FACIAL AFFECT RECOGNITION AND EYE MOVEMENTS IN SCHIZOTYPAL COLLEGE STUDENTS

THESIS

Presented to the Graduate Council of
Texas State University-San Marcos
in Partial Fulfillment
of the Requirements

for the Degree

Master of ARTS

by

Shiho Tsutsui, B.S., B.A.

San Marcos, Texas
August 2010

COPYRIGHT

by

Shiho Tsutsui

2010

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my entire committee, Dr. Reiko Graham, Dr. Oleg Komogortsev, and Dr. Roque Mendez, for their assistance with the completion of this body of work. Special thanks to Dr. Reiko Graham for her tireless effort and support during the whole process of this thesis. Special thanks to Dr.Oleg Komogortsev for his technical expertise in the collection and analysis of the eye-tracker data. In addition, I am grateful to Mr. Zanxun Dai for his assistance with data analysis. Without their careful attention to detail and their assistance, this research could not have been completed. Thank you very much.

This manuscript was submitted on June 18, 2010.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

ABSTRACT

FACIAL AFFECT RECOGNITION AND EYE MOVEMENTS

IN SCHIZOTYPAL COLLEGE STUDENTS

by

Shiho Tsutsui, B.S., B.A.

San Marcos, Texas
August 2010

SUPERVISIING PROFESSOR: REIKO GRAHAM

Schizophrenia is a severe, chronic, and complex mental disorder that causes great damage to an individual's emotions and to his or her social life adjustment. The long-term goal of the current study was to contribute to the understanding of emotional face processing in schizophrenia in order to improve social functioning. The main objective was to examine the role of schizotypal symptoms in the ability to recognize the complex emotions as well as basic emotions. Simultaneously, eye-gaze movements were examined during the

recognition of basic and complex emotional facial expressions. The current study revealed three main findings: relative to individuals low in schizotypal characteristics, schizotypal individuals were significantly less accurate on the complex emotion recognition task, particularly in the recognition of positive emotions; there was a positive relationship between emotion recognition accuracy and total fixation duration across all participants; and schizotypal individuals tended to have more initial fixations to the left stimulus field relative to the low schizotypy group.

The current study has important implications for better understanding of emotion recognition in schizotypy as a feature of the schizophrenic spectrum. Also, the current study provided suggestions for further study to develop knowledge in schizotypy using a combination of eye-tracker and emotion recognition tasks. Characterizing eye movement abnormalities in schizotypy and their relationship to emotional face processing deficits may contribute to the ability of facial affect recognition through the development of training programs that introduce strategies for visual scanning to improve facial affect recognition and social effectiveness.

CHAPTER I

INTRODUCTION

Schizophrenia

Schizophrenia is a severe and chronic mental disease that afflicts about one percent of the world's population. The financial burden of schizophrenia on society is enormous. It exceeds that of the cost of all cancers in the United States (Thaker & Carpenter, 2001). Schizophrenia is characterized mainly by three categories of symptoms: positive, negative, and cognitive symptoms (Lang, Puls, Muller, Strutz-Seebohm, & Gallinat, 2007). Positive symptoms are those that appear to reflect an excess or distortion of normal functions, including hallucinations, thought disorders, and delusions. Many patients with schizophrenia have delusions of persecution, which are irrational, yet unshakable, mistaken beliefs that someone is plotting against them. On the other hand, the negative symptoms appear to reflect a decrease or loss of normal functions. Some of these are lack of emotion and interest in life, social withdrawal, and anhedonia—an inability to experience pleasure. Cognitive symptoms are closely related to negative symptoms, which may be produced by abnormalities in the same regions of the brain (Lang et al., 2007). Cognitive symptoms include lack of attention, poor working memory and executive functions, and low psychomotor speed.

Importance of Study of Emotion in Schizophrenia

Emotional processing in schizophrenia is often impaired. For example, patients with schizophrenia exhibit deficits in facial affect recognition, which is a basic requirements for social interaction and communication (Sass, 2007). Mueser et al. (1996) provided evidence that the deficits in emotion recognition are related to poorer social competence. Moreover, research by Kee, Gree, Mintz, and Brekke (2003) found a correlation between the ability to recognize emotions and psychosocial functions, which include work function and independent living. Thus, the ability to judge others' facial affects is an important skill in maintaining healthy social relationships.

In many cases, patients with schizophrenia isolate themselves from society, which in turn, places a burden on their families. For patients with schizophrenia, bonding and human relationships have a big impact on the course of social outcomes as well as prognosis of the disease. Therefore, an understanding of the factors that affect emotion perception are an important first step in providing better social outcomes for patients with schizophrenia (Kee, Kern, & Green, 1998). Thus, many researchers study emotion with schizophrenia, which in turn, contributes to the improvement of patients' ability to adapt to social life.

Deficit of Emotion in Schizophrenia

Patients with schizophrenia suffer from deficits of emotion in various aspects. With regard to facial expression, patients with schizophrenia often show flat and inadequate expression. To examine the facial expressions of patients with schizophrenia, there are two main types of measurement. One is to simply observe visible facial expression of patients with schizophrenia. The other is to measure physical activation of facial muscles that are related with facial emotional expressions.

Tremeau et al. (2005) studied facial expressive behaviors related to affective deficits in patients with schizophrenia by simply observing their expressions. Three tests were administered to examine the difference between emotional expressions of patients with schizophrenia and healthy non-patients. The first test asked participants to talk about events in their past that were related to a particular emotion such as anger, disgust, fear, sadness, or surprise. While participants discussed past events, Tremeau et al. (2005) looked at their overt facial expressions and counted the number of times that the participants expressed the specific emotion. They also counted the number of facial coverbal gestures, which involve hands, head, and face movements that are tied to their speech. The frequencies of both facial expression and coverbal gestures in patients with schizophrenia were significantly fewer than those in the control group, especially smiles. Therefore, patients with schizophrenia were less likely express emotion facially even when talking about an emotional story.

The second and third tests examined deliberately posed facial expressions. Tremeau et al. (2005) showed participants various facial expression pictures and asked them to imitate these expressions. Also, the participants were required to simply express anger, disgust, fear, happiness, sadness, and surprise on their faces. As observed often in clinical situations, patients with schizophrenia showed irregularities in expressing for both tasks compared to the control group. In other words, patients with schizophrenia had difficulty making deliberate emotion expressions. Their study revealed that both deliberate and spontaneous facial expressions were impaired in patients with schizophrenia relative to the control group. From these results, Tremeau et al. (2005) suggested that patients with schizophrenia are more likely to have fewer emotional expressions, which could cause a major negative symptom of schizophrenia, flat emotion.

As described previously, there are at least two possible measurements for examining facial expression: simply observing facial expressions and measuring activation level of facial muscles that are related to emotional expressions. Electromyography (EMG) is often applied to study subtle muscle activity. EMG techniques provide a precise measurement of muscle activity by isolating the facial muscle which targeted for measurements. For instance, there are three main joy-relevant facial muscles: the M. zygomaticus, the M. orbicularis oculi, and the M. levator labii (Wolf, Mass, Kiefer, Wiedemann, & Naber, 2006). Depending on the types of smile on the face, people show different activity levels in these three muscles. Wolf et al. (2006) examined EMG during smiles in patients with schizophrenia. Emotional states and facial expressions were induced in patients with schizophrenia by showing them emotional pictures from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005), a set of emotionally-valenced pictures that have been normed for various emotional elements, such as pleasure, arousal, and dominance. Interestingly, the activations of these muscles in response to the emotional pictures were not different between patients with schizophrenia and healthy non-patient groups. Thus, according to Wolf et al.'s (2006) study, it could be said that although patients with schizophrenia express fewer facial expressions of emotion, this is not due to physical dysfunctions of their facial muscles.

Kring et al. (1999) also applied EMG to examine facial reactions in patients with schizophrenia. While patients were shown facial expressions, Kring et al. (1999) assessed two muscles: M. zygomaticus, related with positive facial expressions, such as smiling, and M. corrugator, associated with negative facial expressions, such as frowning. Their results suggested that patients with schizophrenia exhibited M. zygomatic reactivity in response to pictures of positive facial expressions and M. corrugator reactivity in response to picture of negative expressions. This result was consistent with Dimberg's (1982) study that examined EMG activity in these two muscle groups with a healthy population. Participants showed activation of M. zygomaticus when watching a happy film and discussing pleasant events, and they also showed activation of M. corrugator when watching a sad film and discussing sad events. Kring et al. (1999) suggested that both patients with schizophrenia and healthy controls showed the same muscle activation patterns even though patients with schizophrenia showed less facial emotion expression on their faces. Therefore, Kring and colleagues' (1999) study provided further evidence that patients with schizophrenia respond facially to emotional stimuli in a manner consistent with their valence. In other words, they did produce differential responses depending upon whether they were viewing positive or negative facial expressions.

Based on these studies, it is assumed that patients with schizophrenia do not have a physical dysfunction in producing facial emotional expressions. Moreover, their facial muscles, which are necessary for emotional expression, are able to respond the same way as healthy people despite the overall lack of emotional expression in patients. Therefore, the impaired facial affect expression in schizophrenia may be caused by psychological deficits in processing of facial expression rather than a physical dysfunction of their facial muscles.

With regard to the emotion recognition of patients with schizophrenia, their impairments in emotion recognition are manifested in various ways (Kucharska-Pietura et al., 2005; Pijnenborg et al., 2007). Kucharska-Pietura et al. (2005) studied facial and vocal emotion recognition in patients with schizophrenia at different stage of the illness: patients in remission, first-episode patients, and chronic patients. They employed the Facial Emotion Recognition Test and the Benton Facial Recognition Test (BFRT; Benton, 1983) for investigating the ability to recognize emotions from facial expressions. In addition, the Voice Emotion Recognition Test (VERT; Kucharska-Pietura et al., 2003) was employed for studying emotion recognition in the auditory modality (i.e., prosodic vocal expression of emotion). Emotional prosody refers to "information conveyed by pitch, amplitude, and duration contours of speech, which informs about a speaker's emotional state" (Pijnenborg et al., 2007, p.763). In the VERT, participants were asked to listen to semantically neutral sentences. Although the sentences were semantically neutral, the spoken voices conveyed prosodic information corresponding to six basic emotions: happiness, sadness, fear, anger, surprise and disgust. Participants were asked which of the six emotional states best described the speaker's tone of voice. Kucharska-Pietura et al. (2005) found that the accuracy of emotion recognition for the two sensory modalities, vision and audition, in schizophrenia with at all stages of the illness were significantly more impaired than a healthy control group. Pijnenborg, Withaar, Bosch, and Brouwer (2007) also found that patients with schizophrenia had a deficit in the perception of emotional prosody. In the emotional prosody perception task, patients listened to the sentences with emotionally neutral content which were pronounced with neutral and five different emotions, fear, sadness, anger, surprise, and happiness. Their results were consistent with findings from Kucharska-Pietura's (2005) study with regard to deficits in emotion recognition through the auditory modality in schizophrenia.

Deficit of Facial Affect Recognition in Schizophrenia

Deficits in emotion recognition are prominent symptoms of schizophrenia. More specifically, several studies have shown that deficits in facial affect recognition are a unique psychiatric feature of schizophrenia. Gaebel and Wölwer (1992) conducted a longitudinal study of facial affect recognition focusing on acute patients with schizophrenia. Patients were shown pictures of faces expressing six basic emotions (happiness, sadness, surprise, fear, disgust, and anger) and were asked to choose an appropriate emotion of each expression from a list of choices. Four weeks after from the first assessment, patients with schizophrenia were re-assessed with the same test. The results revealed that patients with schizophrenia showed a recognition disturbance that remained stable over time. Thus, Gaebel et al. (1992) suggested that the disturbances of facial affect recognition are more likely to be specifically linked to schizophrenia, a trait-like character, and not dependent on stage of the illness.

In addition, Wolwer, Streit, Polzer, and Gaebel, (1996) conducted an individual longitudinal comparison study. Patients with schizophrenia were categorized into remitted and acute patients. Acute patients were assessed for facial affect recognition before and after 4 weeks of neuroleptic treatment. Remitted patients were also assessed for facial affect recognition twice within 12 weeks. Results revealed that the disruption of facial affect recognition in both groups of patients remained stable across the assessment period regardless of treatment type. This study confirmed the previous finding that the deficits of facial affect recognition are specifically linked to schizophrenia (Gaebel et al., 1992). Gaebel et al. (1992) and Wolwer et al. (1996) proposed that impaired emotion recognition is a trait-like character for schizophrenia because it persists throughout the course of the illness.

Schneider et al. (2006) suggested that patients with schizophrenia have a specific impairment in facial emotion discrimination rather than a general face processing deficit. They compared emotion discrimination performance with that on a non-emotional face processing task (age discrimination) to examine whether the inability to recognize facial expressions observed in schizophrenia reflects a specific deficit in processing the emotional facets of the face. Therefore, in addition to the Facial Emotions for Brain Activation Test (FEBA; Gur, et al., 2002), which measures facial expression recognition, Schneider et al. (2006) applied an age-discrimination task to measure the recognition ability to process non-emotional facial information. In the FEBA test, participants were asked to judge the displayed emotion as well as the level of intensity of each picture. In the age-discrimination task, participants were presented various pictures of faces and were required to answer whether the presented face was older or younger than 30 years. Consistent with previous studies, Schneider et al. (2006) found varying levels of impairment in the identification of emotional facial expressions in patients with schizophrenia compared to control group. Meanwhile, there was not a significant difference between the patients with schizophrenia and the control group in terms of processing recognition of non-emotional features of the face. Patients with schizophrenia had no deficits in judging age even though the task for discriminating age was thought to be more difficult than the task for identifying emotion. Schneider et al.'s (2006) results indicate that in spite of having intact non-emotional recognition, the patients with schizophrenia were not able to recognize emotional stimuli correctly. Thus, the deficits of emotion in patients with schizophrenia may be limited to emotion affect recognition.

While studies which focus on deficits in emotion recognition in patients with schizophrenia are widely represented, the interpretations of the deficits are often different. For example, an impaired ability to recognize facial affect is reported consistently, but there are conflicting results regarding the specificity of the facial emotion processing deficits in schizophrenia with respect to different facial expressions. Overall, poor facial affect recognition in schizophrenia has been reported for positive emotions, including happiness and surprise, as well as negative emotions, including sadness and fear (Schneider et al., 1995). However, some researchers found recognition deficits only for negative emotions (e.g., Edwards, Pattison, Jackson, & Wales, 2001; sadness and fear), while others suggest that it is specific to positive emotions (e.g., Waldeck & Miller, 2000, happiness and surprise). In addition, a number of studies have provided evidence of a general impairment of facial affect recognition across the range of basic expressions such as happiness, sadness, fear, anger, disgust and surprise, (Gaebel et al., 1992; Kucharska-Pietura et al., 2005; Salem, Kring, & Kerr, 1996; Schneider et al., 2006; Shean et al., 2007; Wolwer et al., 1995). In contrast, other studies suggest that the deficits do not exist for basic emotional states but for complex mental states, such as arrogance, flirtation, boredom, and admiration (Kington, Jones, Watt, Hopkin, & Williams, 2000).

One potential reason for these inconsistencies is that the expression recognition tasks employed in these studies were relatively easy, giving rise to ceiling effects that prevented the detection of subtle expression processing deficits. If deficits of facial affect recognition are subtle, basic emotion recognition tests might not enough sensitive to detect these deficits. In other words, the deficits may be obscured by the ceiling effects. Therefore, current study sought to increase the level of difficulty of the facial affect recognition task by using the revised adult Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al., 2001) as well as Facial Affect Recognition test (FAR). The RMET consists of eye region pictures which depict complex emotional states (e.g., accusing, contemplative, and arrogant) and has developed to be sensitive to subtle cognitive dysfunction (Baron-Cohen et al., 2001). The FAR consists of pictures of basic emotions selected from Ekman and Friesen's Pictures of Facial Affect (Ekman & Friesen, 1975). Moreover, with these tests, current study also examined the recognition of positive and negative emotions in order to examine the specificity of emotion recognition deficits.

Recognition of Emotion and Eye Movement in Schizophrenia

One of the methods to investigate the eye movements during visual scanning is the use of an eye-tracker, which allows investigators to record the pattern of the eye movements such as visual scan pattern and eye fixation. Evidence from neurocognitive research brings up the importance of visual scanning during emotion perception in schizophrenia (Kee et al., 1998). A visual scan pattern can be observed when people process a complex stimulus, and it provides a direct, objective, and real-time measure of eye movements (Noton & Stark, 1971). The data about eye fixations provide detailed information about how individuals scan visual stimuli, which may yield insights into deficits like emotion recognition in schizophrenia. For example, researchers can investigate visuo-spatial processes by temporal parameters, including median fixation duration, total fixation duration, total number of fixations, and spatial parameters, including median saccade amplitudes, raw scan path length, and fixation scan path length (Williams et al., 1999).

A number of studies have indicated that patients with schizophrenia have abnormal visual scan patterns to various visual stimuli (Mialet & Pichot, 1980; Nummenmaa, Hyona, & Calvo, 2006; Williams et al., 2003). Impairment of smooth eye tracking in schizophrenia has been proposed as one of the psychobiological markers for schizophrenia (Clementz & Sweeney, 1990; Holzman et al., 1974; Sweeney et al., 1994). Sweeney et al. (1994) investigated pursuit eye movements when patients with schizophrenia were required to keep their eyes on a target which was oscillating slowly. "The primary function of pursuit eye movements is to match the angular velocity of the eyes to that of slowly moving objects. The accuracy of this velocity match, reflected in the ratio of average pursuit velocity over target velocity, is referred to as the gain of pursuit eye movements" (Sweeney et al., 1994, p. 224). Their result revealed abnormal low pursuit gain in schizophrenia. Sweeney et al. (1994) suggested that disturbances in brain functioning may disrupt their eye movements which in turn, may result in scanning deficits for emotional faces and impaired recognition.

In addition to the smooth pursuit abnormalities, an abnormality of saccadic eye movements is also suggested as a biological maker in schizophrenia (Kallimani et al., 2009). Research by Karoumi, Ventre-Dominey, Vighetto, Dalery, and d'Amato (1998) investigated the nature of saccadic abnormalities in schizophrenia. They studied three different forms of saccades including the visually guided saccade, the antisaccade, and the remembered saccade. To test the visually guided saccades, participants were required to look at the illuminated target as quickly as possible when the signal of central point offset and a tone were presented. In contrast, for assessing the antisaccades, participants were required not to look at the illuminated target but to look at in the mirror position opposite to the illuminated target when signal was presented. To assess the remembered saccades, the illuminated target presented in 1.5 seconds while participants were asked to focus on the fixation point. After the illuminated target disappeared, the cue signal occurred. The participants were required to look at the remembered location of the previous illuminated target as quickly as possible.

The results showed deficits in the antisaccade and remembered saccade tasks in schizophrenia group. Compared to control group, patients with schizophrenia showed increases in the number of errors, increased latency to make an eye-movement, and reduced gain of pursuit eye movements. Karoumi et al. (1998) suggested that patients with schizophrenia are impaired in inhibiting reflexive saccades to visual targets and in initiating correct voluntary saccades, which may be related to abnormalities in prefrontal cortex associated with schizophrenia.

Kojima et al. (1992) examined eye movement in patients with schizophrenia during viewing of geometric figures. The patients demonstrated fewer frequent eye fixations and a more narrow area of inspection than the control group. Kojima et al. (1992) also examined correlations between eye movements to the geometric stimuli and neuropsychological tests. The Responsive Search Score (RSS) is an eye movement parameter that represents patterns of extended visual scanning. Kojima et al. (1992) found that the RSS was correlated with neuropsychological subtests which were purportedly sensitive to deficits in the posterior part of the right hemisphere, and right frontal lobe. These results suggested that the abnormality of eye movements in schizophrenia might reflect neurocognitive dysfunction in the right hemisphere.

Manor et al. (1999) provided evidence that initial eye movements in patients with schizophrenia showed right-spatial hemi-neglect using the Rey Complex Geometric Figure task (Rey, 1942). They recorded the eye movements while patients with schizophrenia freely viewed the Rey Complex Geometric Figures. The Rey figure is line drawing comprising geometric elements in a complex pattern and originally developed to measure visual memory and perceptual organization (Rey, 1942). It has been reported that the Rey figure initially attracts visual attention to the right field of the stimulus in the majority of people because of a circle feature in the right area of the Rey figure (Manor, Gordon, & Touyz, 1995). However, Manor et al. (1999) found that patients with schizophrenia were less likely to make their first fixation in the right field of the Rey figure stimulus relative to a control group whose initial fixations were consistent with the predictions of Manor et al. (1995). Manor et al. (1999) suggested that the first visual fixation of patients with schizophrenia would be more likely to be located in the left field of the stimulus, possibly mediated by right hemisphere hypofunction.

Streit, Wölwer, and Gaebel (1997) explored eye movements and facial affect recognition simultaneously in patients who were hospitalized with first-episode or chronic schizophrenia. Assessments were conducted twice; the first assessment was within 3 days of admission, and the second was 4 weeks later. The participants were presented a set of pictures of facial affect, which contained the six basic emotions: fear, anger, disgust, happiness, sadness, and surprise. Each face was presented for 8 seconds, and participants were asked to select the appropriate emotion from a list beside the face. During the 8 seconds exposure period, participants' visual scanning behavior was monitored by an infrared-corneal-reflection technique. The basic eye movement parameters, including mean duration of fixation and mean saccade amplitude (distance between two successive fixations), were analyzed. Emotion recognition results from both phases showed that patients with schizophrenia had significant deficits in terms of behavioral accuracy of facial affect recognition. Streit et al. (1997) also found abnormalities of visuomotor behavior in schizophrenia. The mean scan paths of the schizophrenic group were shorter and mean duration of fixations were longer than that of control group. In other words, patients with schizophrenia had narrowed and restricted visual scanning behavior. Furthermore, Streit et al. (1997) revealed that impaired performance of facial affect recognition and eye movement abnormalities remained stable over time and across phases of the illness. These results support the suggestion that these disturbances in schizophrenia might be a trait-like character rather than state-dependent characteristic.

Loughland et al. (2002) provided additional evidence that the restricted scan path described above is trait-like disturbance in schizophrenia. Eye movements of patients with schizophrenia and with affective disorders, including bipolar disorder and major depression, were examined while patients performed a facial affect recognition task. Consistent with previous studies, only patients with schizophrenia showed significant deficits of facial affect recognition. With regard to eye movements, the scan path disturbance was reported in only patients with schizophrenia. Compared to the healthy control and affective disorders groups, the visual scanning to face stimuli of patients with schizophrenia exhibited a more restricted scan path, which was characterized by fewer fixations, longer fixation durations, and saccades of smaller amplitudes. Based on these findings, Loughland et al. (2002) suggested that abnormalities of eye movements, such as the restricted scan path, are more likely to specific to patients with schizophrenia.

A number of experimental studies have demonstrated eye movement abnormalities in schizophrenia, which in turn, may lead to impaired facial affect recognition. Given that deficits of facial expression in schizophrenia are mediated by disturbed facial affect recognition which may be caused by impaired eye movements, improvement of eye movements may lead to more accurate expression recognition ability, which in turn, may lead to more appropriate expression of facial affect (Figure 1). Therefore, the current study examined the relationship between accuracy of emotion recognition and eye movements parameters. Since eye movement abnormalities are one of the potential factors behind the deficits of facial affect recognition, finding the significant feature of their eye movement abnormalities may contribute their social rehabilitation, allowing for training strategies to improve their visual scanning and the ability to decode facial expression in real social situations. From this point of view, the importance of research focusing on eye movements in schizophrenia is emphasized.

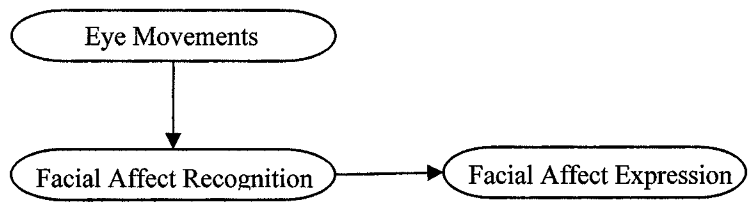

Figure 1. A possible facial emotion model.

Schizotypy in the Healthy Population

Meehl (1962, 1990) proposed a continuity model of schizotaxia, schizotypy, and schizophrenia. Schizotaxia is a genetic and neurophysiological defect which plays an important factor for development of schizophrenia (Meehl, 1962, 1990). Under normal conditions, some of individuals with schizotaxia develop schizotypy, which refer to as "the predisposition to schizophrenia at the level of the organization of the personality" (Vollema & Bosch, 1995, p.19). While schizotypy is considered part of the normal spectrum of personality in the healthy population, all schizotypal individuals display some evidence of schizophrenia-like characteristics in the form of aberrant psychobiological or psychological functioning (Jarrett, Phillips, Parker, & Senior, 2002; Lenzenweger, 2006). Although schizotypal individuals show various schizophrenia-like impairments such as affect recognition (Poreh et al., 1994; Williams, Henry, & Green, 2007), eye-tracking dysfunctions (Lencz et al., 1993), sustained attention deficits, psychomotor impairment (Jarrett et al., 2002), subtle thought disorder (Meyer & Shean, 2006), and excessive interpersonal fear (Berenbaum et al., 2006), not all schizotypal individuals develop diagnosable schizophrenia (Lenzenweger, 2006). In extraordinary environments, such as during negative emotional experiences, a small group of these schizotypal individuals may develop schizophrenia (Vollema & Bosch, 1995). Because of this, schizotypy is considered to be a marker of the predisposition to develop schizophrenia (Lenzenweger, 2002).

Resulting from Meehl's (1962, 1990) description of schizotypal signs, many self-report instruments for schizotypy have been developed, such as Magical Ideation Scale (MIS; Eckblad & Chapman, 1983), Schizotypal Personality Scale (SPS; Claridge & Brokes, 1984), and Schizotypal Personality Questionnaire (SPQ; Raine, 1991). These instruments have advantages, such as ease of administration, low cost, objectivity, and standardization (Vollema & Bosch, 1995). Therefore, in recent research, these schizotypy scales are often used to screen schizotypal individuals from healthy populations for studying the causal and underlying mechanisms of schizophrenia.

Many researchers study schizotypy rather than schizophrenia because there are advantages to employing schizotypal individuals in studying nature of the illness. According to Williams et al. (2003), facial emotion perception in patients with schizophrenia presents itself differently depending on antipsychotic medication. In addition, if patients with schizophrenia have been chronically ill, it is difficult to distinguish specific deficits in emotion perception from the general tendency to perform poorly. In contrast, schizotypal individuals usually have not been prescribed antipsychotic medication and as they are assumed to be of the healthy population, the potential confounds such as disease duration are not a factor. As such, researchers are able to eliminate or control possible confounding psychiatric factors of schizophrenia, including diagnostic criteria, duration of institutionalization, chronicity, and medication status (Poreh, Whitman, Weber, & Ross, 1994).

A number of studies, which employed various schizotypy scales, have provided evidence that individuals scoring highly on schizotypy scales have impaired emotional recognition, similar to the deficits described in patients with schizophrenia. Williams et al. (2007) studied the facial affect recognition of schizotypal individuals who were screened from a healthy population using the SPQ. Participants who scored in the top and bottom 15% of the distribution were asked to perform two types of facial affect recognition tests: identification and discrimination. For assessing the ability to identify facial affects, the Facial Expressions of Emotion Stimuli and Tests (FEEST; Young, 2002) was given to participants, which consisted of high-schizotypy and low-schizotypy groups. Participants were asked to pick up the best fitting label of emotion when an emotional face picture was presented in the screen. Williams et al. (2007) found that the high-schizotypy group showed poor performance on the FEEST, especially for positive emotional face pictures including happiness and surprise.

In order to assess expression discrimination, Williams et al. (2007) administered the Ekman and Friesen's Pictures of Facial Affect (PFA; Ekman & Friesen, 1975) test. In the PFA test, participants were presented with a set of eight face pictures; one was a target face and the other seven were comparison faces, depicting anger, fear, happiness, sadness, surprise, disgust, and neutral. Participants were required to choose one face picture displaying the same emotion as each target face. This test revealed that the high-schizotypy group was more likely to fail in discriminating emotional faces than low-schizotypy group. The results of Williams et al. (2007) converge with other evidence described above in support of for deficits in both facial emotion identification and discrimination in high-schizotypal individuals.

Shean, Bell, and Cameron (2007) examined the relationship between the severity of schizotypal characteristics and the ability to recognize the emotion through nonverbal affect cues including facial, postural, and paralinguistic expressions (the non-verbal emotional elements of communication such as pitch, volume, and intonation of speech). The Adult Face test (DANVA2-AF; Nowicki & Carton, 1993) assesses facial affect recognition. The Adult Paralanguage (voice) test (DANVA2-AP; Baum & Nowicki, 1998) is an auditory task designed to assess the ability to identify emotion through vocal tone and inflection. The Postures test (DANVA2-POS; Pitterman & Nowicki, 2004) consists of full-body pictures that express certain emotions through whole body postures. Participants from a healthy population completed the MIS and SPQ, as well as the three nonverbal affect recognition tests: DANVA2-AF, DANVA2-POS, and DANVA2-AP.

Shean et al. (2007) found that the ability to recognize postural expressions was correlated with schizotypal scale scores, specifically the interpersonal subscale, which is an index of interpersonal relationships that includes questions about close friends and suspiciousness about others. They also found that the ability to recognize paraverbal expressions, such as the emotional tone of voices, was correlated with score of the cognitive-perceptual subscale in the SPQ, which measures unusual perceptual experiences, such as seeing things invisible to other people. In terms of deficits of emotion recognition, Shean et al.'s (2007) study of schizotypal symptoms in a healthy population is consistent with previous studies with both schizotypal and schizophrenic individuals: impairments in the ability to accurate perceive and respond to expressions of affect.

The study of eye movements in schizotypal individuals was investigated by Lencz et al. (1993). They examined whether the impairment of smooth pursuit eye movements that has been proposed in schizophrenia (Clementz et al., 1990; Holzman et al., 1974; Sweeney et al., 1994) was specific to a clinical population of patients with schizophrenia or if they would also be observed in a non-clinical population scoring highly in schizotypal symptoms. First, Lencz et al. (1993) screened schizotypal individuals from a healthy population by the SPQ. Then, high schizotypal and control groups asked to view a swinging pendulum while their smooth pursuit eye movements were monitored. Using qualitative ratings of smooth pursuit eye movements, Lencz et al. (1993) found that pursuit eye movements of the schizotypal group were significantly different from those of control groups, indicating tracking impairments. The result addressed the abnormalities in smooth pursuit eye movement in schizotypy, which are similar to that in schizophrenia (Clementz et al., 1990; Holzman et al., 1974; Sweeney et al., 1994).

Objectives and Hypotheses of the Current Study

As described above, a number of studies have revealed deficits of emotion affect recognition in both schizophrenia and schizotypy. Overall, deficits of emotion affect in schizophrenia have been reported on positive emotions, including happiness and surprise, as well as negative emotions, including sadness and fear (Schneider et al., 1995). However, research has provided conflicting results: some studies show recognition deficits specific to negative emotions (e.g., Edwards, Pattison, Jackson, & Wales, 2001; sadness and fear), while others suggest deficits in decoding positive emotions (e.g., Waldeck & Miller, 2000; happiness and surprise). In addition, a number of studies have provided evidence of impaired ability to recognize basic facial expression with schizophrenia (Gaebel et al., 1992; Kucharska-Pietura et al., 2005; Schneider et al., 2006; Streit et al., 1997; Waldeck et al., 2000; Wolwer et al., 1996) and with schizotypy (Shean et al., 2007; Williams et al., 2007). With regard to complex emotions, although some studies reported recognition deficits with schizophrenia (e.g., Kington et al., 2000), deficits in recognizing complex emotional expressions in schizotypal individuals have not yet been systematically studied.

Many studies have shown eye movement abnormalities in schizophrenia (Clementz & Sweeney, 1990; Holzman et al., 1974; Mialet & Pichot, 1980; Nummenmaa, Hyona, & Calvo, 2006; Sweeney et al., 1994; Williams et al., 2003) and in schizotypy (Lencz et al., 1993). Impairment of smooth eye tracking in schizophrenia been proposed as one of the psychobiological markers for schizophrenia (Clementz & Sweeney, 1990; Holzman et al., 1974; Sweeney et al., 1994) and it has also been confirmed in schizotypy

(Lencz et al., 1993). Eye movements in schizophrenia are characterized by fewer fixations, longer fixation durations, and shorter eye movements between fixations, which indicating narrowed and restricted visual scanning behavior. However, it is unknown whether eye movement patterns while viewing faces and expression recognition are systematically related to schizotypal symptoms in normal adults. Manor et al. (1999) suggested that the first visual fixation of patients with schizophrenia would be more likely to be located in the left field of the stimulus, possibly mediated by right hemisphere hypofunction. Kojima et al. (1992) found that an eye movement parameter correlated with the neuropsychological subtests which sensitive to deficits in the posterior part of the right hemisphere and right frontal lobe. The results suggest that abnormalities in eye movements in schizophrenia might reflect neurocognitive dysfunction in the right hemisphere.

From these studies, several issues remain unresolved: 1) whether the ability to recognize emotion in schizotypy is different depending on negative or positive emotions, 2) whether the deficits of emotion recognition in schizotypy are different depending on basic or complex emotions, 3) whether the initial fixation in schizotypy has tendency to be located in the left field of the stimulus, 4) whether the eye movements in schizotypy show a narrowed and restricted scanning visual pattern, and 5) whether there is a relationship between accuracy of emotion recognition and eye movements parameters.

The current study identified college students as belonging to high-schizotypy and low-schizotypy groups using the Schizotypal Personality Questionnaire (SPQ; Raine, 1991). Participants who scored in the top and bottom 15 % of the distribution of the SPQ scale scores were identified high- and low- schizotypy individuals, respectively. Selected participants belonging to high- or low- schizotypy groups completed two facial affect recognition tests: the Facial Affect Recognition test (FAR) and the revised adult Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al., 2001). The FAR test was chosen to measure ability to recognize basic emotions. The RMET, a recognition test of complex emotional states, was chosen because of its sensitivity to detect of subtle affect recognition deficits. During these recognition tests, their eye movements were recorded with the Tobii x120 Eye-tracking System (Tobii, 2009).

The main objective of current study was to examine the ability to recognize the complex emotions, both complex emotions depicted in the eyes as well as basic emotions shown on full faces, in high- and low-schizotypal individuals. Simultaneously, the eye movements of schizotypal individuals were monitored. Abnormalities of eye movements during recognition of facial affect might be associated with recognition accuracy. Therefore, the relationship between eye movement parameters and recognition performance (number of correct answers) in each group was examined.

On the basis of previous studies, the current study included following three hypotheses. The first hypothesis was that compared to low-schizotypy group, high-schizotypal individuals would have lower facial affect recognition accuracy, both in the assessment of basic facial expressions and in the assessment of complex emotions depicted in the eye region. The second hypothesis was that the eye movements of high-schizotypal individuals during presentation of the facial stimuli would demonstrate abnormalities, similar to those found in schizophrenics, characterized primarily by restricted and narrow scan paths. On the basis of previous research with schizophrenics, it was predicted that the scan paths of high-schizotypal individuals would differ from those of low-schizotypal individuals. Specifically, compared to low-schizotypy group, the eye movements during face viewing in individuals with high-schizotypy should have fewer fixations, longer fixation durations, saccades of smaller amplitudes, and shorter scan path length during both the basic and complex emotion recognition tests. The third hypothesis was that spatial location of the initial fixation in schizotypy would be more likely to be located in left field of the photograph stimulus. In addition, the current study examined the levels of empathy and anxiety as possible covariates since these might also affect visual scan patterns and/or emotion recognition.

CHAPTER II

RESEARCH DESIGN AND METHODS

Phase I: Screening

Participants

The procedure for the recruitment of study participants is presented in Figure 2. Prospective participants consisted of 481 undergraduate college students in psychology classes. The age range was 18 to 49 with a mean age of 22.5 years. One hundred-twenty eight participants were male and 353 participants were female. Criteria for initial inclusion were that participants were 18 years of age or older, with normal or corrected to normal vision, and without any history of neurological or psychiatric illness. Prior to participation, the screening process was explained and all participants were required to sign the informed consent disclosure. Prior to data collection, the Institutional Review Board at Texas State University approved procedures for human subjects and consent materials.

Participants were also asked if they would be interested in participating further in Phase II. If so, they were asked to provide their contact information, e-mail address or phone number, on a separate contact information sheet. In order to protect participants' privacy, participants were not required to leave any contact information. However, if they did choose to participate further, their personal information was protected. First, their contact information was kept separate from survey responses, which was assigned a unique numeric identifier known only to the principal investigator. In the event that participants were not asked to participate in the second phase of the study, their contact information was destroyed immediately.

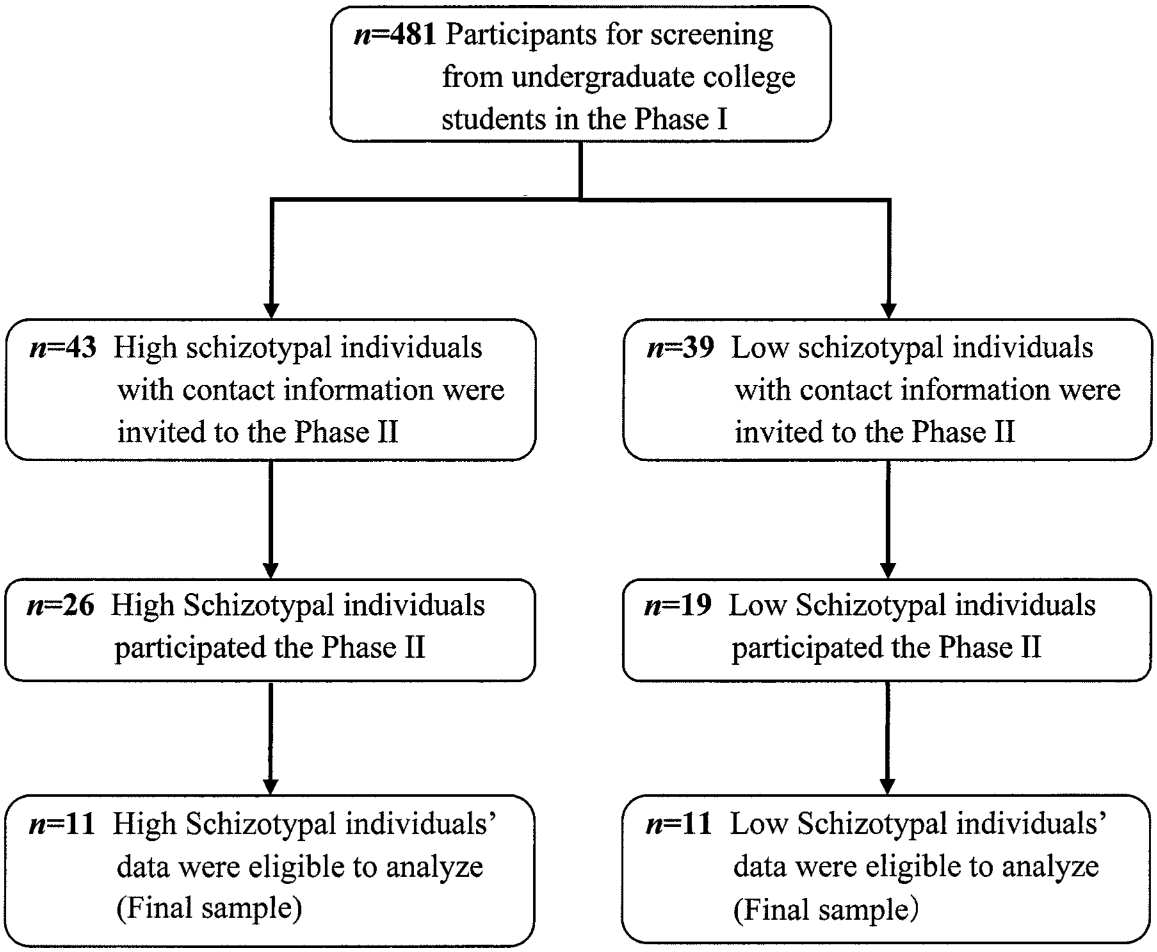

Figure 2. Procedures for Participant Recruitment and Data Collection.

Materials

Schizotypal Personality Questionnaire (SPQ; Raine, 1991). The SPQ consists of a 74-item, yes-or-no, self-report questionnaire which was developed to assess all nine features of schizotypal personality disorder in the Diagnostic and Statistical Manual of Mental Disorders, fourth edition, revised (DSM-IV-R; American Psychiatric Association, 1994): 1) Ideas of reference, 2) social anxiety, 3) odd beliefs and magical thinking, 4) unusual perceptual experiences, 5) odd or eccentric behavior, 6) no close friends, 7) odd speech, 8) constricted affect, and 9) suspiciousness. As a measure of schizotypy, the SPQ has been found to have substantial internal (Cronbach's coefficient alpha of 0.91) and test-retest (0.82) reliability (Raine, 1991). The SPQ was chosen for screening in the current study because it provides an overall measure of individual differences in schizotypal personality disorder as described by the DSM-III-R (American Psychiatric Association, & American Psychiatric Association, 1987).

Procedure

The screening package, which contained a consent form, the SPQ, a scantron answer sheet, a demographic form, and a contact information form, was distributed to undergraduate students in selected Psychology classes. Participants were asked to complete the SPQ at home, indicate their willingness to continue with the study if qualified, and to return the package on a subsequent class day. Participants who returned the package received extra course credit for their participation. The SPQ were scored for screening schizotypal individuals. Possible scores on the SPQ range from 0 to 74. Raine et al. (1992) found the gender differences on the SPQ scale depending on sub scales. Therefore, in order to reduce effects sizes for gender differences, participants were stratified by gender. Participants who scored in the top and bottom 15 % of the distribution of the SPQ scale scores, and also who indicated willingness to participate in Phase II of the study then were invited to participate in Phase II study by e-mail or phone call.

Phase II: Facial Affect Recognition and Eye Tracking

Participants

The procedures for participant recruitment and data collection are presented in Figure 2. Participants who scored in the top and bottom 15 % of the each gender distribution of the SPQ scale scores from Phase I were identified as high-schizotypy and low-schizotypy individuals, respectively. Forty-three participants scoring highly on the SPQ who provided contact information were invited to participate in Phase II. Twenty-six participants, five male and 21 female with a mean age of 21.9 (SD = 4.5), in high-schizotypy group completed the Phase II study and seventeen participants declined further participation. Thirty-nine participants in the low schizotypy group who provided contact information were invited to the Phase II study. Nineteen participants, eight male and eleven female with a mean age of 22.3 (SD = 3.3), in low-schizotypy group completed Phase II and twenty participants opted not to participate further. Prior to participation in Phase II, all participants were required to sign the informed consent disclosure. Participants received their choice of either extra course credit for selected Psychology courses or monetary compensation of $10 for study participation. If participants were contacted to participate in the second phase of the experiment, their contact information was destroyed immediately after they finish the second part of the study.

Prior to data collection, the Institutional Review Board at Texas State University—San Marcos approved procedures for human subjects and consent materials.

Materials and Apparatus

Facial Affect Recognition test (FAR). The FAR consisted of 60 black and white photographs of facial emotions, which were selected from Ekman and Friesen's Pictures of Facial Affect (Ekman & Friesen, 1975). There were 30 male and 30 female grey-scale face photographs, which excluded hair and other external features. The stimuli consisted of 14 different individuals expressing different basic emotions: happiness, sadness, anger, surprise, disgust, and fear. Ten photographs (399 x 563 pixels) of each emotion were centrally presented on a computer screen.

The trial sequence proceeded as follows: a fixation cross for 1000 ms, a face photograph for 4000 ms, and a list of emotions which remained on the screen until the participant made a response. First, a fixation cross was displayed at the center of the screen, and the participant was asked to focus his/her gaze on the cross mark. When the participant was ready, an investigator pressed space bar to initiate the trial. The participant was presented with each photograph for 4000 ms, followed by a list of the names of six basic emotions. The participant was required to choose the emotion that reflected the appropriate expression for the face, by naming it orally, while the investigator recorded the response. There were no time limits for responding. Then, the investigator pressed the space bar to proceed to the next trial. The fixation cross was presented for again 1000 ms again, and the participant focused their gaze on the cross mark until next photograph appeared. To eliminate order effects, four different sequences of stimulus faces were prepared and applied to participants randomly. Accuracy was determined by summing the total number of correct emotion choices (range = 0-60).

The revised adult Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al., 2001). The RMET was developed to detect subtle differences in the ability to recognize complex mental states of others from expressive information contained in the eye regions of faces (Baron-Cohen et al., 2001). The RMET consisted of 36 black and white photographs of emotions depicted only in the eye regions, of which 18 were male and 18 were female. Each photograph depicted a complex emotion such as pensiveness, interest, hostility, caution, and reflectiveness. Each photograph (618 x 247 pixels) was centrally presented on a computer screen.

The eye pictures were grouped into two valence categories, including 16 positive 20 negative emotions, by two different investigators. For this process of categorization, each investigator analyzed the photos and labeled them positive or negative independently. When comparing the results of each investigator, where the two investigators conflicted in opinion, they repeated the categorization process together, discussed their differences and ultimately came to an agreement as to the emotional valence of all the items.

The trial sequence proceeded as follows: a fixation cross was presented for 1000 ms, followed by a photograph of the eye region for 4000 ms, then the same photo with a list of emotions which remained on the screen until the participant responded. First, a participant was required to gaze at the fixation at the center of screen. When the participant was ready, an investigator pressed the space bar to initiate the trial. A photograph of the eye region was presented in the computer screen for 4000 ms. Following it, the same photograph with six response options at the bottom of the photograph was displayed in the computer. One of the options represented the emotion portrayed in the photo, and the participant was required to name aloud which of the six emotions was best depicted in the photograph while the investigator recorded the responses. After the response (self-paced), the investigator pressed the space bar to proceed to the next trial. To eliminate order effects, four different sequences of stimulus faces were prepared and applied to participants randomly. Accuracy was determined by summing the total number of correct emotions (range = 0-36).

Davis Interpersonal Reactivity Index (IRI; Davis, 1980). The IRI consists of 28 items which assess the multidimensional construct of empathy. These items, which inquire about thoughts and feelings in a variety of situations, can be divided into four subscales. The perspective-taking scale assesses spontaneous attempts to adopt the perspectives of other people and see things from their point of view. The fantasy scale measures the tendency to identify with characters in fictional situations such as movies and novels. The empathic concern scale assesses feelings of warmth, compassion, and concern for others, while the personal distress scale measures the personal feelings of anxiety and discomfort when observing another's negative experience. The inter-item correlations average 0.31 and Cronbach's reliability coefficient is 0.76. Test-retest and internal reliabilities of all four scales were substantial (Davis, 1980).

Spielberger Trait Anxiety Inventory Scales (STAIT; Spielberger & Gorsuch, 1983). The STAIT consists of 20 items and a self report scale, which developed to measure state and trait anxiety. The scoring includes two subscales: the state anxiety and the trait anxiety. For the Trait-anxiety scale, Cronbach's coefficient alpha ranged from 0.65 to 0.86, whereas the range for the State-anxiety scale was 0.16 to 0.62 (Spielberger

& Gorsuch, 1983).

Eye movement data. Eye movements were recorded with the Tobii x120 System (Tobii, 2009) which is standalone eye tracking units designed for eye tracking studies. This system consists of a 12x15 inches stimulus-presentation monitor, placed approximately 50 cm from the participant, an eye tracker, and a chin-rest. The eye tracker performs binocular tracking at a sampling rate of 120Hz, with 0.5 degree accuracy (difference between the recorded and actual eye position). A custom-built PC with an Intel Core 2 Quad processor running Microsoft Windows Vista and Tobii Studio software received eye gaze data via TCP/IP from the eye tracker. Custom saccade/pursuit stimuli displaying and eye position recording software was developed in .NET environment" using C#. Before the experiment, participants were screened for the actual accuracy and noise levels of the eye-tracker hardware using software developed in the Human Computer Interaction Laboratory in Texas State University (additional information is available from Dr. Komogortsev). Criteria for exclusion were accuracy of less than 1 deg and a noise level of more than 16 %. Under some conditions, such as squinting and excessive moisture of the eye, the data recorded by the eye tracker showed poor validity. As a result, only participants with data exceeding 60 % validity were used in the final analysis.

Forty-four participants completed the study. Of these, 22 participants were excluded on the basis of poor data quality. Thus, 22 participants, 11 participants in high-schizotypal and 11 in low-schizotypal groups, were used for final analysis. High-schizotypal group included two male and nine female with a mean age of 24.3 (SD = 5.5) and low-schizotypal group included seven male and five female with a mean age of 23.3

(*SD* = 3.5).

The eye movement parameters for analysis were (a) total number of fixations, (b) total fixation duration, (c) mean of saccade amplitude (median distance between two successive fixations), and (d) total scan path length. The percentage of spatial location of the initial fixations to the left field of the photographs was also calculated.

A fixation was defined as a set of consecutive gaze samples, confirmed within a diameter of 2 degrees of visual field for a duration of 100 ms or more (Ceballos, Komogortsev, & Turner, 2009). Blinks of less than 75 ms were considered part of the fixation and were included in the calculation of fixation duration, which was defined as the time difference between the last and first samples in the fixation sequence. Saccade amplitude was measured as the Euclidean distance between the coordinates of the first and last point in that sequence and was represented with degrees of visual angle. Saccades with amplitudes of less than 2 degrees and saccades in which the eye tracker failed to detect an eye position were excluded from subsequent analyses. The analyses of spatial location of the initial fixation were created using MATLAB software (The Mathworks, Inc., Natick, MA; additional information is available from Dr. Komogortsev).

Procedure

The facial affect recognition tests and the eye tracking took place in a small and quiet room on an individual basis. Each participant was seated in a chair approximately 50 cm away from a computer screen. The participant rested his/her head on a chin-rest during the two experimental tasks in order to minimize head movement and standardize the distance between the participant's eyes and the monitor. The participant was told that he/she was going to see pictures of faces or eyes, and at the same time, his/her eye movements would be monitored by the eye tracker. Then, the two expression tasks were administered to participants in a randomly determined order to protect against systematic fatigue or practice effects.

For the calibration, the participant was asked to look at a single dot which appeared on the screen. Then, the fixation cross mark appeared at the center of the screen to control the initial point of retinal attention. When the participant focused his/her gaze on the cross, an investigator pressed the space bar to start recognition tests. After the recognition tests, the participant was asked to complete the IRI and STAIT.

Data Analysis

Accuracy of affect recognition. The first hypothesis of the current study was that compared to low-schizotypy group, high-schizotypal individuals would have lower facial affect recognition accuracy both in the assessment of basic facial expressions and in the assessment of complex emotions depicted in the eye region. To examine this, the emotion items were grouped into two valence categories: positive for facial stimuli such as happy, interest and surprise, and negative for facial stimuli emotion such as sad, anger, fear, and disgust. Two 2 x 2 mixed Analysis of Variance (ANOVA) with group (high- vs. low-schizotypy) as a between subjects factor and emotion valence (positive vs. negative) as a within subjects factor were conducted for accuracies associated with each task (FAR and RMET) separately to analyze the recognition accuracy for affect expression both between and within groups.

Eye movements. The second hypothesis was the current study was that the eye movements of high-schizotypal individuals during presentation of the facial stimuli would show abnormalities such as fewer fixations, longer fixation durations, shorter saccade amplitudes, and shorter scan path lengths. The eye movements' parameters for analysis were (a) total number of fixations, (b) total fixation duration, (c) mean of saccade amplitude (median distance between two successive fixations), and (d) total scan path length.

Primary analyses of each eye movement parameter of (a) to (d) were conducted using four separate Analyses of Variance (ANOVA mixed models, one for each of the four parameters) with group (high vs. low schizotypy) as the between subjects factor and recognition tests (the FAR and RMET) as within-subjects factors.

To examine the relationship between each eye movement parameter of (a) to (d) and recognition performance (number of correct answers) in each test, regression analyses were conducted in order to determine whether abnormalities in eye movements during the recognition of facial affect were associated with recognition accuracy. Thus, two regression analyses were conducted, one for each expression recognition test. For each analysis, the predictors were eye movement parameters, (a) total number of fixations, (b) total fixation duration, (c) mean of saccade amplitude, and (d) total scan path length, and the criterion variables were recognition test scores (scores on the FAR and RMET).

The third hypothesis was that spatial location of the initial fixation in schizotypy would be more likely to be located in left field of the photograph. To test spatial location of the initial fixation in each recognition test, the spatial location of the initial fixation in left field of the photograph was analyzed with a 2 (group: high- and low-schizotypy) x 2 (task: the FAR and RMET) Analysis of Variance (ANOVA) mixed model.

In addition, prior to all analyses, empathy and anxiety scores from the IRI and STAIT were examined as a possible confounding variable of eye-tracking parameters and schizotypy. First, the Pearson's correlations were conducted in order to find any correlations between empathy and anxiety scales scores and eye movement parameters. Then, the scales which had significant correlations were used as covariates in ANOVAs analysis, where applicable.

CHAPTER III

RESULTS

Phase I: Screening

Descriptive characteristics for participants in Phase I are presented in Table 1. The participants consisted of 481 undergraduate college students in psychology classes. The age range was 18 to 49 with a mean age of 22.5 years. One hundred-twenty eight participants were male and 353 participants were female. The Schizotypal Personality Questionnaire (SPQ) scores in male ranged 0 to 48 with a mean of 22.3 (SD = 12.3). The SPQ scores in female range 0 to 59 with a mean of 20.7 (SD = 11.0).

Table 1

Characteristics for Participants in Phase I

Gender	***N***	***Percentage of total***
Male	128	26.6
Female	353	3.4
Ethnics	***N***	***Percentage of total***
White	274	57.0
Hispanic	128	26.6
Black	32.0	6.70
Other	47.0	9.70
Age	***Mean***	***Range***
	22.5	18-49
SPQ score	***Mean***	***Standard Deviation***
Male	22.3	12.3
Female	20.7	11.0

Phase II: Facial Affect Recognition and Eye Tracking

Participants

The procedures for participant recruitment and data collection are presented in Figure 2. Twenty-five out of 43 participants who were invited as high-schizotypal individuals completed the Phase II study. Nineteen out of 39 participants who were invited as low-schizotypal individuals completed the Phase II study. Thus, total 44 participants completed the Phase II of the study. Participants who had less than 60 % overall validity of eye tracking data during a testing session were excluded. As a result, 22 participants were used for final analysis.

Descriptive characteristics for participants in final analysis of Phase II are presented in Table 2. High-schizotypy consisted of 11 participants, two male and nine female with a mean age of 24.3 (*SD* = 5.5), and low-schizotypy group consisted of 11 participants, seven male and five female with a mean age of 23.3 (*SD* = 3.5). The mean of eye-tracker validity was 85.8% (*SD*=11.2).

Table 2

Characteristics for Participants in Final Analysis of Phase II

	Total Participant *N* = 22	
	High-Schizotypy	Low-Schizotypy
Gender	***N***	***N***
Male	2	7
Female	9	5
Ethnics	***N***	***N***
White	7	7
Hispanic	3	4
Black	2	1
Age	***Mean (Standard deviation)***	
	24.3 (5.5)	23.3 (3.5)

Accuracy of Affect Recognition

Mean recognition accuracy was computed separately for each emotion valence (positive and negative) for each task: the Facial Affect Recognition test (FAR) and Reading the Mind in the Eyes Test (RMET). The FAR contained six basic emotions and categorized into two positive emotions (happy and surprise) and four negative emotions (sad, fear, disgust, and anger). The RMET contained 36 complex emotions pictures which were categorized into 17 positive and 19 negative emotions by two coders, depending on meaning of emotion as well as expression in the eye pictures.

The FAR data were analyzed using a 2 (group: high- and low- schizotypy) x 2 (emotion valence: positive and negative) analysis of variance. Group mean data for accuracy of the FAR are presented in Table 3. The results of the ANOVA did not show significant differences between groups in main effects ($F(1, 20) = 1.04, p > .05$) and interactions ($F(1, 20) = .121, p > .05$).

Table 3

Group Means and Standard Deviations (in parentheses) for FAR

	Emotion Valence	
	Positive emotion	Negative emotion
High-Schizotypy	94.5 (6.7)	80.7 (9.6)
Low-Schizotypy	93.2 (9.4)	77.0 (12.5)
Total group	93.9 (8.3)	78.9 (10.5)

The RMET data were analyzed using a 2 (group: high- and low- schizotypy) x 2 (emotion valence: positive and negative) analysis of variance. Group mean data for accuracy of the RMET are presented in Table 4. The results revealed a significant main effect of emotion valence on the RMET ($F(1, 20) = 4.67$, $p = .043$). Participants performed less accurately on positive emotions ($M = 71.7$, $SD = 10.9$) than negative emotions ($M = 77.8$, $SD = 10.0$) on the RMET. This main effect was mitigated by a significant interaction between group and emotion valence for the RMET accuracy ($F(1, 20) = 5.12$, $p = .035$). Planned comparisons in the form of paired *t*-tests were conducted for each group and revealed that this interaction was due to a significant difference between positive ($M = 67.9$, $SD = 10.6$) and negative emotion accuracy ($M = 80.4$, $SD = 8.8$) for participants in the high-schizotypy group ($t(1, 10) = 3.76$, $p = .004$). In contrast, independent *t*-tests did not reveal significant differences between emotion valences in low-schizotypy group (positive emotions: $M = 75.4$, $SD = 10.8$ vs. negative emotions: $M = 75.1$, $SD = 10.5$). High-schizotypal individuals performed less accurately on positive emotion relative to negative emotions, while low-schizotypal individuals did not differ in recognition accuracy across emotional valence.

Table 4

Group Means and Standard Deviations (in parentheses) for RMET

	Emotion valence	
	Positive emotion	Negative emotion
High-Schizotypy	67.9 (3.2)	80.4 (3.0
Low-Schizotypy	75.4 (3.2	75.1 (3.0)
Total group	71.7 (2.3)	77.8 (2.1)

Eye Movements

The four eye movement parameters, (a) total number of fixations, (b) total fixation duration, (c) mean of saccade amplitude, and (d) total scan path length, were analyzed using four 2 (group: high- and low- schizotypy) x 2 (task: FAR and RMET) analyses of variance. The means and standard deviations of each parameter for each group are presented in Table 5. The results of these ANOVAs of eye movement failed to reveal any significant differences between and within groups (*Fs* (1, 20) $< 2, p > .05$). Empathy and anxiety scales from the IRI and STAIT were examined as possible confounding variable of eye movements' parameters. The Pearson's correlation analyses revealed five significant correlations between empathic concern scale and (b) total fixation duration on the FAR ($r = -.452, p = .035$), empathic concern scale and (d) total scan path length on the FAR ($r = -.483, p = .023$), personal distress scale and (d) total scan path length on the FAR ($r = -.430, p = .046$), perspective-taking scale and (a) total number of fixations on the RMET ($r = -.514, p = .014$), and perspective-taking scale and (d) total scan path length on the RMET ($r = -.495, p = .019$). Thus, these scales were then used as covariates in the ANOVAs. However, the results did not differ from the initial ANOVAs, and did not show any significant differences between the groups

Table 5

Means and Standard Deviations (in parentheses) of Eye Movement Parameters Recorded During the FAR and REMT Tasks

Eye movement parameters	Task	Schizotypy: High	Schizotypy: Low
(a) Total number of fixations	FAR	511.4 (63.0)	475.4 (89.2)
	REMT	287.1 (49.0)	298.0 (50.2)
(b) Total fixation duration (sec)	FAR	189.9 (18.5)	167.0 (44.7)
	REMT	105.9 (17.5)	101.5 (17.9)
(c) Mean of saccade amplitude	FAR	3.100 (0.40)	3.000 (0.57)
(degree)	REMT	4.100 (0.78)	4.300 (0.61)
(d) Total scan path length (mm)	FAR	1386 (352)	1296 (357)
	REMT	1057 (342)	1071 (331)

The spatial location of initial fixations to left field of the photograph was analyzed by a 2 (group: high- and low-schizotypy) x 2 (task: the FAR and RMET) ANOVA mixed model. The dependent variable was proportion of fixations to the left field of the photograph and independent variables was group and task. The analysis revealed a significant main effect for group. Participants in high-schizotypy group were more likely to make an initial fixation to the left field of the photograph ($M = 85.7$, $SD =$

20.9) relative to the low-schizotypy group (M = 67.8, SD = 19.8), F (1, 20) = 7.65, p = .012, regardless of the task.

Relationship between eye movements and recognition accuracy

The two regression analyses were performed to examine any associations between performance on the FAR and RMET tasks (criterion variables) with and eye movement parameters, (a) total number of fixations, (b) total fixation duration, (c) mean of saccade amplitude, and (d) total scan path length as predictors. Thus, two regression analyses for each test were conducted and forward stepwise regression was used to determine the final models. The results of the first regression indicated that accuracy on the FAR was significantly and positively related to total fixation duration, β = -.4984, t (20) = 2.54, p < .05, which explained a significant proportion of variance in the FAR scores, R^2 = .206, F(1, 20) = 6.435, p < .05. The linear relationship between the FAR accuracy and fixation duration is represented in the scatterplot shown in Figure 3, which shows values for both groups (high- vs. low-schizotypy). The results of the second regression failed to indicate any significant relationship between accuracy on the REMT and eye movement parameters.

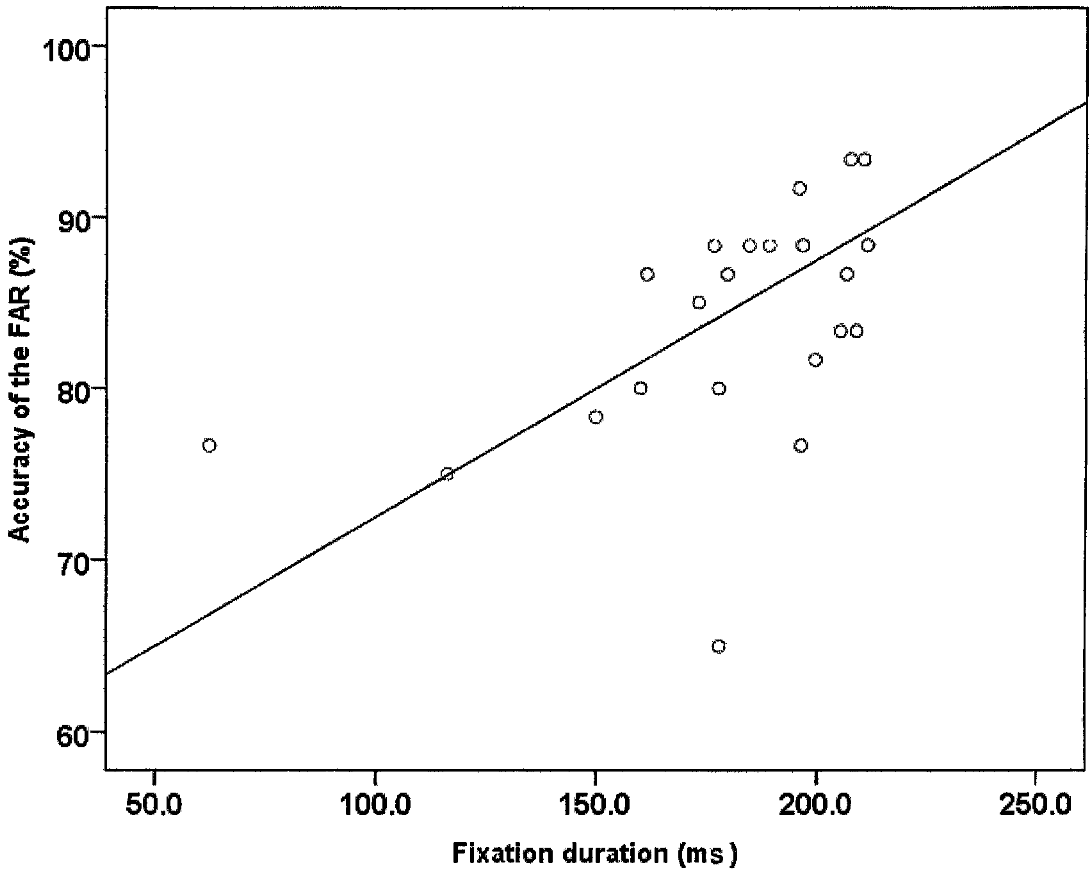

Figure 3. Scatterplot of FAR Accuracy and Fixation Duration.

CHAPTER IV

DISCUSSION

Schizophrenia is severe, chronic, and complex mental disorder that causes great damage to the individuals' affects and to having difficulty of social life adjustment. The main symptoms include flat affect and abnormalities in emotional expressions and recognition. To contribute social rehabilitation of patients with schizophrenia, research regarding the mechanisms underlying these emotional deficits is paramount. Several studies have shown eye movement abnormalities in schizophrenia (Clementz & Sweeney, 1990; Holzman et al., 1974; Mialet & Pichot, 1980; Nummenmaa, Hyona, & Calvo, 2006; Sweeney et al., 1994; Williams et al., 2003), which may in turn cause impaired emotion processing.

Schizotypy is considered part of the normal spectrum of personality in healthy populations and a risk factor (Meehl, 1962, 1990). Schizotypal individuals have been reported to display some evidence of aberrant psychobiological or psychological functioning similar to that of schizophrenics (Berenbaum et al., 2006; Jarrett et al., 2002; Lenzenweger, 2006; Meyer & Shean, 2006; Poreh et al., 1994; Shean, Bell, & Cameron, 2007; Vollema et al., 1995; Williams, Henry, &Green, 2007), including deficits of emotion affect recognition. However, it is unknown whether eye movement patterns while viewing faces and expression recognition are systematically related to schizotypal characteristics in normal adults. The main objective of the current study was to examine the ability to recognize the complex emotions as well as basic emotions in schizotypal individuals who were screened from a healthy population. At same time, the eye movements were monitored during the recognition tests.

The first hypothesis was that compared to the low-schizotypy group, high-schizotypal individuals would have lower accuracy of facial affect recognition both in the assessment of basic facial expressions and in the assessment of complex emotions depicted in the eye region. In addition, the facial expressions were grouped into two valence categories, positive and negative emotions, to examine whether recognition impairments were specific to positive or negative emotions. The current study did not find any significant differences of the accuracy between groups for the FAR, but revealed a significant difference in the accuracy between negative and positive emotions in high-schizotypy group for the assessment of complex emotions. The high-schizotypy individuals were significantly less accurate on the RMET on positive emotions relative to negative emotions. This result provided two main points; one was that a significant difference was found only on the assessment of complex emotions, and the other was that this deficit was only observed for positive emotions.

With regard to assessment of basic and complex emotion recognition, previous studies have found deficits in the ability to recognize basic facial expressions with schizophrenia (Gaebel et al., 1992; Kucharska-Pietura et al., 2005; Schneider et al., 2006; Streit et al., 1997; Waldeck et al., 2000; Wolwer et al., 1996) and schizotypy (Poreh et al., 1994; Shean et al., 2007; Williams et al., 2007). In contrast, the current study did not show significant differences in basic emotion task between groups. One possibility for this discrepant result is that previous studies applied multiple schizotypal tests for screening, while the current study used one screening test (the SPQ). For example, Poreh et al. (1994) used three psychosis proneness screening scales including Perceptual Aberration Scale (PAS; Chapman, Chapman, & Raulin, 1978), Schizotypal Personality Scale (STA; Claridge & Broks, 1984), and Magical Ideation Scale (MAG; Eckblad & Chapman, 1983). The inclusion of multiple screening measures might change the overall characteristics of the high- and low- schizotypy groups and might cause different results because each test was developed from different perspective. Some are symptom-oriented (e.g., the MIS and PAS), some are syndrome-oriented (e.g., the STA and SPQ), and some are personality-oriented (e.g., Eysenck Personality Questionnaire; Eysenck and Eysenck, 1975) (Vollema et al., 1995). Also each test focuses on different dimension of schizotypy, such as positive features, negative features, perceptual dysfunctions, social anxiety, and neuroticism (Vollema et al., 1995). Thus, they are a heterogeneous set of instruments. Using only one screening method might cause differences in selection of the participants of the schizotypy groups. Further studies should consider choosing appropriate multiple screening tests which match the studies' focus.

The ability to recognize complex emotions with schizotypal individuals has received less attention although some studies reported the recognition deficits on complex emotion with schizophrenia (Kington et al., 2000). Kington et al. (2000) found that patients with schizophrenia had an impaired ability to recognize complex mental states from eye expression and no impairment in the recognition of basic emotions. They suggested that "complex mental state terms, such as arrogant, are intrinsically more difficult to understand than basic emotion terms, such as happy, and that the performance of the schizophrenia patients was impaired simply due to their lower IQ" (Kington et al., 2000). However, it could be argued that since the current study found low accuracy of complex emotion recognition with schizotypal individuals who were considered part of the normal spectrum of personality in the healthy population, lower IQ might not explain their impairment. Moreover, the current study found that the deficit was only for positive emotions, not for all emotions, this could argue against a general IQ or a general emotion processing deficit. Rather, these results suggest that impairments in facial emotion recognition in schizotypal individuals are specific to positive emotions (e.g., happiness and surprise).

One explanation for the finding of a significant difference only on the assessment of complex emotions and not for basic emotions may be because the basic expression recognition task was relatively easy, especially recognizing positive emotions such as happiness. While basic emotion recognition test requires participants to simply observe daily used facial expressions, the RMET requires participants to make inferences about the feelings or intentions of the person in the photograph (Hallerbäck, Lugnegård, Hjärthag, & Gillberg, 2009), which makes the test harder than basic emotion recognition test. Hence, subtle deficits might be obscured by the ceiling effects when basic emotion test applied. In other words, even though schizotypal individuals have deficits in recognizing emotions, these deficits were not revealed by the simpler task because it was not enough sensitive to detect the deficits (see Tables 3 and 4). Increasing the level of difficulty of the facial affect recognition task by using complex emotions depicted by only the eye region may have succeeded to detect these more subtle deficits, especially for positive emotions.

With regard to whether the deficits would be restricted to either positive or negative emotional expressions, conflicting results have been reported. Some researchers found recognition deficits for positive emotions (e.g., Waldeck & Miller, 2000; happiness and surprise), while others suggest that it is specific to negative emotions (e.g., Williams, Henry, & Green, 2007; disgust, anger, sadness, and fear) in schizotypal populations. The current study found that schizotypal individuals were significantly less accurate on positive emotions. This result might explain negative symptoms of schizophrenia, such as flat affect and anhedonia, and inappropriate social reactions. Because of deficits in processing information about people's positive expressions, patients with schizophrenia may, in turn, might not have appropriate emotional reactions, which could account for interpersonal communication deficits in schizotypy and schizophrenia.

Also, the finding of a significant difference in the accuracy for negative and positive emotions in the high-schizotypy group on the RMET may provide clues for further understanding previous conflicting results of positive and negative emotion recognition and schizotypy. Williams et al. (2002) categorized schizotypal individuals into positive and negative schizotypal characteristics based on their SPQ sub-scale scores. They found recognition impairment of negative emotion with negative schizotypy, and suggested that there might be a specific relationship between negative schizotypal characteristics and the recognition of negative emotions. Unfortunately, due to the small number of participants with valid data, the current study did not categorize schizotypal individuals according to these two characteristics. However, if Williams et al.'s (2002) suggestion also applies to positive schizotypal characteristics and positive emotions, the high-schizotypal individuals in the current study might have had more positive schizotypal characteristics than negative schizotypal characteristics. To confirm this proposal, further studies should examine positive and negative schizotypal characteristics and whether they are systematically related to specific expression recognition deficits.

The second hypothesis was that compared to the low-schizotypy group, eye movements with high-schizotypy would demonstrate a restricted scan path relative to the low schizotypy group, characterized by fewer total number of fixations, shorter total fixation duration, shorter saccade amplitudes, and shorter total scan path length. The current study did not find any significant differences between eye movement parameters for high- and low-schizotypy groups for either the basic or the complex task. This result was surprising, for although the four eye movement parameters in the current study, (a) total number of fixations, (b) total fixation duration, (c) mean of saccade amplitude, and (d) total scan path length, did not demonstrate abnormalities in schizotypy, there were behavioral differences in the recognition of positive complex emotions for schizotypy group.

Contrary to hypothesis in the current study, this result may suggest that the eye-movement abnormalities while viewing emotional faces seen in schizophrenia are not applied to part of schizotypy. As described earlier, the abnormalities in smooth pursuit eye movement while viewing a swinging pendulum in schizotypy were found (Lencz et al., 1993). However, to our knowledge, it is the first study to examine the eye movements during affect recognition tests in a schizotypal population. If this result is valid, it might be proposed that abnormalities of eye movements during affect recognition might be presented in only schizophrenia as a clinical population but not schizotypy as a general population. Further studies are required to confirm the current finding with larger samples.

Another possibility is that if the current study analyzes eye movement parameters to different parts of the face image, such as feature regions (eyes, nose, and mouth) vs.

non-feature regions, there might be significant differences in eye movement behavior between the two groups. According to Williams et al. (2003), schizophrenics' eye movements to facial stimuli are characterized by a reduced attention to salient facial feature, such as eyes and mouth, for stimuli. In the current study, schizotypal individuals might fail to attend to salient facial feature region in order to obtain the details of facial features to recognize emotion. Instead, they might have an abnormal emphasis on processing specific facial features; non-salient facial areas may be scanned as equally or even more significant as salient facial regions. To confirm this issue, further studies should examine pattern of eye movements to salient facial features including eyes, nose, and moth, or to non-salient features. Since eye movement abnormalities are one of the potential factors behind the deficits of facial affect recognition, finding the significant feature of their eye movement abnormalities may contribute their social rehabilitation, allowing for training strategies to improve their visual scanning and the ability to decode facial expression in real social situations.

A final consideration when considering these results is that the sample size in the current study might have been too small, providing insufficient statistical power to reveal significant differences. Thus, type II error should be considered. Further studies should involve a greater number of participants to improve power and reduce the possibility of type II error. If the further studies with larger groups did find a narrowed visual scan pattern in schizotypy, it could be suggested that a schizotypal individual's visual attention field is restricted, which in turn, would indicate deficits in integrating visual information to accurately judge the emotion on the face. If the further studies were replicated the results in the current study with a larger sample, it could be proposed that abnormalities of eye movements during affect recognition are presented in only patients with schizophrenia as a clinical population but not schizotypal individuals as a general population. The eye movement abnormalities might emerge only when full-blown symptoms of schizophrenia emerge.

The current study also examined the relationship between accuracy of emotion recognition and eye movement parameters. The result revealed a significant positive relationship between accuracy on the FAR and total fixation duration across all participants, regardless of group. As a general finding rather than specific to schizotypy, longer durations were associated with greater accuracy on the assessment of basic emotions. Given that fixations are associated with processing facial details, longer fixation durations might account for higher recognition accuracy especially for basic emotions rather than complex emotions.

The third hypothesis was that the spatial location of initial fixation in high schizotypal individuals would be more likely to be located in left field of the photograph. The current study found that the initial fixation of the high-schizotypy group was more likely to be on left field of the stimulus for both tasks, confirming the suggestion of Manor et al. (1999); the first visual fixation in schizophrenia was more likely to be located in the left field of the stimulus, possibly mediated by right hemisphere hypofunction. As such, this result provided additional evidence that the deficits of emotion recognition might reflect neurocognitive abnormal functioning in the right hemisphere (Kojima et al., 1992). To our knowledge, this finding of tendency to have a first fixation in the left filed of picture in a schizotypal population is novel and suggests that schizotypal individuals display schizophrenia-like characteristics in the form of aberrant psychological functioning (Jarrett et al., 2002; Lenzenweger, 2006) even though schizotypy is considered part of the normal spectrum of personality. For further understanding, the future studies should examine the relationship between initial fixation positions and neuropsychological tests designed to be sensitive for right hemisphere function or use neuroimaging techniques (ERP or fMRI).

One of the limitations of the current study was sample selection. The difference between the high- and low- SPQ scores in this study might not have been large enough to find existing eye movement abnormalities in schizotypy group. Also, using only the SPQ for screening might have affected the selection of participants for the schizotypy groups, which might influence the results. In addition, sample population should be considered because participants in the current study were recruited from a college population. Hence, the sample was predominantly younger and more educated population than the general population and might not be representative of schizotypy in general. Therefore, the results of the study might not generalize to other populations.

The ecological validity of the tasks used to assess facial expression in the current study may have also contributed to the results. Since photographs of face were not dynamic and without social context, they were different from situations when emotions are normally encountered in daily life. Emotion recognition in daily situations might be more complicated due to multiple sources of incoming information, such as tone of voices and gestures as well as dynamic changes in facial affect. Thus, interpretations of the current study with regard to overall social functioning in schizophrenia should be made with caution. For future studies, facial recognition test should contain simply facial emotion photograph as well as emotional photograph with social context background.

Moreover, the test might be video clip which displays people' conversation with particular emotional faces.

In summary, the result that the high-schizotypal individuals were significantly less accurate on the RMET of positive emotions than that of negative emotions may help to clarify the inconsistencies in the literature regarding the specificity emotion processing deficits in schizophrenia. In the current study, high-schizotypal individuals had deficits in recognizing positive emotions, but only complex emotional states depicted only by the eyes. Furthermore, this result proposed the idea that complex emotion task could reveal subtle deficits of emotion recognition, which might be obscured by the ceiling effects when using basic emotion task. The result of the positive relationship between accuracy of emotion recognition and total fixation duration across groups provided insight into resolving complicated emotion mechanisms by finding the eye movement parameter that might contribute to differences in the ability to recognize facial expressions although this result was general finding not specific to schizotypy. The result of the initial fixation on the left field in high-schizotypal individuals provided additional evidence that the deficits of emotion recognition might reflect neurocognitive abnormal functioning in the right hemisphere (Kojima et al., 1992). To our knowledge this is the first such suggestion a schizotypal population and provided evidence in support of the idea that schizotypal individuals display schizophrenia-like characteristic in the form of aberrant psychological functioning (Jarrett et al., 2002; Lenzenweger, 2006).

The results from the current study are relevant to the diagnosis and rehabilitation of schizophrenia. For example, the tendency to neglect the right field of the stimuli may be used as a biopsychological marker to assist in the diagnosis of schizophrenia. The results of the current study suggest that rehabilitation to improve social skills in schizophrenia should emphasize recognition of positive emotions. Also, patients with schizophrenia should be trained to scan all fields of the face, particularly the right field. In addition, the current study provides suggestions for further study to develop knowledge of the role of eye movements in emotion recognition in schizotypy using a combination of eye-tracker and behavioral methodologies. Such studies may not only help to find critical factors for the understanding of schizotypy, but may aid in the future improvement of clinical intervention for schizophrenia.

REFERENCES

American Psychiatric Association., & American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders: DSM-III-R.* Washington, DC: American Psychiatric Association.

Baron-Cohen, S., & Wheelwright, S. (2001). The 'reading the mind in the eye's test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology & Psychiatry & Allied Disciplines*, *42*(2), 241.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, A. (1997). Is there a language of the eyes? Evidence from normal adults, and adults with autism or Asperger syndrome. *VisualCognition*, *4*(3), 311-331.

Baum, K. M., & Nowicki, S. Jr. (1998). Perception of emotion: measuring decoding accuracy of adult prosodic cues varying in intensity. *Journal of Nonverbal Behavior, 22*(2), 89-107.

Benton, A. L. (1983). *Contributions to neuropsychological assessment: a clinical manual.* New York: Oxford University Press.

Berenbaum, H., Boden, M., Baker, J., Thompson, R., Abramowitz, A., & Dizen, M. (2006). Emotional correlates of the different dimensions of schizotypal personality disorder. *Journal of Abnormal Psychology, 115*(2), 359-368.

Ceballos, N., Komogortsev, O., & Turner, G. (2009). Ocular imaging of attentional bias among college students: automatic and controlled processing of alcohol-related scenes. *Journal of Studies on Alcohol and Drugs*, *70*(5), 652-659.

Claridge, G., & Broks, P. (1984). Schizotypy and hemisphere function: I. Theoretical considerations and the measurement of schizotypy. *Personality and Individual Differences, 5*(6), 633-648.

Clementz, B. A., & Sweeney, J. A. (1990). Is eye movement dysfunction a biological marker for schizophrenia? A methodological review. *Psychological Bulletin, 108*(1), 77-92.

Chapman, L., Chapman, J., & Raulin, M. (1978). Body-image aberration in schizophrenia. *Journal of Abnormal Psychology*, *87*(4), 399-407

Davis, M. H. (1980). *A multidimensional approach to individual differences in empathy*. Washington, D.C.: American Psycholog. Ass., Journal Suppl. Abstract Service.

Dimberg, U. (1981). *Facial reactions to facial expressions*. Uppsala, Sweden: Dept. of Psychology, University of Uppsala.

Eckblad, M., & Chapman, L. (1983). Magical ideation as an indicator of schizotypy. *Journal of Consulting and Clinical Psychology*, *51*(2), 215-225.

Edwards, J., Pattison, P. E., Jackson, H. J., & Wales, R. J. (2001). Facial affect and affective prosody recognition in first-episode schizophrenia. *Schizophrenia Research. 48*(2-3), 2-3.

Ekman, P., & Friesen, W. V. (1975). *Pictures of facial affect.* Palo Alto, Calif: Consulting Psychologists Press.

Eysenck, S. B. G., & Eysenck, H. J. (1975). *Manual of the Eysenck personality questionnaire (junior and adult)*. London: Hodder and Stoughton.

Gaebel, W., & Wölwer, W. (1992). Facial expression and emotional face recognition in schizophrenia and depression. *European Archives of Psychiatry and Clinical Neuroscience, 242*(1), 46-52.

Green, M., Waldron, J., Simpson, I., & Coltheart, M. (2008). Visual processing of social context during mental state perception in schizophrenia. *Journal of Psychiatry & Neuroscience: JPN, 33*(1), 34-42.

Gur, R. C., Sara, R., Hagendoorn, M., Marom, O., Hughett, P., Macy, L., . . . Gur, R. E. (2002). A method for obtaining 3-dimensional facial expressions and its standardization for use in neurocognitive studies. *Journal of Neuroscience Methods, 115*(2), 137.

Hallerbäck, M., Lugnegård, T., Hjärthag, F., & Gillberg, C. (2009). The Reading the Mind in the Eyes Test: Test-retest reliability of a Swedish version. *Cognitive Neuropsychiatry, 14*(2), 127-143.

Holzman, P. S., Proctor, L. R., Levy, D. L., Yasillo, N. J., Meltzer, H. Y., & Hurt, S. W. (1974). Eye-tracking dysfunctions in schizophrenic patients and their relatives. *Archives of General Psychiatry, 31*(2), 143-51.

Jarrett, C., Phillips, M., Parker, A., & Senior, C. (2002). Implicit motion perception in schizotypy and schizophrenia: A Representational Momentum study. *Cognitive Neuropsychiatry, 7*(1), 1-14.

Kallimani, D., Theleritis, C., Evdokimidis, I., Stefanis, N., Chatzimanolis, I., & Smyrnis, N. (2009). The effect of change in clinical state on eye movement dysfunction in schizophrenia. *European Psychiatry, 24*(1), 17-26.

Karoumi, B., Ventre-Dominey, J., Vighetto, A., Dalery, J., & d'Amato, T. (1998). Saccadic eye movements in schizophrenic patients. *Psychiatry Research, 77*(1), 9-19.

Kee, K., Kern, R., & Green, M. (1998). Perception of emotion and neurocognitive functioning in schizophrenia: What's the link? *Psychiatry Research, 81*(1), 57-65.

Kington, J. M., Jones, L. A., Watt, A. A., Hopkin, E. J., & Williams, J. (2000). Impaired eye expression recognition in schizophrenia. *Journal of Psychiatric Research, 34*(4-5), 341-347.

Kucharska-Pietura, K., David, A. S., Masiak, M., & Phillips, M. L. (2005). Perception of facial and vocal affect by people with schizophrenia in early and late stages of illness. *The British Journal of Psychiatry : the Journal of Mental Science, 187*, 523-8.

Kucharska-Pietura, K., Phillips, M. L., Gernand, W., & David, A. S. (2003). Perception of emotions from faces and voices following unilateral brain damage. *Neuropsychologia, 41*(8), 1082-90.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual.* Gainesville, Fla: NIMH, Center for the Study of Emotion & Attention.

Lang, U. E., Puls, I., Muller, D.J., Strutz-Seebohm, N., & Gallinat, J. (2007). Molecular mechanisms of schizophrenia. *Cellular Physiology and Biochemistry : International Journal of Experimental Cellular Physiology, Biochemistry, and Pharmacology, 20*(6), 687-702.

Lencz, T., Raine, A., Scerbo, A., Redmon, M., Brodish, S., Holt, L., et al. (1993). Impaired eye tracking in undergraduates with schizotypal personality disorder. *The American Journal of Psychiatry, 150*(1), 152-4.

Lenzenweger, M. (2006). Schizotaxia, schizotypy, and schizophrenia: Paul E. Meehl's blueprint for the experimental psychopathology and genetics of schizophrenia. *Journal of Abnormal Psychology*, *115*(2), 195-200.

Loughland, C. M., Williams, L. M., & Gordon, E. (2002). Schizophrenia and affective disorder show different visual scanning behavior for faces: a trait versus state-based distinction? *Biological Psychiatry, 52*(4), 338-48.

Manor, B., Gordon, E., & Touyz, S. (1995). Consistency of the first fixation when viewing a standard geometric stimulus. *International Journal of Psychophysiology: Official Journal of The International Organization of Psychophysiology*, *20*(1), 1-9.

Manor, B. R., Gordon, E., Williams, L. M., Rennie, C. J., Bahramali, H., Latimer, C. R., . . . Meares, R. A. (1999). Eye movements reflect impaired face processing in patients with schizophrenia. *Biological Psychiatry. 46*(7), 963-9.

Meehl, P. (1962). Schizotaxia, schizotypy, schizophrenia. *American Psychologist*, *17*(12), 827-838.

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

Meyer, J., & Shean, G. (2006). Social-cognitive functioning and schizotypal characteristics. *Journal of Psychology*, *140*(3), 199-207.

Mialet, J. P., & Pichot, P. (1981). Eye-tracking patterns in schizophrenia. An analysis based on the incidence of saccades. *Archives of General Psychiatry*, *38*(2), 183-186.

Mueser, K., Doonan, R., Penn, D., Blanchard, J., Bellack, A., Nishith, P., & DeLeon, J. (1996). Emotion recognition and social competence in chronic schizophrenia. *Journal of Abnormal Psychology*, *105*(2), 271-275.

Noton, D., & Stark, L. (1971). Eye movements and visual perception. *Scientific American, 224*(6), 35-43.

Nowicki, S. Jr., & Carton, J. (1993). The measurement of emotional intensity from facial expressions. *The Journal of Social Psychology, 133*(5), 749-50.

Nummenmaa, L., Hyönä, J., & Calvo, M. (2006). Eye movement assessment of selective attentional capture by emotional pictures. *Emotion*, *6*(2), 257-268.

Pitterman, H., & Nowicki, S. Jr. (2004). A test of the ability to identify emotion in human standing and sitting postures: The diagnostic analysis of nonverbal accuracy-2 posture test (DANVA2-POS). *Genetic, Social, and General Psychology Monographs, 130*(2), 146.

Poreh, A. M., Whitman, R. D., Weber, M., & Ross, T. (1994). Facial recognition in hypothetically schizotypic college students. The role of generalized poor performance. *The Journal of Nervous and Mental Disease. 182*(9), 503-7.

Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*(4), 555-564.

Rey, A. (1941). *L'examen psychologique dans les cas d'encéphalopathie traumatique: Les problèmes*.

Salem, J., Kring, A., & Kerr, S. (1996). More evidence for generalized poor performance in facial emotion perception in schizophrenia. *Journal of Abnormal Psychology, 105*(3), 480-483.

Schneider, F., Gur, C. R., Koch, K., Backes, V., Amunts, K., Shah, N. J., . . . Habel, U. (2006). Impairment in the specificity of emotion processing in schizophrenia. *The American Journal of Psychiatry, 163*, 442 - 447.

Shean, G., Bell, E., & Cameron, C. (2007). Recognition of nonverbal affect and schizotypy. *Journal of Psychology: Interdisciplinary and Applied, 141*(3), 281-291.

Spielberger, C. D., & Gorsuch, R. L. (1983). *Manual for the State-trait anxiety inventory (form Y) ("self-evaluation questionnaire").* Palo Alto, CA: Consulting Psychologists Press.

Sass, L. (2007). Contradictions of emotion in schizophrenia. *Cognition &; Emotion, 21*(2), 351-390.

Streit, M., Wölwer, W., & Gaebel, W. (1997). Facial-affect recognition and visual scanning behaviour in the course of schizophrenia. *Schizophrenia Research, 24*(3), 311-7.

Sweeney, J. A., Clementz, B. A., Haas, G. L., Escobar, M. D., Drake, K., & Frances, A. J. (1994). Eye tracking dysfunction in schizophrenia: characterization of component eye movement abnormalities, diagnostic specificity, and the role of attention. *Journal of Abnormal Psychology, 103*(2), 222-30.

Thaker, G. K., & Carpenter, W. T. (2001). Advances in schizophrenia. *Nature Medicine, 7*, 667-671.

TOBII. (2009). *TOBII.* Retrieved from http://www.tobii.com.

Vollema, M., & van den Bosch, R. (1995). The multidimensionality of schizotypy. *Schizophrenia Bulletin, 21*(1), 19-31.

Waldeck, T. L., & Miller, L. S. (2000). Social skills deficits in schizotypal personality disorder. *Psychiatry Research, 93*(3), 237-246.

Williams, B., Henry, J., & Green, M. (2007). Facial affect recognition and schizotypy. *Early Intervention in Psychiatry, 1*(2), 177-182.

Williams, L., Loughland, C., Green, M., Gordon, E., & Harris, A. (2003). Emotion perception in schizophrenia: An eye movement study comparing the effectiveness of risperidone vs. haloperidol. *Psychiatry Research, 120*(1), 13-27.

Wolf, K., Mass, R., Kiefer, F., Wiedemann, K., & Naber, D. (2006). Characterization of the facial expression of emotions in schizophrenia patients: Preliminary findings with a new electromyography method. *The Canadian Journal of Psychiatry / La Revue canadienne de psychiatrie, 51*(6), 335-341.

Wolwer, W., Streit, M., Polzer, U., & Gaebel, W. (1996). Facial affect recognition in the course of schizophrenia. *European Archives of Psychiatry and Clinical Neuroscience, 246*(3), 165.

Young, A. W. (2002). *Facial expressions of emotion Stimuli and tests*. Bury St. Edmunds: Thames Valley Test.

VITA

Shiho Tsutsui was born in Japan, on September 13, 1977. After graduating from Ohstuma-Tama High School, Tokyo, Japan, in 1997, she entered Kumamoto University. She received the degree of Bachelor of Science in Pharmacy in March 2003. During the following years, she worked as a research associate to study three-dimensional protein structure at the University of Tokyo. After deciding on a career change in August 2006, she enrolled at the University of Mississippi and began her studies in psychology. She received her degree of Bachelor of Arts in Psychology in May 2008. In August 2008, she entered the Graduate College of Texas State University-San Marcos.

Permanent Address: 3465 Greystone Drive

Austin, Texas 78731

This thesis was typed by Shiho Tsutsui.