The Contingent Negative Variation of High and Low Schizotypes During a Continuous Performance Task: An EEG Study

A thesis submitted in partial fulfillment of the requirements

For the degree of Master of Arts in Psychology,

Clinical Psychology

By

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December 2015
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Acknowledgment

I would like to thank the neuroscience lab and my committee members who contributed to and supported my efforts in writing this thesis. To Theresa Trieu, Jaime Morales, Jeremy Neswald, and Katherine Morain from the neuroscience lab, your hard work and dedication in collecting this study’s data was invaluable. To Dr. Razani, thank you for all of your clinical and psychological expertise. I have learned so much from you which has assisted me personally and academically. The completion of my thesis is not possible without your wisdom and insight. To Dr. Otten, thank you for all of your support, insight, and statistical knowledge. Our numerous brainstorming sessions were instrumental to the success of my thesis and without you the completion of my thesis does not happen. To Dr. Abara, without your help, knowledge in neuroscience, trust, and acumen my thesis does not happen, furthermore, it does not come to fruition. It was in your neuroscience lab I discovered the universal possibilities neuroscience research has on the study of psychology; moreover, your lab was where I developed my hypotheses’. You are a very special person and I am honored you provided me the opportunity to learn from you – thank you. To my chair Dr. Mark Sergi, your unwavering dedication, insight, knowledge, sacrifice and expertise were paramount to the success, completion, and development of my thesis. Without your help, trust, and encouragement this thesis does not happen and for that I am eternally grateful.
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Abstract
The Contingent Negative Variation of High and Low Schizotypes During a Continuous Performance Task: An EEG Study

By
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Schizotypy is a dimensional construct of proneness to schizophrenia. Persons high in schizotypy experience symptoms similar to those of persons with schizophrenia but their symptom severity and social dysfunction are less than persons with schizophrenia. Persons with schizotypy have deficits in cognition that are less severe than those of persons with schizophrenia. Twenty-seven persons high in schizotypy and 50 persons low in schizotypy, identified by scores on the Schizotypal Personality Questionnaire – Brief, were assessed during a continuous performance task using electroencephalography (EEG) to capture their contingent negative variation (CNV) waves. At the parietal site, persons with high schizotypy displayed early CNV amplitudes that were significantly less negative than those of the persons with low schizotypy. High schizotypes showed no evidence of impairment in, working memory and executive functioning as the amplitudes of their late CNVs were not different than those of the persons with low schizotypy. Results indicate high schizotypes may have an early spatial attentional processing abnormality that could affect their spatial working memory and posterior attentional network.
Chapter I

Introduction

Schizophrenia is a mental disorder that affects about 1% of the population (American Psychiatric Association [DSM-5], 2013). The cognitive dysfunctions of schizophrenia manifest themselves through impairments in verbal memory, perceptions, inferential thinking, language and communication, fluency and productivity of thought and speech, and attention (American Psychiatric Association [DSM-5], 2013). According to the DSM-5 (2013), the symptoms of schizophrenia may be separated into positive symptoms and negative symptoms. Positive symptoms are behaviors in excess of the behavior of healthy persons, and negative symptoms are behaviors that are diminished relative to those of healthy persons. Positive symptoms include delusions, hallucinations, disorganized speech, grossly disorganized or catatonic behavior, and are divided in two dimensions. The first is the psychotic dimension, which includes delusions and hallucinations. The second is the disorganized dimension, which includes disorganized speech and behaviors. Negative symptoms consist of affective flattening, alogia, and avolition (American Psychiatric Association [DSM-5], 2013).

Relevant to the current study are the cognitive dysfunctions evident in schizophrenia. Cognition may be defined as intellectual functions involving the acquisition, storage, transformation, and use of knowledge. Seminal studies in cognition and schizophrenia (Fuster 1996; Gold & Harvey, 1993; Saykin, 1991) report dysfunctions in executive functioning (EF), attention, and working memory (WM).

Numerous studies within neuroscience have deemed the prefrontal cortex (PFC), the most rostral structure of the cerebral cortex, responsible for EF. (Tan et al., 2006;
EF is a term used to explain high level processes that mediate the ability to plan and carry out goal directed behavior based on information within the environment through feedback management and inhibitory processes (Braver & Barch, 2008; Gold & Harvey, 1993; Kerns, Nuechterlein, Braver, & Barch, 2008). Several studies have found EF in schizophrenia to be impaired (Braff, Heaton, Kuck, & Cullum, 1991; Fey, 1951; Weickert et al., 2000).

Attention may be defined as the concentration of mental activity that allows one to focus on the sensory world efficaciously and accurately (Fernandez-Duque & Johnson, 2002), and has been reported to be impaired in schizophrenia (Leonhard & Corrigan, 2000). Neuroscience studies have localized two distinct structures of the cerebral cortex allocated for attention. These structures are the parietal (Chun & Wolf, 2001; Luck & Vecera, 2002) and frontal lobes (Stuss, Binns, Murphy, & Alexander, 2002). The anatomical location of these areas within the cortex house what Fuentes & Santiago (1999) termed the posterior attention network (PAN) and the anterior attention network (AAN). The PAN is part of the cortex responsible for visually attending to stimuli in various spatial locations (Chun & Wolf, 2001; Luck & Vecera, 2002). The AAN is part of the cortex activated when one inhibits automatic responses to stimuli (Stuss et al., 2002). Neuroimaging and neurocognitive studies of these cortical areas in schizophrenics reveal impairments compared to controls (Barch & Csernansky, 2007; Fuentes & Santiago, 1999; Henseler, Falkai, & Gruber, 2009).
WM, according to Baddeley (1986), is a system that temporarily stores and manipulates new and old information simultaneously to aid one in a variety of cognitive tasks. In 1976, Baddeley and Hitch proposed the central executive, phonological loop, and visuo-spatial sketchpad as three necessary components to explain the role of short-term memory on cognitive processes. In 2000, Baddeley revised his WM model by adding a fourth element, the episodic buffer. He posited the episodic buffer to better explain the central executive’s role on WM and the retrieval of material from short and long-term memory (Baddeley, 2000).

The central executive is an attentional control system that integrates information from the phonological loop, visuospatial sketchpad, and episodic buffer. Baddeley argued this central hub is limited in its capacity. Unlike the other components, the central executive does not store information. Its primary function is to mediate goal directed behavior and inhibit irrelevant information (Engle & Conway, 1998; Gathercole & Baddeley, 1993). Brain-imaging research has identified the frontal cortex as being the most active part of the brain on a variety of central-executive tasks (Smith & Jonides, 1997). The phonological loop is part of the WM responsible for holding and rehearsing a limited number of acoustic and speech-based information for a short period of time (Baddeley, 1998). Brain-imaging studies have located this component to be active within the frontal, parietal, and the left temporal lobes of the cortex (Gazzaniga, Ivry, & Mangun, 2002; Henseler, Falkai, & Gruber, 2009; Schacter, 2001). The visuo-spatial sketchpad is the WM system responsible for the storage of spatial information and visual characteristics (Baddeley, 1998). Neuroscience research conducted on this portion of
WM has revealed stimuli with a strong visual component activates the posterior region of the cortex, the right hemisphere, and parietal region of the brain (Jonides et al., 1993; Smith & Jonides, 1997); in addition, regions of the frontal cortex are also active during visual and spatial tasks (Smith, 2000). The episodic buffer is an aspect of WM which allows one to interpret earlier experiences, plan future activities, and solve problems by integrating, temporally, information from the phonological loop, visuospatial sketchpad, and long term memory systems (Baddeley, 2000). Imaging studies have classified the medial temporal lobe (i.e., the hippocampus and surrounding cortical structures) as the region of the brain active while assessing this component of WM (Luck et al., 2010).

Neuroimaging studies have indicated deficits in the anatomical brain regions of the four WM components in schizophrenics’ and discrepancies during neurocognitive tasks assessing these components (Braff et al., 1991; Goldstein, 1990; Lee & Park, 2005; Heckers, 2001; Ranganath, Minzenberg, & Ragland, 2008). As they are integrated, deficits within central executive and the episodic buffer are connected to deficits in the other two WM systems. Henseler, Falkai, & Gruber (2009) using functional magnetic resonance imaging (fMRI) located areas of the brain active during phonological and visuospatial tasks. They found the cortical areas allocated during the spatial WM component differed significantly from controls (i.e., superior parietal, temporal, and occipital cortex), which may be useful in comprehending the deficits Myles-Worsely & Park (2002) observed in a non-imaging study of schizophrenics during a spatial task.

With regards to the phonological loop, Henseler, Falkai, & Gruber (2009) discovered when subjects were not allowed to use articulatory rehearsal (non-articulatory
rehearsal comprises of repeating something sub-vocally different between onset of stimuli and response; it is a distractor preventing rehearsal of information, which makes responding accurately more difficult), they displayed attenuations in active cortical regions compared to controls (i.e., fronto-opercular, intraparietal, anterior cingulate cortex, and hippocampus). The decreased regional activity observed may assist in understanding the deficits found in other non-imaging phonological studies of schizophrenics, as in Peterson & Peterson (1959). Conversely, when subjects were allowed to use articulatory rehearsal, the cortical regions active during this task mimicked controls. Such findings corroborate similar research (Oram, Geffen, Geffen, Kavanagh, & McGrath, 2005).

Schizophrenia, as postulated by Rado (1953), possesses an underlying schizophrenic phenotype present within the disorder before psychosis develops. This schizophrenic phenotype was referred to by Rado as schizotype: An aspect of one’s personality which develops from a schizophrenic genotype interacting with environmental factors. According to Rado’s model, individuals with this disorder suffer from an integrative pleasure deficiency which manifests itself symptomatically in the form of anhedonia, fearfulness, and disorganization.

Meehl (1962; 1990) elaborated on Rado’s model of schizotype and proposed schizophrenia has a genetic neural deficit. Individuals with this genotype, which Meehl termed schizotypy, possess schizotaxia: A set of schizotypal traits triggered by social factors. According to Meehl, these traits included cognitive slippage, anhedonia, interpersonal aversion, and ambivalence. Recent research on schizotypy has added to
these traits to include social withdrawal (Tyrka et al., 1995), flat affect (Chapman, Chapman, & Raulin, 1976), unusual sensory experiences (Lenzenweger & Korfine, 1992), magical ideation and referential thinking (Lenzenweger, 1999).

Research in the area of cognition on psychometrically identified schizotypic individuals has been incongruent. EF, a pertinent area within schizotypic research, contains conflicting results. Raine (2006) conducted a meta-analysis evaluating 254 schizotypic studies across many cognitive domains; one of the domains with an observed decline was EF. Other studies using measures designed to isolated EF, such as the Wisconsin Card Sorting Task (WCST; Heaton, 1981) and the Trail-Making Test (TMT; Reitan & Wolfson, 1985), have also revealed impairment within this population (Diforio, Walker, & Kestler, 2000; Poreh, Ross, & Whitman, 1995; Vogelmaier, Seidman, Salisbury, & McCarley, 1997). On the contrary, studies analyzing these same measures and population discovered no such impairments (Jahshan & Sergi, 2007; Lin, Chen, Yang, Hsiao, & Tien, 2000; Mitropoulou et al., 2002; Spitznagel & Suhr, 2002; Suhr, 1997).

In the area of attention, studies assessing schizotypes found consistent impairments. Lenzenweger (1991; 2001) and Bergida and Lenzenweger (2006) revealed significant results between psychometrically identified schizotypes and the Continuous Performance Task - identical pairs (CPT-IP). The results indicated deficits in sustained attention, the ability to discriminate between pairs of stimuli, production of random errors, and longer reaction times to target stimuli compared to control groups. Moreover,
Raine (2006) also found attention to be another area of cognition affected during his analysis of schizotypic studies.

Studies assessing WM of schizotypes have not shown unilateral deficits. Research pertaining to the spatial WM routinely found dysfunction in schizotypes compared to healthy controls. Spatial WM involves holding visuospatial information of a stimulus in the mind over a brief period of time. Park and McTigue (1997) found schizotypic individuals who had elevated scores on the Schizotypic Personality Questionnaire (SPQ) sub-scale social functioning were significantly impaired in spatial WM. Furthermore, these researchers found schizotypic subjects who scored high on the overall SPQ made more errors on spatial WM tasks compared to controls. Roitman et al. (2000) using a time delayed spatial task designed to stress the spatial WM of schizotypic subjects found similar results.

Research assessing verbal WM functioning of schizotypal participants has lacked systemic cohesion. Lenzenweger and Gold (2000) using the Perceptual Aberration Scale to psychometrically identify schizotypal subjects found no impairment in verbal WM within this population when they were tasked to recall a series of word lists consisting of thirty-eight words. Other studies have gone on to support these findings (Jahshan & Sergi, 2007; Mitropoulou et al., 2002). Vogelmaier, Seidman, Salisbury, & McCarley (1997), however, found those with schizotypal personality disorder (SPD) performed poorly on the California Verbal Learning Test (CLVT; Delis, Kramer, Kaplen, & Ober, 1987) compared to controls. During the recognition section of the test, these individuals made more commission errors and remembered fewer words.
The current study aims to use a divergent type of modality other than the previous psychometric measures of neurocognition to further determine cognitive impairments in individuals psychometrically identified as schizotypic via the Schizotypal Personality Questionnaire – Brief (SPQ-B; Raine and Benishay, 1995). Electroencephalography (EEG) measures the spontaneous circulatory signaling of neuronal activity by way of electrodes which are placed on the scalp. The signaling of neurons produces a galvanized response created by the excitatory and inhibitory post-synaptic activation resulting in a potential which can be electronically measured (Frodl-Bauch, Bottlender, & Hegerl, 1999). These electronically measured potentials provide objective information on how the disorder or disease present in the sampled population is affected while involved in a particular cognitive task.

Human EEG displays a voltage variation ranging from 1 to 150 Hz with amplitudes varying from 20 to 100 μV. Four types of waves exist within EEG, and each type of wave has its own personal signature measured in hertz (Hz). Alpha, beta, theta, and delta are names of the waves produces when using EEG. Alpha range lies between 8 to 13 Hz, and is observed during relaxed wakefulness while the eyes are closed. Its rhythm is attenuated by eye opening, sleep, drowsiness, attention to tasks, and mental effort. The height of its amplitude is seen at the posterior site; however, it may extend forward to the central and frontal sites depending on one’s health and state of consciousness. Beta ranges from 13 to 30 Hz, and its rhythm is most prominent in the frontal regions of the brain during wakefulness. Its activity increases during drowsiness and light sleep, and it replaces alpha when one opens their eyes or is mentally aroused.
Theta rhythmic waves range from 4 to 8 Hz. During a wakeful state, the wave is more pronounced in the posterior temporal regions. Similar to beta, theta’s activity occurs during drowsiness or light sleep. Lastly, delta has a frequency below 4 Hz and is the lowest frequencies recorded within EEG. The topography of delta activation lies around the posterior region of the head. This wave is recorded during deep sleep.

An EEG can be time locked to a stimulus with a defined epoch. Within this epoch voltage changes occur, and these changes in voltage are the direct result of neuronal processes via information processing (i.e., specific sensory, motor, and cognitive events; Donchin et al., 1984) more specifically, the depolarization of apical dendritic neuronal trees (Rockstroh, Elbert, Canavan, Lutzenberger, & Birbaumer, 1989). The changes in voltage during this process are referred to as event-related potentials (ERP). The averaging of time locked event-related potentials to a stimulus presentation across different electrode sites on the scalp provide objective information into cognitive processes (Cohen, 1991; Polich, 1991; Pritchard, 1986).

ERP studies analyzing schizotypic individuals assessing certain potentials found deficits in attention to an assigned task and an inability to inhibit irrelevant information. Evans, Grey, & Snowden (2007) studied the schizotypic population using the O-LIFE (Mason et al., 1995), and used an auditory dual click modality requiring them to attune to pairs of clicks. The study found individuals who scored high on the dimension of cognitive disorganization within the O-LIFE (Mason, Claridge, & Jackson, 1995) yielded weak P50 suppression (i.e., an inability to inhibit pre-attention processing; Näätänen, 1990), which was discussed as being synonymous with this certain schizophrenic
symptomology. Kiang & Kutas (2005) found greater activation of the N400 corresponded to one’s ability to inhibit irrelevant information when assessing concepts within semantic memory. They assessed the former wave using a word-pair modality in psychometrically identified schizotypic individuals who were assessed via the Schizotypal Personality Questionnaire (SPQ). Their study revealed that these individuals were impaired on a word-pair task where the subjects were given a category and asked to match a highly-related, low-related and non-related examples to which they displayed a decreased ability in activating this former wave. Thus, leading the researchers to conclude the population lacks the necessary cognitive factors contextually to alert related and inhibit non-related examples.

Latent within endogenous ERPs,’ which is helpful in interpreting cognitive processes, is the contingent negative variation wave (CNV). The CNV wave was first reported by Walter and colleagues (Walter, Copper, Aldridge, McCallum, & Winters, 1964) as a slow surface negativity wave, which depends on the contingency of two successive stimuli. First, a warning stimulus (S1) is presented as a preparatory signal then an imperative stimulus (S2) to which a somatic response is made follows. Between S1 and S2 there is a lull in wave amplitude. This lull was coined by Walter as contingent negative variation and it has two main parts. Using the standard CNV paradigm (S1-S2-motor response) the early wave created was termed the orienting wave (O wave) (Loveless and Stanford, 1973). This wave occurs in response to S1. The second part is the expectancy wave (E wave) (Walter et al., 1964). This wave occurs as one anticipates S2.
Each type of wave has a certain topographical dominant distribution corresponding to stimulus type (e.g., visual or auditory) and brain region. For instance, early CNV or O waves tend to be elevated, during visual tasks, along the central, parietal, and occipital regions of the brain (Simson, Vaughan, & Ritter, 1977); however, during auditory tasks O waves tend to be pronounced frontally (Denoth, Zappoli, Navona, & Ragazzone, 1984). Late CNV or E waves are centrally localized with reductions in the frontal and parietal regions (Tecce, 1972).

While researching the CNV wave, Walter et al. (1964) identified the CNV wave as being related to attentiveness. Further investigation by Hillyard and Galambos (1966) postulated that attention, preparatory set, and expectancy are contributory cognitive factors associated with the CNV. They determined these cognitive factors associated with the CNV wave contribute to the intention to respond and reaction time. Moreover, the findings also led the researchers to suggest the CNV wave to be “an electrical component of the attentional process, the function of which is to prepare the organism for reception and action” (Hillyard & Galambos, 1966 p. 303). Several other studies have indicated attention to be a necessary cognitive component latent within the CNV wave (Roth et al., 1979; Tecce, 1970; Tecce & Cole, 1976).

A plethora of CNV research has been conducted analyzing its amplitude in relation to psychopathology, particularly schizophrenia (Abraham, McCallum, & Gourlay, 1976; Callaway, 1970; McCallum & Walker, 1968; McCallum & Abraham, 1973; Rockstroh et al., 1994; Roth et al., 1979; Timsit-Berthier, Delaunoy, Konickx, & Rousseau, 1973; Van den Bosch, 1984; Wagner, Rendtorff, Kathmann, & Engel, 1996;
Pritchard, 1986; Simlai, Nizamie, & Khess, 2010). An apparent theme throughout the research points to an attenuation of the CNV, irrespective of illness severity; and has been viewed by some (Pritchard, 1986; Simlai, Nizamie, & Khess, 2010) as being a marker of the disorder. Although the CNV phenomenon is not fully understood, researchers tend to agree that attention deficits are related to the attenuation of the CNV.

The enigmatic nature of the CNV wave in relation to psychological processes makes it difficult to ascertain what cognitive functioning is related to its different wave types. Thus, researchers have only been able to suggest, through different ERP paradigms, the cognitive functions related to the CNV waves. The results of CNV research in schizophrenia vary across the topographical locations of the mid-line (i.e., Fz, Cz and Pz). The late CNV (lCNV) is a wave cropped prior to the onset of S2 and has been found to be attenuated in schizophrenics (Verleger et al., 1999). Researchers have contributed this part of the wave to be associated with preparation for movement required after S2 onset (Rohrbaugh, Syndulko, & Lindsley, 1976), anticipation of S2 (Van Boxtel & Brunia, 1994), WM (Honda et al., 1996; Ruchkin, Canoune, Johnson, & Ritter, 1995) and task effort (Van Boxtel & Brunia, 1994).

Research conducted by Verleger et al. (1999) found the CNV wave at the Cz lead to be attenuated amongst schizophrenics (i.e., inpatients compared to out-patients) and related this reduction to their inability to activate their movement preparation. Verleger’s study supports Rohrbaugh (1976) findings pertaining to the lCNV being related to preparation for movement required after S2 onset. Furthermore, Verleger’s findings suggest attenuations at this lead might be related to deficits in WM and sustained
attention. Wagner, Rendtroff, Kathmann, & Engel (1996) also found the Cz CNV lead to be reduced in relation to controls. By using a visual reaction timed test with an intermediate distractor, they were able to determine that schizophrenics had a marked reduction at this lead, and corroborate attention, working memory, and somatic preparation as functions of the Cz site and ICNV. Hillyard and Galambos (1966) further support the above CNV findings at the vertex being associated with attention.

The research has been varied regarding the CNV at the Fz site. Some research has reported a deficit in the ICNV at the Fz lead while others have found none (Van den Bosch, 1983; Verlerger et al., 1999). The findings reporting normalcy at the Fz CNV in schizophrenics goes against what one might expect as other modalities report deficits within the PFC and EF (i.e., using goal directed behavior to carry out the completion of a task via environmental information), and being related to processes that control task performances (Van Boxtel & Brunia, 1994). On the other hand, researchers who have found attenuations at the late Fz CNV lead have theorized a relationship to dopaminergic activity (Simlai, Nizamie, & Khess, 2010; Tecce, 1991) and an inability to compensate for their impairment (Verlerger et al., 1999). The latter finding is based off of a comparison between schizophrenic in-patients and out-patients. The research suggests that out-patients have the ability to compensate for their disorder whereas in-patients do not. The results point to level of severity in the disorder as contributing to Fz ICNV reduction.

The CNV at the Pz electrode site for schizophrenics compared to controls is consistent across studies. Simlai, Nizamie, & Khess (2010) administered an auditory
warning stimulus (S1) and a visual imperative stimulus (S2) to schizophrenics and controls and found significance in latency amplitude within ICNV Fz, Cz and Pz electrodes. Based on their finding, they also extrapolated the CNV to be a possible marker of the disorder. The above research on schizophrenia adds credence to past studies suggesting a reduction of the CNV as being a marker of the disorder. Wagner, Rendtroff, Kathmann, & Engel (1996) using a S1-S2 paradigm found a decrement in the ICNV lead at the Pz site as well. These results align with Simlai, Nizamie, & Khess (2010) and support the diminution of CNV at the Pz lead affecting anticipation of S2, WM activity, and effort invested in the task.

The Current Study

All of these studies concerning the CNV of schizophrenics have used specific paradigms (i.e., warning stimulus modality) to elicit cortical responses; therefore, this study will follow suit. The specific paradigm used in this study to analyze the difference between high and low schizotypes will be the AX-Continuous Performance Task (Wohlberg & Kornetsky, 1973). The AX-CPT, also known as an N-back task or the No/Go inhibitory task, is derived from the Continuous Performance Task (CPT) developed by Rosvold and colleagues (see Rosvold et al., 1956). During the AX-CPT subjects are instructed to respond to a target stimulus (X) which follows a cue stimulus (A). Deficits observed in CPTs performances have been related to issues with cognitive processing, specifically attention, executive functioning, and working memory (Brikett et al., 2007; MacDonald, Carter, Flory, Ferrell, & Manuck, 2007; Owen, McMillan, Laird, & Bullmore, 2005).
Schizotypy represents a continuum of symptoms and cognitive deficits of schizophrenia which have been documented using many paradigms. Lacking, are studies assessing these same deficits pertaining to schizotypy. The present research aims to fill in some of the gaps within the neurocognitive deficits associated with schizophrenia by analyzing ERPs’ produced from an AX paradigm and report if they affect those with schizotypy. Conducting research using an EEG component, such as ERP, allows for high temporal resolutions of cortical activity connected to stimuli to be captured instantaneously (Nunez et al., 1994). Applying this method to schizotypes could also prove to be advantageous in detecting neurocognitive abnormalities which resemble those seen in schizophrenia. Some studies have used ERP when looking for similar differences between populations along the schizophrenic spectrum and various ERP components (Cadenhead, Light, Geyer, & Braff, 2000; Kiang, Prugh, & Kutas, 2010; Kiang & Kutas, 2005; Klein, Anderson, Berg, Kruger, & Rochstroh, 1998), but few have studied schizotypy in relation to CNV amplitude at the mid-line corresponding with a CPT.

**Research Questions and Hypotheses**

This study will examine if there are significant differences between high and low schizotypes in executive functioning, attention, and working memory at the Fz, Cz and Pz leads corresponding to early and late CNVs respectively. The hypotheses are as follows: (a) the eCNV at the Fz lead of high schizotypes will have a reduced amplitude compared to low schizotypes; (b) the lCNV at the Fz lead of high schizotypes will have a reduced amplitude compared to low schizotypes; (c) the eCNV at the Cz lead of high schizotypes will have a reduced amplitude compared to low schizotypes; (d) the ICNV at the Cz lead
of high schizotypes will have a reduced amplitude compared to low schizotypes; (e) the eCNV at the Pz lead of high schizotypes will have a reduced amplitude compared to low schizotypes; and (f) the ICNV at the Pz lead of high schizotypes will have a reduced amplitude compared to low schizotypes.
Chapter II

Method

Participants

Subjects were acquired from California State University, Northridge Psychology Department. Using the 22-item Schizotypy Personality Questionnaire-Brief (Raine & Benishay, 1995), 1,200 undergraduate students were screened for schizotypy. Scores of 15 or higher and 0 to 1 made up the schizotypy and control group. Subjects were contacted via telephone to schedule participation times. The inclusion criteria were: right-handedness; no excessive use of drugs or alcohol; no current history of seizures, strokes or severe head injuries; or the presence of psoriasis or hair weaves; and no use of diet pills, pain killers, anti-anxiolytics, anti-depressants, anti-psychotics, and Benadryl. A total of 83 participants were assessed in the study and ask to refrain from alcohol and caffeine use 24 hours prior to their scheduled times. Furthermore, they were required to wash and dry their hair thoroughly prior to testing.

Schizotypal Measure

The Schizotypal Personality Questionnaire – Brief (SPQ-B; Raine & Benishay, 1995) is a paper based questionnaire consisting of 22 yes/no items and yields a score from 0 to 22. The SPQ-B yields an overall score and three sub-scales of schizotypy (Cognitive-Perception, Interpersonal, and Disorganized). Reliability of these sub-scales range from .72 to .80 with a mean of .76. Correlations between SPQ-B factors and SPQ (longer version) factors range from .89 to .94 (mean = .91).

Procedure
All data was collected in Monterey Hall. Upon arrival, participants were asked to read over an informed consent form. Once consent was obtained, they were re-screened to ensure they met the requirements of the study. If all criteria were met they were seated and electrodes were placed on designated areas of the head using the 10-20 method. The mid-line of the scalp was where the Fz, Cz, Pz, and Oz electrodes were secured. The ground electrode was placed in the middle of the forehead and reference electrodes were place on the earlobes. Vertical (VEOG) and horizontal (HEOG) electrodes were placed on the face, numbering four in all. Throughout electrode placement, impedance levels were monitored on all sites to ensure clinically acceptable ranges, which were below or at 15 kΩ. A Neuroscan amplifier and Neuroscan Acquire software 4.0 was used to collect the electroencephalography data.

Once the integrity of the electrodes had been established, participants were seated in front of a computer monitor and presented three different CPT’s ranging from 10-12 minutes each. Before testing ensues the lights were turned off and all distracting materials were eliminated from the testing area. The AX-CPT task, the focus of the present study, was the first of three tasks administered.

Neurocognitive Measure

There were three CPTs’ used in this study and they each ranged from 10 to 12 minutes. The AX-task (i.e., N-back task or Go/No task) was the first administered in the neurocognitive battery. The Happy/Happy task and the emotion recognition task followed the AX-task. During the Happy/Happy task participants were instructed to identify the
emotion happy displayed on a computer screen and if it was followed by another emotion of happy a somatic response was required. The emotion recognition task consisted of the participants identifying the emotion displayed on the computer screen and verbally stating what emotion they perceived. Before the AX-task was administered participants were instructed, verbally, to keep their vision fixed on the computer screen in front of them and to keep their blinking to a minimum. During this task participants were told to push the button located under their right hand when they see the letter A followed by the letter X. When they see the letter A not followed by the letter X, they were instructed not to push. A pretest phase was administered to ensure the participants understand the requirements of the task and to validate that the instrumentation continues meeting all the necessary clinically acceptable levels. Once the pretest phase was completed, participants were instructed the task was about to commence after a 5 second countdown was presented to them on the computer monitor. When the task began, the participants visually attended to 80 non-AX (subjects see the letter A 80 times) and the AX combination 40 times. Once the task was completed, instructions were administered for the next modality in the study.

**Statistical Analysis**

Independent samples t-tests were used to assess differences between high and low schizotypes in attention, working memory, and executive functioning via the eCNV and lCNV at the Fz, Pz, and Cz leads. The sample size (N = 83) consisted of 29 high schizotypes and 54 low schizotypes. After screening for outliers and pruning two participants from the subject group and four from the control group (n scores were converted to z scores and participants revealing scores quantitatively above/below ± 1.96
were pruned), the statistical analysis was repeated on the adjusted population. In all, 6 individual \( t \)-test (one-tailed) were ran to assess the quantitative differences between high and low schizotypes at a \( p \)-value of .05 with a Bonferroni correction (.05/6 = .008).

### Table 1

*Sample \( t \)-test Table*

<table>
<thead>
<tr>
<th>Leads/eCNV</th>
<th>High Schizotypes</th>
<th>Low Schizotypes</th>
<th>( t )-test (one-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fz</td>
<td>-5.39</td>
<td>2.06</td>
<td>-5.59</td>
</tr>
<tr>
<td>Cz</td>
<td>-6.90</td>
<td>2.13</td>
<td>-7.17</td>
</tr>
<tr>
<td>Pz</td>
<td>-4.92</td>
<td>2.07</td>
<td>-6.10</td>
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<thead>
<tr>
<th>Leads/ICNV</th>
<th>High Schizotypes</th>
<th>Low Schizotypes</th>
<th>( t )-test (one-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fz</td>
<td>-4.62</td>
<td>2.27</td>
<td>-4.77</td>
</tr>
<tr>
<td>Cz</td>
<td>-7.34</td>
<td>2.76</td>
<td>-7.33</td>
</tr>
<tr>
<td>Pz</td>
<td>-7.02</td>
<td>2.16</td>
<td>-6.74</td>
</tr>
</tbody>
</table>

**\( p \) < .008**

*Table 1: Sample Descriptive Using \( t \)-test for Equality of Means.*
Figure 1: estimated means for the Fz, Cz, and Pz leads at the eCNV and ICNV wave amplitude. The eCNV was evaluated at the most negative point after 700ms and the ICNV at the most negative point around 1100ms. Significance was found at the Pz eCNV lead.
Chapter III

Results

High schizotypes evidenced a reduced eCNV at the Pz site compared to that of the low
schizotypes, \( t(75) = 2.51, p = .007 \) (one-tailed), \( d = .56 \). This group difference holds when
a Bonferroni correction for the 6 \( t \)-tests was performed at a \( p \)-value of .008. The five
other \( t \)-tests comparing the CNVs of high and low schizotypes did not find differences
(eCNV Fz, \( t(79) = .401, p = .344, d = .09 \); eCNV Cz, \( t(79) = .482, p = .315, d = .11 \);
lCNV Pz, \( t(76) = -.514, p = -.304, d = .12 \); lCNV Fz, \( t(78) = .290, p = .386, d = .06 \);
lCNV Cz, \( t(78) = -.023, p = .491, d = .00 \)). Table 1 displays the sample descriptive using
a \( t \)-test assessing mean differences. Figures 1 show the mean differences between high
and low schizotypes cortically.
Chapter IV
Discussion

High schizotypes produced reduced cortical amplitudes compared to low schizotypes at the eCNV Pz lead (see Figure 1). The significant variability between groups alludes to their deficits in attention at the parietal lead affecting spatial function and retention of objects topographically; this bolsters research conducted on previous schizophrenic and schizotypic populations related to this schema (Park & McTigue, 1997; Roitman et al., 2000; Park & Lee, 2002; Mazhari et al., 2010; Simlai, Nizamie, & Khess, 2010; Wagner, Rendtroff, Kathmann, & Engel, 1996). Moreover, the significant result also supports past schizophrenic research concerning spatial encoding issues related to attentional atrophy hampering their ability to make sound spatial judgements (Park & Lee, 2002; Mazhari et al., 2010; Simlai, Nizamie, & Khess, 2010; Wagner, Rendtroff, Kathmann, & Engel, 1996) which potentially affects their social and occupational functioning. This study also points to dysfunctions in the posterior attention network (PAN; Fernandez-Duque & Johnson, 1999) and the visuo-spatial sketchpad (Baddeley, 1998) of schizotypes and falls in line with research that found these networks impaired in schizophrenics (Barch & Csernansky, 2007; Fuentes & Santiago, 1999; Henseler, Falkai, & Gruber, 2009).

The current study did not reveal a working memory or executive functioning deficit of high schizotypes which was likely due to the task not stressing spatial working memory; this was revealed when there was no observed deficit at the ICNV Pz lead. The schizotypal participants did not allow their early orientation impairment to affect their ability to complete the task. This effect was possibly due to the AX-task not straining the spatial attention of the schizotypal participants by requiring them track the topographical
location of stimuli and accurately responding to the given task requirements somatically. Moreover, the non-significance at ICNV Pz lead could also be understood as schizotypy being low on the spectrum and not exhibiting elevated symptomology associated with schizophrenia that systemically affects their cognition. The non-significance this study produced from the schizotypic population also parallels prior research findings indicating executive functioning is not affected within this population (Jahshan & Sergi, 2007; Lin, Chen, Yang, Hsiao, & Tien, 2000; Mitropoulou et al., 2002; Spitznagel & Suhr, 2002; Suhr, 1997; Lenzenweger & Gold, 2000).

Several implications can be drawn from the present study. The group differences observed at the eCNV Pz lead suggests parietal site eCNV attenuation and its phenotype dysfunction as being a marker of schizophrenia and high schizotypes. The findings are consistent with the marked cognitive difference between schizotypy and schizophrenia (e.g. schizophrenic cognitive deficits are systemic and severe whereas schizotypes are not). The results of this study point to the cognition associated with the parietal lobe as being impaired. The identification of cognitive deficits within schizotypes has pertinent implications on schizophrenics, due to schizotypes being on the spectrum. Significant results at the eCNV Pz lead obtained from this clinical neurocognitive study elucidates where the spatial impairment of high schizotypes resides and complies with the NIMH initiative to validate neurocognitive lesions in schizophrenia to help improve cognitive research in this area of study. The present study falls in line with Mazhari et al. (2010) in conducting more cognitive clinical research to better Cognitive Neuroscience Treatment Research to Improve Cognition in Schizophrenia (CNTRICS), and helps to explain where
in their spatial working memory study on schizophrenics the early processing deficit resides.

The population of study was unique in several ways. First, they were psychometrically identified schizotypes. Second, they were college students. This in itself points to the cognitive differences between schizotypes and schizophrenics, and the roles plasticity and resiliency might play in pathology. Moreover, it reveals this study’s limitations on acquiring the true parameters of the schizotypal population. Future research should focus on acquiring the schizotypal population within the community along with those in the university setting and determine if the observed effect can be replicated using the AX-paradigm within an EEG study.
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