^2_p=.057).

The significant interaction between emotion and group for N-back accuracy for facial stimuli was followed by a series of independent-samples t-tests, using a False Discover Rate correction (α = .05) for multiple comparisons. Only one of the four independent-samples t-tests was significant according to the computed FDR cutoff (.0125). There was a significant difference in N-back accuracy scores between the schizotypy (M = 10.13, SD = 1.61) and the control group (M = 11.21, SD = 1.37) for angry facial stimuli (t(63) = -2.91, p = .005, two tailed), but not for fearful (M = 10.53 , SD = 1.36; M = 10.96 , SD = 1.66; t(63) = -1.12, p = .267), happy (M = 10.13 , SD = 1.43; M = 9.71 , SD = 1.67; t(63) = 1.09, p = .3278), or sad faces (M = 9.12 , SD = 1.40; M = 9.65 , SD = 1.50; t(63) = .754, p = .454). Results are displayed in figure 3.

A two-way mixed between-within ANOVA (4 stimuli valences x 2 groups) was also conducted to examine N-back accuracy for postural stimuli, averaging across N-back load. Mauchly's test indicated that the assumption of sphericity had not been violated (p > .05). Results indicated a significant main effect of emotion (F(1,63) = 9.98, p =.044, η^2_p=.063), but no significant interaction between emotion and group (F(3,189) = 1.27, p =.286, η^2_p=.020). The main effect of emotion was further analyzed using pairwise comparisons, with an FDR correction (α = .05; established cutoff = .033).

There was a significant difference in N-back accuracy for angry (M = 9.92, SD = 1.66) and fearful postures (M = 11.18, SD = 1.36; t(64) = -5.79, p < .001),

fearful and happy postures (M = 10.18 , SD = 1.53; $t(64)$ = 4.89, p < .001), and

fearful and sad postures (M = 9.68 , SD = 1.62; $t(64)$ = 5.88, p < .001). There

were no significant differences in N-back accuracy for happy and sad postures

$t(64)$ = -1.89, p = .064), angry and happy postures ($t(64)$ = -1.89, p = .064), or

angry and sad postures ($t(64)$ = -1.89, p = .064). Results are displayed in figure

4.

3.4 N-back Reaction Time

A four-way mixed between-within analysis of variance (2 n-back loads x 2

stimuli types x 4 stimuli valences x 2 groups) was conducted on the data N-back

reaction time (s). Mauchly's test indicated that the assumption of sphericity had

been violated for the interaction of N-back load and emotion ($\chi^2(5)$ = 18.22, p <

.05), and the interaction of n-back load, stimuli type, and emotion ($\chi^2(5)$ = 15.87,

p < .05), therefore degrees of freedom were corrected using Greenhouse-

Geisser estimates of sphericity (ε = 0.88; ε = 0.88). There were significant main

effects of N-back load ($F(1,63)$ = 7.37, p = .009, η^2_p=.105), stimuli type ($F(1,63)$ =

58.33, p < .001, η^2_p=.481), and emotion ($F(3,189)$ = 4.38, p = .005, η^2_p=.065).

There was also a significant main effect of group ($F(1,63)$ = 5.66, p = .020,

η^2_p=.082). However, there were no significant interactions. Levene's test of

equality of error variances indicated error variances were fairly homogenous for

each condition (p > .05).

The significant main effect of N-back load that was observed suggests that

for both groups, N-back reaction time varied depending on the condition (2-back

or 3-back), collapsing across stimuli type and emotional valence. Surprisingly,

pairwise comparisons revealed that reaction time was greater for 2-back conditions as compared with 3-back conditions (M = 1.20, SE = .07; M = 1.07, SE = .07) The significant main effect of stimuli type that was observed suggests that for both groups, reaction time varied with the type of stimuli presented, irrespective to N-back load or emotional valence. Again, pairwise comparisons revealed an unexpected slower reaction time for facial stimuli, as compared with postural stimuli (M = 1.32, SE = .08; M = .96, SE = .06). The significant main effect of emotion suggests that for both groups, when collapsing across N-back load and stimuli type, emotion recognition accuracy differed depending on emotional valence of the stimuli. The main effect of emotion was further analyzed using pairwise comparisons, with an FDR correction (α = .05; established cutoff = .033), revealing a significant difference in N-back reaction time for angry (M = 1.19, SD = .57) and fearful stimuli (M = 1.11, SD = .55; $t(64)$ = 3.21, p <=.002) and angry and happy stimuli (M = 1.09 , SD = .53; $t(64)$ = 3.16, p = .002). There were no significant differences in N-back reaction time for angry and sad stimuli (M = 1.13, SD = .58; $t(64)$ = 1.89, p = .063), fearful and happy stimuli ($t(64)$ = .558, p = .589), fearful and sad stimuli ($t(64)$ = -.834, p = .407), or happy and sad stimuli ($t(64)$ = -1.38, p = .172). Results are displayed in figure 5.

The significant main effect of group indicates that after collapsing across N-back load, stimuli type, and emotional valence, there was a significant difference in reaction time between the two groups. Pairwise comparisons showed an overall slower reaction time for the schizotypy group, compared with the control group (M = 1.29, SE = .09; M = .98, SE = .09).

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4. Discussion

The goal of this study was to examine the influence of emotionally valenced stimuli on working memory in a psychometrically-defined schizotypy sample, as compared with a control sample. Additionally, we aimed to discover the confines of this influence by incorporating both overt facial stimuli and, less explicit, postural stimuli. In doing so, we anticipated discovering differential working memory performance that was contingent upon the degree of emotional valence. Lastly, we sought to discover the threshold of the influence of emotion on working memory by varying the cognitive demands of the task, using both a 2-back and 3-back version. Below is a detailed account of the results and the implications of these findings.

4.1 Emotion Recognition Accuracy

Emotion processing impairments in schizotypy samples have been previously demonstrated, though results of these studies have been mixed (Brown and Cohen, 2010; Kerns, 2005; Waldeck and Miller, 2000). In order to better understand the core of this deficit, whether it lie in the identification of positive or negative emotions, we evaluated emotion recognition accuracy for the presented emotional stimuli. However, results of our study revealed no significant group differences in emotion recognition accuracy across the various conditions. There was, however, a significant interaction between stimuli type and emotion for both the 2-back and the 3-back conditions, when eliminating group, suggesting that emotion recognition accuracy was dependent upon the stimuli type (facial or postural). In the 2-back condition, emotion recognition accuracy

was greater for facial depictions of the four emotions (angry, fearful, happy, sad) compared with postures, though this difference was not statistically significant for angry faces. This finding aligns with our study premise, that facial expressions of emotion are more easily discernible than postural displays of emotion. However, in analyzing emotion recognition accuracy for the four emotions within the 3-back condition, we found accuracy was slightly better for postures across the four emotions, though only statistically significant for happy depictions. Interpretation of this unexpected result cannot be substantiated by previous literature, though a possible explanation may be that as cognitive demands of the overall task were increased, emotion processing resources may have been sacrificed in all participants. This may have resulted in overall faster processing of the emotional stimuli, at the expense of accurately processing of emotional stimuli. For the facial stimuli that had greater emotion salience, this effect was more pronounced. In the 2-back conditions sufficient cognitive resources were available to fully process the emotional stimuli, which led to better recognition of the more overt facial stimuli. However, when the cognitive load of the task was increased during the 3-back conditions, fewer resources were available to process the emotional stimuli, leading to a decrease in accuracy for the facial stimuli. This hypothesis is discussed further in the ensuing discussion.

The absence of group differences in emotion recognition accuracy conflicts with the only prior study to have evaluated emotion recognition in schizotypy, using DANVA-2 facial, paralinguistic, and postural stimuli. Results from this study revealed impairments in accurately identifying postural and

paralinguistic displays of emotion that were associated with schizotypal traits (Shean, Bell, & Cameron, 2007). However, these researchers did not discover differences in emotion recognition accuracy for the facial stimuli, as is corroborated in our results. Therefore, it may be speculated that overt displays of emotions may not be sufficient in eliciting emotion recognition impairments in schizotypy, and these deficits may arise only during the identification of less discernible displays of emotion. Additionally, rather than classifying participants according to an extreme-groups method, this study used a continuous design where associations were examined between specific traits and emotion recognition accuracy. Through this approach, there is the potential for greater power as opposed to an extreme groups design, potentially providing an explanation for our lack of group differences (Kraemer, Noda, & O'Hara, 2004).

The ambiguous nature of emotion processing in both schizophrenia and schizotypy populations has been previously discussed. While many studies support the existence of deficits within this domain, the mechanism through which these deficits are conveyed less clear. Recent evidence suggests individuals with schizophrenia may have intact subjective responses to emotional stimuli, and rather a diminished capacity for the expression of emotion (Kring & Moran, 2008). Thus, it is reasonable to conclude that in schizotypy samples, where evidenced emotion processing deficits are less severe, this disconnection may also occur. Therefore, in tasks requiring recognition of emotional stimuli, schizotypy samples may in fact perform comparably to controls and demonstrate no impairments in accurately perceiving emotional valence. Though evaluating

the expression of emotion was not within the scope of this study, we found no

significant differences in emotion recognition abilities between the schizotypy and

normal control groups, which may be suggestive of an unimpaired ability to

recognize emotions among individuals with low levels of schizotypal traits.

4.2 N-back Accuracy

The primary objective of this research was to examine the impact of

emotion on working memory in schizotypy, by assessing performance on an N-

back task using task-relevant emotional stimuli. Despite relatively intact emotion

recognition displayed by the schizotypy group, results indicated accuracy of the

emotionally loaded working memory task was dependent upon stimuli type,

emotional valence, and group membership. In disentangling this interaction, we

discovered group differences were rooted in N-back accuracy for angry facial

stimuli, across both the 2-back and 3-back conditions. Specifically, the schizotypy

group performed significantly worse on angry face trials of the N-back task. This

finding is in line with our primary hypothesis regarding N-back accuracy. This

hypothesis was based upon Kerns (2005) study evaluating performance on an

affective priming task and word recognition task in positive schizotypy raters

versus controls, where the schizotypy group did not experience the congruence

and contrast effects demonstrated by healthy controls nor did they experience

enhanced memory for negative words. However, results from our study suggest

the schizotypy group experienced greater difficulty solely on trials of the N-back

task that involved processing angry facial cues. While findings regarding the

specific valence (positive or negative) of emotion processing deficits in

schizophrenia are mixed, a meta-analytic review by Mandal, Pandey, and Prasad (1998) found that despite a general impairment of facial emotion perception, individuals with schizophrenia seemed to be highly sensitive to negative emotions, particularly depictions of fear and anger. Taken together, these previous studies may provide an explanation for the results of this study. The schizotypy group may have experienced a greater influence of emotion on cognition, and instead of benefitting from the task-relevant emotional stimuli, the angry facial stimuli impaired performance. This is in accordance to our hypothesis that reasoned individuals with schizotypy, who demonstrate cognitive impairments similar to those evidenced in schizophrenia samples, would not experience the same enhanced working memory for the emotional stimuli as healthy individuals. Instead, the schizotypy sample had greater difficulty on the N-back task incorporating task-relevant emotional stimuli, specifically on angry facial conditions that may have required additional processing.

It is interesting to note, though the only significant group differences in N-back accuracy for faces were found with angry facial stimuli, the schizotypy group performed worse on the N-back for all negative facial stimuli. However, for conditions displaying happy faces, the schizotypy group actually performed slightly better than the control group, though again this difference was not significant. This finding provides marginal support for a specific deficit in processing negative emotions that has been established in some prior research with schizophrenia and schizotypy samples (Edwards, Jackson, & Pattison, 2002; Kerns, 2005).

Contrary to results from N-back facial conditions, we found no significant group differences in working memory performance for postural stimuli. After collapsing across groups, we discovered significant differences in N-back accuracy for angry compared with fearful postural stimuli, fearful compared with happy postural stimuli, and fearful compared with sad postural stimuli, where accuracy was greatest for fearful postural stimuli. Superior accuracy for the fearful postural stimuli may be due to the distinctive bodily depiction of fear, as compared with other emotional poses. For example, postural fear was typically depicted by open palm gestures, a feature that was not shared by other postural expression of emotion. Perhaps this more unique representation of emotion was better remembered by all participants.

Nevertheless, the lack of group differences in working memory performance for the postural stimuli was surprising. Based on previous emotion recognition literature (Shean, Bell, & Cameron, 2007), we anticipated the greater ambiguity of the postural stimuli would require additional cognitive resources to process such stimuli, resulting in fewer resources available to meet the demands of the working memory task, for the schizotypy group. However, we found no group differences in working memory performance for the postural stimuli. We therefore conclude that processing the postural stimuli may have required substantially different, and potentially even less emotion processing. This is supported by previous literature that has shown specific neural processes are recruited for the processing of faces (Kanwisher, 2000). Therefore, less overt postural displays of emotion might exert less of an influence on cognition in

schizotypy, than more prominent facial depictions of emotion. In populations with more vulnerable cognitive systems, such as in schizophrenia, and to a lesser extent in schizotypy, the more salient the presentation of emotion, the greater the influence on cognition.

Additionally, we expected to find group differences in working memory performance corresponding to the varied cognitive load. This hypothesis was based on a recent study examining the effects of cognitive load on neurocognitive performance, in a psychometrically-defined schizotypy sample where neurocognitive performance declined with increases in cognitive load (Xavier, Best, Schorr, & Bowie, 2015). However, our results revealed no differences in working memory accuracy for the various cognitive loads. We may conclude that the 2-back versus 3-back conditions were not substantially different in cognitive demand, and perhaps a larger increase in cognitive load would have produced group differences.

4.3 N-back Reaction Time

Reaction time for the emotionally-loaded N-back task was evaluated in order to discover any potential associations with N-back accuracy. Though analyzing N-back reaction time data did not result in any intriguing variable interactions, results did provide some clarity for the more complex working memory performance findings.

N-back reaction time results indicated that the schizotypy group was significantly slower at responding than the control group, irrespective of condition. The slower reaction time demonstrated by the schizotypy group may

provide additional support for the greater influence of emotion on cognition by this group. Specifically, the increased influence of emotional stimuli may have required additional processing, and consequently more time, in order to accomplish the task. Alternatively, the slower reaction time of the schizotypy group may be entirely generated by a substandard working memory. Previous studies have evidenced working memory impairments in schizotypy samples (Park, Holzman, & Goldman-Rakic, 1995) and several have demonstrated these impairments using an N-back task (Smyrnis et al., 2007; Kerns and Becker, 2008). It may be that a decreased working memory capacity in the schizotypy sample was exhibited through slower reaction time.

N-back reaction time data also revealed some unexpected results. Disregarding all other variables, overall reaction time for the N-back task was slower for the 2-back condition, compared with the 3-back. Additionally, N-back reaction time was slower for the facial stimuli, when ignoring all other variables. While these results were certainly unexpected, they may provide additional insight to previously discussed findings regarding emotion recognition accuracy. The greater emotional salience of facial stimuli may have required more extensive emotion processing, resulting in additional time. However, postural displays of emotion that were less explicit, may have expended fewer emotion processing resources. When cues are explicit and working memory load is low, adequate emotion processing may occur, but with increased cognitive demands, emotion processing may be forfeited. Therefore, when less cognitive resources could be devoted to emotion processing, there were specific consequences for

the more explicit facial stimuli. This resulted in less accurate emotion recognition for faces during the 3-back conditions, in favor of a faster response time overall for 3-back conditions. Additionally, while it has been shown salient emotional stimuli can facilitate processing through enhanced attention in healthy individuals (Anderson & Phelps, 2001; Öhman, Flykt, & Esteves, 2001; Anderson, 2005), Kesinger and Corkin (2003) found that healthy participants had slower response times to negative facial stimuli than to neutral facial stimuli during an n-back task, though there were no effects of emotional stimuli on other working memory tasks used in the study. These results suggest that in some instances emotional salience may impede working memory performance. Therefore, in our emotionally-loaded working memory task, even controls may have been influenced by the emotional stimuli, which specifically affected performance on the 3-back conditions of the n-back task, with greater cognitive demand.

Lastly, irrespective of all other variables, reaction time was slowest for stimuli depicting anger. This finding may have been driven by the schizotypy group, that demonstrated lower performance on N-back trials of angry faces, potentially reflecting a distraction by angry stimuli.

4.4 Limitations

The results of the current study address the complex interplay between emotion and cognition in schizotypy, however, a number of limitations must be noted.

A potential weakness of our study is the absence of neutral stimuli in our study design. Some prior research has shown individuals with schizotypy may

demonstrate impairments when processing neutral stimuli (Brown & Cohen, 2010). Therefore, examining emotion recognition accuracy, N-back accuracy, and N-back reaction time for positive, negative, and neutral stimuli may have elicited some interesting results. Additionally, neutral stimuli may have served as a baseline measure of N-back performance, with which we could compare the effect of emotionally valenced stimuli.

Another limitation of the current study is our sample of college students. Thus, the sample was somewhat limited in age, education, and other socio-economic factors. Also, although participants endorsed a broad range of schizotypyal traits, college students at this College tend to be high functioning. Therefore, our results may not be generalizable to individuals with schizotypal symptomotology within the general community. The use of established clinical cutpoints to select participants might also enhance population validity, in future research. This study utilized less stringent inclusion cutoffs in determining groups, however, Raine's proposed 10% criteria would perhaps be more indicative of true schizotypal symptomotology (Raine, 1991).

It is also important to note that participants from this study were drawn from a psychology research pool. As such, all were currently enrolled in Introduction to Psychology at the College of William and Mary. It is possible that individuals who choose to take this course might have certain shared characteristics, such as greater awareness of and/or interest in psychopathology. In future research it will be important to replicate with more diverse samples.

4.5 Future directions

While the results of the present study provide insight into the relationship between emotion and cognition, an area largely neglected by previous research, given the range of divergent findings in the existing literature, further research is required in order to disentangle the effects of emotion on working memory. Rather than merely focusing on the influence of irrelevant or distractor emotional stimuli on cognition, the findings of the current study highlight that it is important for future research to consider the role task-relevant emotional stimuli may play in facilitating working memory in schizophrenia and schizotypy samples. This factor has been largely overlooked in the existing body of research, and examining this relationship may help to elucidate the complex interplay of emotion and cognition, across the schizotypy spectrum. As such, future research should investigate the influence of emotional processing in all domains of cognition, and in individuals across the range of schizotypyal symptom severity.

5. Conclusions

This foundational study sought to explain the impact of task-related emotional stimuli on working memory in schizotypy. The goal was to identify the specific point during the increase of cognitive load, and the particular type of emotional expression, that would limit the ability of a psychometrically-defined schizotypy sample to perform the working memory task. Based on the results obtained in this study it can be concluded that the interplay between emotion and cognition along the schizotypy continuum is yet to be reliably understood. These data show that in the domain of emotion recognition, the schizotypy group was able to perform comparably to the control group, across all experimental

conditions. Due to the ambiguous nature of previous research on emotion recognition impairments in schizotypy, this result may provide support for an unimpaired ability to recognize emotions among schizotypal individuals. Alternatively, both the depictions of emotion utilized in this study may have been too overt to educe impairments in individuals with relatively low levels of schizotypy traits. However, the data also revealed a worse performance on the working memory task during the presentation of angry facial stimuli, by the schizotypy group. This finding demonstrates aberrant processing of these stimuli in schizotypy, which may imply a distractibility ensuing from the presentation of angry facial stimuli, instead of the expected facilitation effect.

In addition the schizotypy group had an overall slower reaction time for the working memory task, as compared with controls. These data further support the greater influence of emotion on cognition by this group. Alternatively, the slower reaction time may result from a deficient working memory, previously evidenced in schizotypy samples. Based on these findings, more research is needed to determine the effect of task-relevant emotional stimuli on working memory, in individuals with psychometrically-defined schizotypy. Efforts to better understand emotion-processing deficits across the schizotypy spectrum should be sustained. What's more, future research should investigate this influence using a sample exhibiting higher levels of schizotypy traits, and therefore, more likely representative of schizotypy pathology than our college student sample. From this research, the relationship between cognition and emotion processing might be better explained, and results may inform this complex interaction in

schizophrenia.

Table 1. *Sample Descriptives*

Variable	High N(%)	Low N(%)
Gender		
Female	22(71%)	22(64.7%)
Male	9(29%)	12(35.3%)
Age (Mean[SD])	19.81(2.94)	19.73(2.36)
Ethnicity		
Caucasian	21(67.7%)	29(85.3%)
African-American	5(16.1%)	4(11.8%)
Asian	5(16.1%)	3(8.8%)
Latino	2(6.5%)	0(0%)
Other	1(3.2%)	1(2.9%)

Table 2. *Distribution of Measures*

Scale		Mean	Median	Standard deviation	Range	Skewness	Kurtosis
SPQ Total	**SCZY**	**43.29**	**40.00**	**11.00**	**39**	**1.33**	**.76**
	NC	1.97	2.00	1.47	4.00	.05	-1.41
Cog/Percep.	**SCZY**	**18.07**	**15.5**	**6.97**	**24.00**	**.63**	**-.22**
	NC	.39	.00	.63	2.00	1.40	1.00
Interpersonal	**SCZY**	**20.57**	**20.00**	**5.62**	**21.00**	**.02**	**-.59**
	NC	1.32	1.00	1.22	3.00	.25	-1.54
Disorganized	**SCZY**	**9.96**	**11.00**	**3.09**	**12.00**	**-.07**	**-.73**
	NC	.29	.00	.66	2.00	2.12	3.17
SPQ-B Total	**SCZY**	**12.45**	**13.00**	**4.14**	**20.00**	**-.86**	**1.52**
	NC	2.27	1.00	2.67	9.00	1.22	.40
Cog/Percep.	**SCZY**	**3.65**	**3.00**	**2.01**	**8.00**	**-.03**	**-.66**
	NC	.88	.00	1.75	7.00	2.34	5.24
Interpersonal	**SCZY**	**5.42**	**6.00**	**2.20**	**8.00**	**-.58**	**-.54**
	NC	1.15	1.00	1.48	6.00	1.56	2.46
Disorganized	**SCZY**	**3.39**	**3.00**	**1.33**	**6.00**	**-.51**	**.40**
	NC	.42	.00	.86	4.00	2.75	8.83

Figure 1. Emotion recognition accuracy for 2-back conditions, collapsing across group. There was a significant difference in 2-back emotion recognition scores for fearful faces and postures, happy faces and postures, and sad faces and postures, but not for angry faces and postures. Error bars reflect standard error.
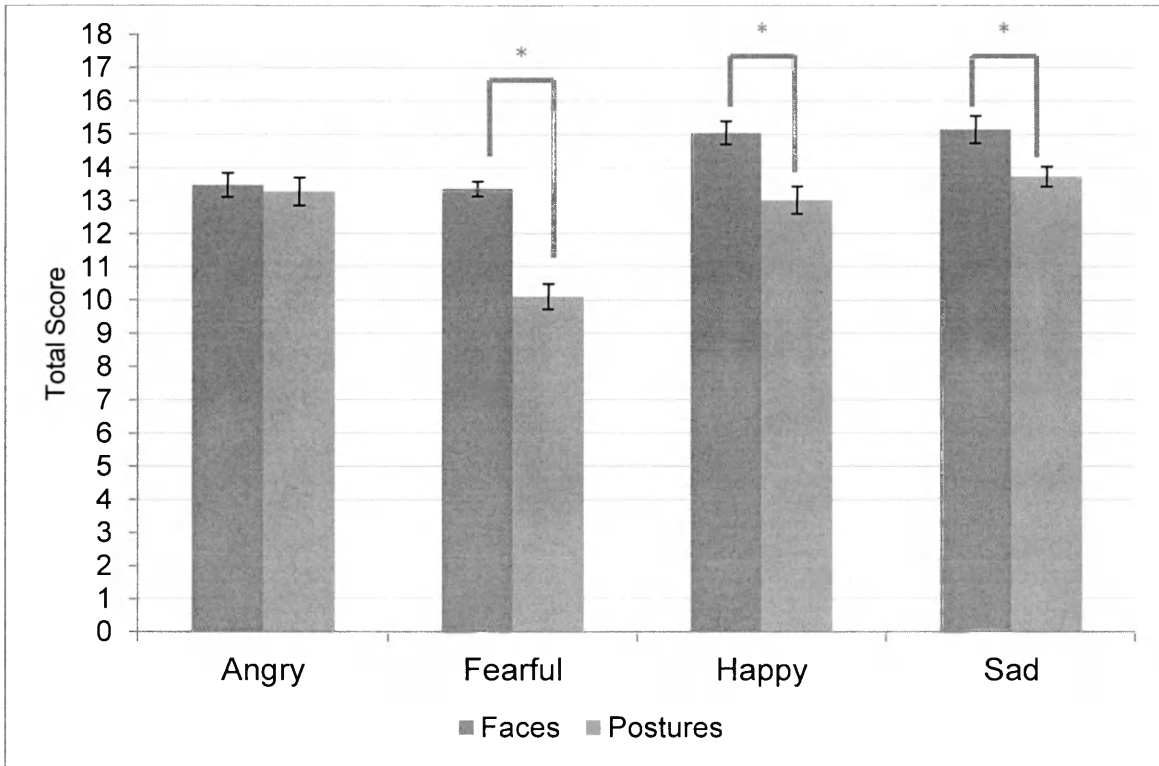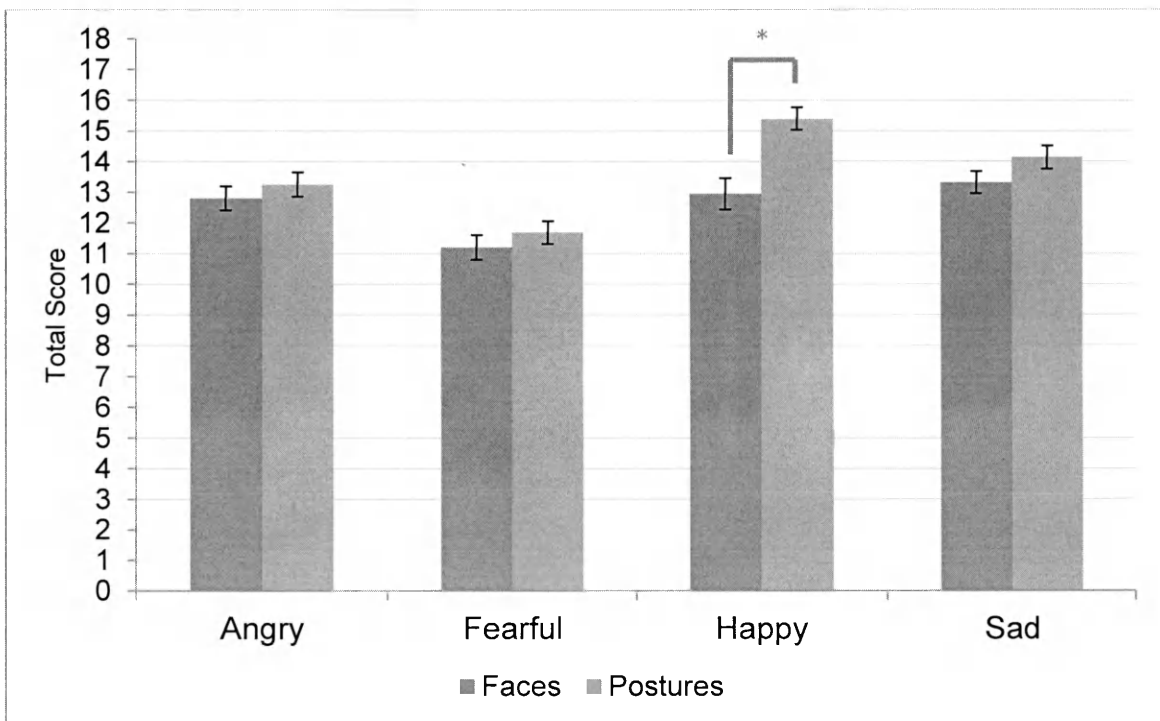
Figure 2. Emotion recognition accuracy for 3-back conditions, collapsing across group. There was a significant difference in 3-back emotion recognition scores for happy faces and postures, but not for angry faces and postures, fearful faces and postures, or sad faces and postures.

Figure 3. N-back accuracy for facial stimuli, collapsing across n-back load. There was a significant difference in n-back accuracy scores between the schizotypy and the control group for angry facial stimuli, but not for fearful, happy, or sad faces.
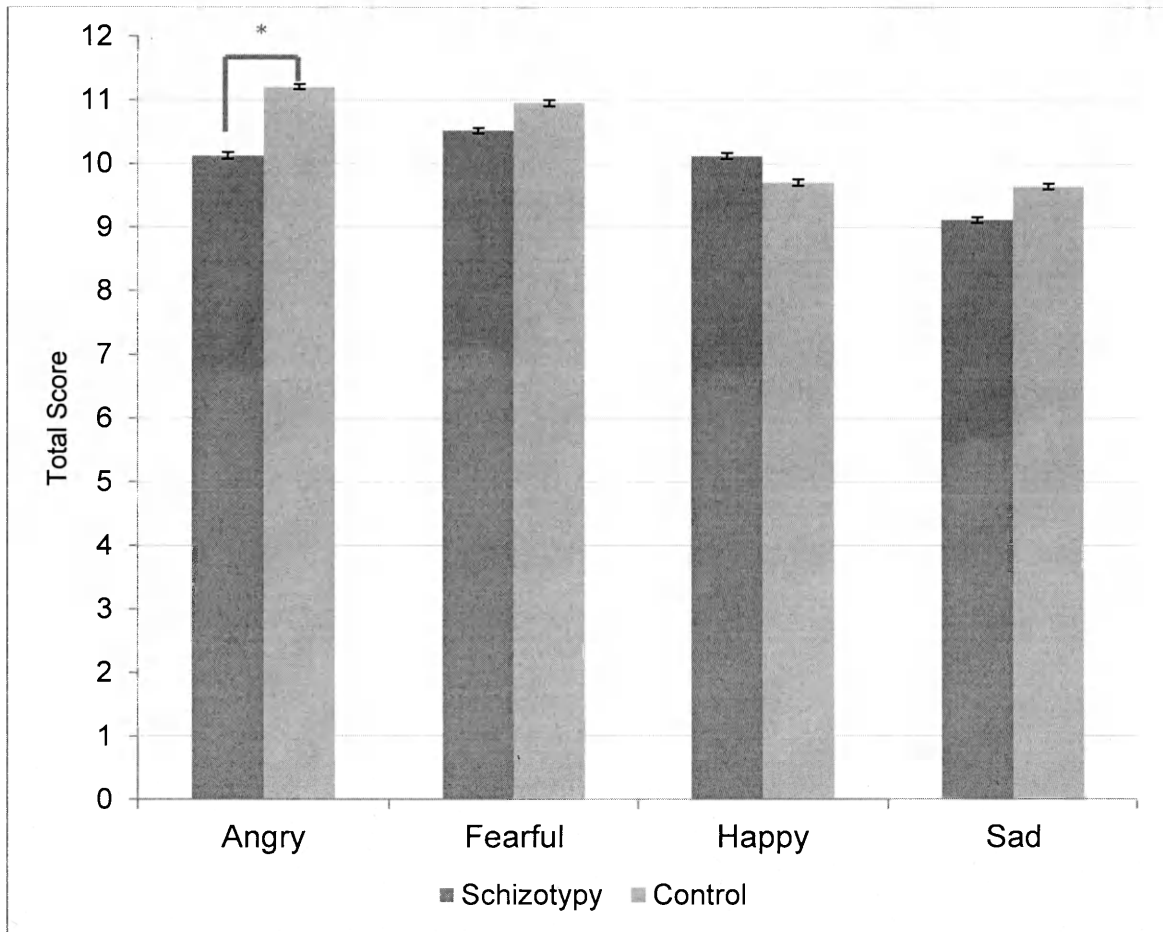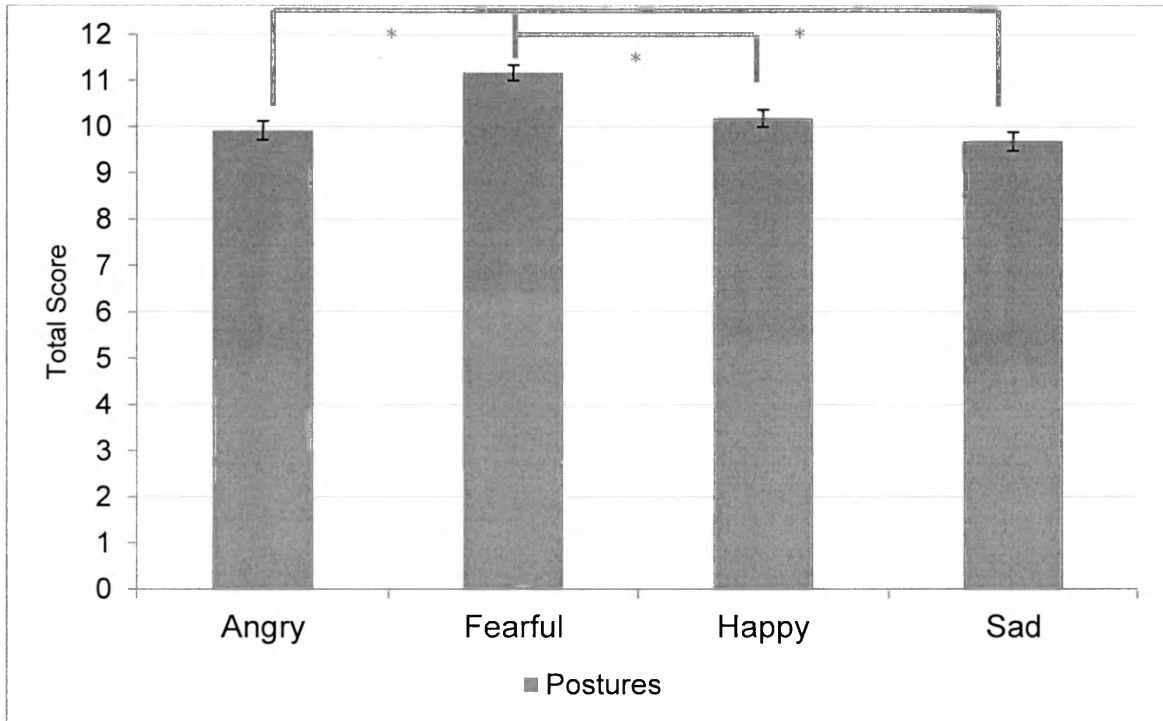
Figure 4. N-back accuracy for postural stimuli, collapsing across group and n-back load. There was a significant difference in n-back accuracy for angry and fearful postures, fearful and happy postures, and fearful and sad postures. There were no significant differences in n-back accuracy for happy and sad postures, angry and happy postures, or angry and sad postures.
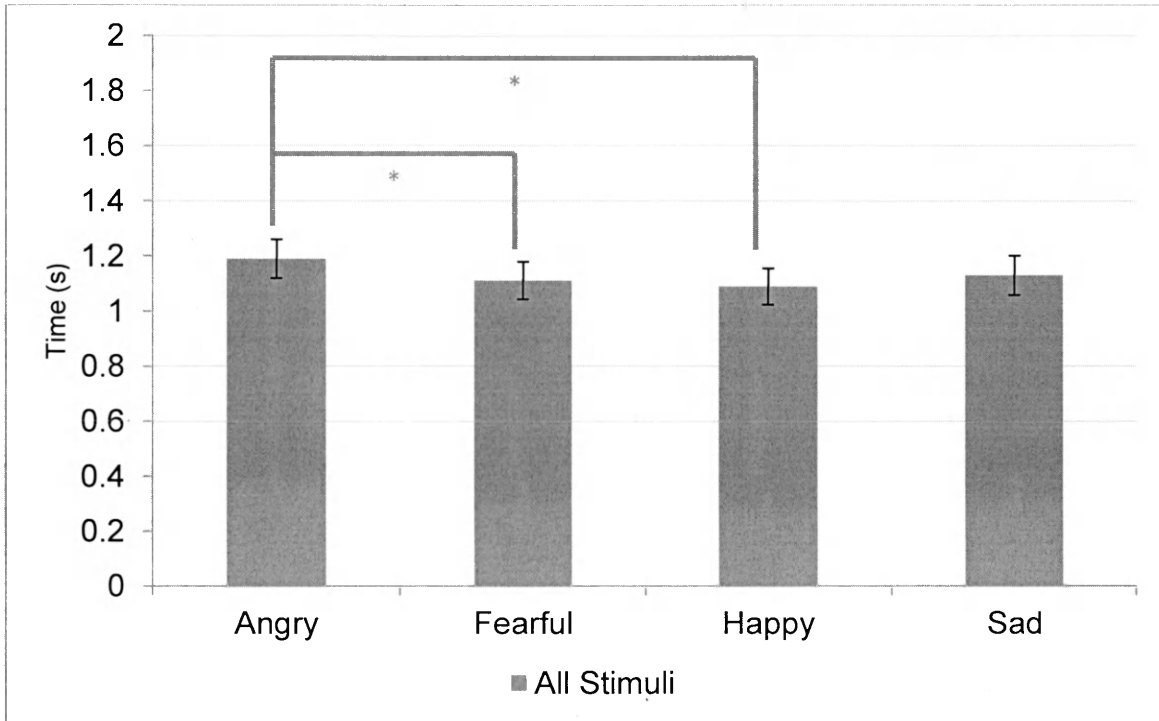
Figure 5. N-back reaction time (s) for facial and postural stimuli, collapsing across group and n-back load. There was a significant difference in n-back reaction time for angry and fearful stimuli and angry and happy stimuli. There were no significant differences in n-back reaction time for angry and sad stimuli, fearful and happy stimuli, fearful and sad stimuli, or happy and sad stimuli

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Schizotypal Personality Questionnaire

For each question participants responded either YES (1) or NO (0). Increasing scores reflect increasing levels of schizotypy. All items were combined to compute a total score.

1. Do you sometimes feel that things you see on the TV or read in the newspaper have a special meaning for you?
2. I sometimes avoid going places where there will be many people because I will get anxious.
3. Have you had experiences with the supernatural?
4. Have you often mistaken objects r shadows for people, or noises for voices?
5. Other people see me as slightly eccentric (odd).
6. I have little interest in getting to know other people.
7. People sometimes find it hard to understand what I am saying.
8. People sometimes find me aloof and distant.
9. I am sure I am being talked about behind my back.
10. I am aware that people notice me when I go out for a meal or to see a film.
11. I get very nervous when I have to make polite conversation.
12. Do you believe in telepathy (mind-reading)?
13. Have you ever had the sense that some person or a force is around you, even though you cannot see anyone?
14. People sometimes comment on my unusual mannerisms and habits.
15. I prefer to keep myself to myself.
16. I sometimes jump quickly from one topic to another when speaking.
17. I am not good at expressing my true feelings by the way I talk and look.
18. Do you often feel that other people have it in for you?
19. Do some people drop hints about you or say things with a double meaning?
20. Do you ever get nervous when someone is walking behind you?
21. Are you sometimes sure that other people can tell what you are thinking?
22. When you look at a person, or yourself in a mirror, have you ever seen the face change right before your eyes?
23. Sometimes other people think I'm a little strange.
24. I am mostly quiet with other people.
25. I sometimes forget what I am trying to say.
26. I rarely laugh and smile.
27. Do you sometimes get concerned that friends or co-workers are not really loyal or trustworthy?
28. Have you ever noticed a common event or object that seemed to be a special sign for you?
29. I get anxious when meeting people for the first time.
30. Do you believe in clairvoyancy (psychic forces, fortune telling)?
31. I often hear a voice speaking my thoughts aloud.

32. Some people think that I am a very bizarre person.
33. I find it hard to be emotionally close to other people.
34. I often ramble too much when speaking.
35. My "nonverbal" communication (smiling and nodding during a conversation) is not very good.
36. I feel that I have to be on my guard even with friends.
37. Do you sometimes see special meanings in advertisements, shop windows, or in the way things are arranged around you?
38. Do you often feel nervous when you are in a group with unfamiliar people?
39. Can other people feel your feelings when they are not there?
40. Have you ever seen things invisible to other people?
41. Do you feel that there is no one you are really close to outside of your immediate family, or people you can confide in or talk to about personal problems?
42. Sometimes I find me a bit vague and elusive during a conversation.
43. I am poor at returning social courtesies and gestures.
44. Do you often pick up hidden threats or put-downs from what people say or do?
45. When shopping do you get the feeling that other people are taking notice of you?
46. I feel very comfortable in social situations involving unfamiliar people.
47. Have you had experiences with astrology, seeing the future, UFOs, ESP, or a sixth sense?
48. Do everyday things seem unusually large or small?
49. Contacting friends is more trouble than it is worth.
50. I sometimes use words in unusual ways.
51. I tend to avoid eye contact when conversing with others.
52. Have you found that it is best not to let other people know too much about you?
53. When you see people talking to each other, do you often wonder if they are talking about you?
54. I would feel very anxious if I had to give a speech in front of a large group of people.
55. Have you ever felt you are communicating with another person telepathically (by mind-reading)?
56. Does your sense of smell sometimes become unusually strong?
57. I tend to keep in the background on social occasions.
58. Do you tend to wander off the topic when having a conversation?
59. I often feel that others have it in for me.
60. Do you sometimes feel that other people are watching you?
61. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?
62. I attach little importance to having close friends.
63. Do you sometimes feel that people are talking about you?
64. Are your thoughts sometimes so strong that you can almost hear them?
65. Do you often have to keep an eye out to stop people from taking advantage

of you?
66. Do you feel you cannot get "close" to people?
67. I am an odd, unusual person.
68. I do not have an expressive and lively way of speaking.
69. I find it hard to communicate clearly what I want to say to people.
70. I have some eccentric (odd) habits.
71. I feel very uneasy talking to people I do not know well.
72. People occasionally comment that my conversation is confusing.
73. I tend to keep my feelings to myself.
74. People sometimes stare at me because of my odd appearance.

Appendix B

Chapman Infrequency Scale

For each question participants responded either TRUE (1) or FALSE (0). Items 2, 8, 12, and 13 are reverse-coded.

1. Sometimes when walking down the sidewalk, I have seen children playing.
2. I cannot remember a single occasion when I have ridden on a bus. **(-)**
3. At times when I was ill or tired, I have felt like going to bed early.
4. I believe that most light bulbs are powered by electricity.
5. On some mornings I didn't get out of bed immediately when I first woke up.
6. Driving from New York to San Francisco is generally faster than flying between these cities.
7. There have been times when I have dialed a telephone number only to find that the line was busy.
8. I find that I often walk with a limp, which is the result of a skydiving accident. **(-)**
9. I go at least once every two years to visit either northern Scotland or some part of Scandinavia. **(-)**
10. There have been a number of occasions when people I know have said hello to me.
11. On some occasions I have noticed that some other people are better dressed than myself.
12. I have never combed my hair before going out in the morning. **(-)**
13. I cannot remember a time when I talked with someone who wore glasses. **(-)**

Appendix C

Schizotypal Personality Questionnaire - Brief

For each question participants responded either YES (1) or NO (0). Increasing scores reflect increasing levels of schizotypy. All items were combined to compute a total score.

1. People sometimes find me aloof and distant.
2. Have you ever had the sense that some person or force is around you, even though you cannot see anyone?
3. People sometimes comment on my unusual mannerisms and habits.
4. Are you sometimes sure that other people can tell what you are thinking?
5. Have you ever noticed a common event or object that seemed to be a special sign for you?
6. Some people think that I am a very bizarre person.
7. I feel I have to be on my guard even with friends.
8. Some people find me a bit vague and elusive during a conversation.
9. Do you often pick up hidden threats or put-downs from what people say or do?
10. When shopping do you get the feeling that other people are taking notice of you?
11. I feel very uncomfortable in social situations involving unfamiliar people.
12. Have you had experiences with astrology, seeing the future, UFOs, ESP or a sixth sense?
13. I sometimes use words in unusual ways.
14. Have you found that it is best not to let other people know too much about you?
15. I tend to keep in the background on social occasions.
16. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?
17. Do you often have to keep an eye out to stop people from taking advantage of you?
18. Do you feel that you are unable to get "close" to people?
19. I am an odd, unusual person.
20. I find it hard to communicate clearly what I want to say to people.
21. I feel very uneasy talking to people I do not know well.
22. I tend to keep my feelings to myself.