Inter- and Intrapersonal Body Perception in Schizophrenia

By

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CHAPTER I

OVERVIEW

The major aim of this dissertation is to elucidate key mechanisms underlying abnormal social cognition in schizophrenia by implementing innovative and ecologically valid methodology. Social cognitive deficits are a significant barrier to intact social functioning in individuals with schizophrenia and are present throughout the illness course (Couture, 2006; Kohler, Walker, Martin, Healey, & Moberg, 2010). In addition to expanding upon our current understanding of social cognitive deficits in schizophrenia, the series of experiments presented in this dissertation, are intended to examine the interaction between the internal emotional experience of individuals with schizophrenia and their understanding of others' emotional states and intentions in the external world. In recent years, there has been increasing interest in the interplay between one's own emotional experiences and the understanding of other's emotional experiences (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Niedenthal, 2007). Indeed, there appears to be a growing body of research suggesting that one of the ways in which we come to understand the emotional states of others is through a "sharing" of their emotional experience (Neal & Chartrand, 2011; Niedenthal, 2007; Ochsner, 2008). While a number of names have been used to describe the neural substrates of this "shared representation" of emotional experiences (e.g. mirror neuron system; (Iacoboni, 1999), a shared representation network has been put forth as the network underlying this process of understanding others' emotional states by instantiating the congruent emotional state within ourselves (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005;

Nummenmaa, Glerean, Hari, & Hietanen, 2014; Zaki, Davis, & Ochsner, 2012). How such a process plays out in individuals with schizophrenia is only beginning to be explored systematically.

CHAPTER II begins with an overview of the literature on emotion recognition across several different channels (e.g. facial expression and body movement) in schizophrenia. Research methods in this area has been dominated by the use of static images of facial expressions representing discrete emotions (Kohler et al., 2010). While the facial emotion recognition is of significant importance in adaptive social functioning, recognition of other socially relevant cues (e.g. one's gender or disposition) is also central to an individual's functional capacity in social situations (Couture, 2006; Horan et al., 2012). Chapter II will further evaluate the literature on emotional functioning in individuals with schizophrenia and the sub-processes underlying emotion perception that interact to engender subjective emotional experiences. Finally, the integrity of the "shared network hypothesis" (Singer, 2006; Singer & Lamm, 2009) will be applied to the case of schizophrenia. Systematic analysis of social cognitive deficits in individuals with schizophrenia within this framework could lead to new perspectives and potential solutions to understanding the intractable social functioning deficits of schizophrenia and related conditions.

CHAPTER III presents a study investigating the accuracy of socio-emotional recognition, using dynamic walking avatars, in inpatients with schizophrenia currently experiencing acute psychotic symptoms. While deficits in socio-emotional recognition are present across the course of illness (Horan et al., 2012; Kohler et al., 2010), how these deficits potentially interact with schizophrenic symptomatology is important to determine as difficulties in recognizing the emotional states of others, or false perception and interpretation of social cues could reaffirm or strengthen delusions that are exacerbated in acute psychosis and further hampers social interactions (Green & Phillips, 2004; Hoffman, 2007).

CHAPTER IV presents a study which investigates the generalizability of a currently accepted causal explanation for emotion recognition deficits in schizophrenia, which suggests that social deficits arise from inattention to the emotionally salient aspects of the face (Loughland, Williams, & Gordon, 2002a; 2002b; Williams, Loughland, Green, Harris, & Gordon, 2003). By comparing the visual scanning behavior of individuals with schizophrenia to that of healthy controls, this study directly tests the hypothesis that emotion recognition deficits arise from inattention to the salient aspects of social stimuli in the external world.

CHAPTER V focuses on how individuals with schizophrenia perceive their own emotional experiences; a departure from the previous chapters that examined the mechanisms underlying perception of others. Furthermore, perception of one's own emotional experience is investigated by exploring how individuals with schizophrenia respond, physiologically, subjectively, and expressively, to emotionally-laden social and nonsocial scenes.

CHAPTER VI presents a study that indirectly examined how shared representations of emotional experiences break down in individuals with schizophrenia. By using avatars expressing facial emotions dynamically while concurrently measuring electromyographic activity in muscles responsible for producing the facial expressions, the study aimed to index the congruence of this shared representation and its role in the explicit recognition of the expressed emotions (Davis, Senghas, Brandt, & Ochsner, 2010; Neal & Chartrand, 2011).

CHAPTER VII summarizes and integrates findings described in the previous chapters. Together, this series of experiments investigated the nature of social cognitive deficits from a “body-centric” perspective, thus further expanding our understanding of how we recognize and interpret the bodily movements of others, and how the phenomenological experience of our own bodies may lead to our emotional experience. The evolutionary course of our species has given rise to incredible social cognitive abilities that allow us to consider and understand those around us as having unique states and motivations. It is important to remember that these abilities evolved in the context of a body that directly experiences the environment and that our minds “experience” this environment through that body.

CHAPTER II

SOCIO-EMOTIONAL RECOGNITION AND FUNCTIONING IN SCHIZOPHRENIA

Emotion Recognition

The ability to accurately detect and identify the emotional states of others is an important component of social functioning (Hooker & Park, 2002; Pinkham & Penn, 2006) and predicts functional outcome in schizophrenia (Hooker & Park, 2002; Pan, Chen, Chen, & Liu, 2009; Pinkham et al., 2014; Sergi, Rassovsky, Nuechterlein, & Green, 2006). Emotion recognition has been consistently shown to be impaired in individuals with schizophrenia (Edwards, Jackson, & Pattison, 2002; Kohler et al., 2010; 2003) including first-episode patients (Herbener, Hill, Marvin, & Sweeney, 2005), unaffected first-degree relatives (Kee, 2004; Phillips & Seidman, 2008), and individuals at elevated risk for schizophrenia (Amminger, Schafer, et al., 2012a; Amminger, Schäfer, et al., 2012b; Cohen, Mohr, Ettinger, Chan, & Park, 2015; Gooding & Tallent, 2003; Phillips & Seidman, 2008). Such deficits seem to be independent of medication status and demographic factors (Kohler et al., 2010).

In the assessment of emotion recognition capacity in individuals with schizophrenia, the majority of the methodologies have relied on presentation of static images of faces posed to express discrete emotions (e.g. happy, angry, sad, disgust, fear, surprise, and neutral; (Ekman, 1992; Kohler et al., 2010). Individuals with schizophrenia show particular impairment in the recognition of negative emotions (e.g. fear or anger) from static faces (Dickey et al., 2011; Hooker & Park, 2002; Johnston, Stojanov, Devir, & Schall, 2005; Kerr & Neale, 1993; Kohler et al., 2003; Pan et al., 2009). Some have argued that this selective deficit for negative emotions is driven by anomalous neural processing of negative emotion expressions (Kohler et al., 2003; Phillips et al., 1999) but this selective deficit may in fact be due to the design of the tasks used to assess emotion recognition deficits. Typically, emotion recognition tasks assess one positive emotion (e.g. happiness) and a number of negative emotions (e.g. sadness, anger, and disgust). The structural overlap for the negative emotions in facial expressions leads to greater difficulty parsing apart the negative emotions. This translates to variation in the difficulty level for perceiving a particular negative emotion while leaving the difficulty of perceiving the positive emotion unaffected. When stimuli are matched in terms of perceptual difficulty, across both positive and negative emotions, this selective deficit for negative emotions disappeared (Johnston, Devir, & Karayanidis, 2006).

Eye movement patterns have been used to understand the role of attention in emotion perception from visual stimuli. In a seminal study by Walker-Smith and colleagues (1977), healthy participants were found to engage in a distinct pattern of eye movements and fixations when viewing emotional faces. Specifically, fixations and movements were concentrated around the areas of the face that were most engaged in the expression of emotions (e.g. eyes and mouth). Studies using eye-tracking with clinical populations indicate that, compared to healthy individuals, patients with schizophrenia exhibit restricted patterns of movements and fixations given static visual stimuli (Loughland, Williams, & Gordon, 2002b; Streit, Wolwer, & Gaebel, 1997). Furthermore, patients with schizophrenia tend to fixate on areas of the face that are not typically rich in emotional cues (Loughland, Williams, & Gordon, 2002a). This restricted visual scanning pattern also appears to be specific to schizophrenia. Loughland and colleagues (2002a) found that compared to patients with schizophrenia, those with affective disorders showed greater allocation of fixations to the eyes and mouth. This suggests that these visual scanning abnormalities maybe specific to schizophrenia and not just the result of having a severe mental illness. In fact, aberrant visual scanning behavior is also present in healthy, un-medicated first-degree relatives of individuals with schizophrenia, which rules out a simple medication effect (Loughland, 2004). Finding similar deficits in first-degree relatives is also suggestive of a trait rather than state deficit. Importantly, amount of fixation to the eyes and mouth was associated with recognition performance of the emotions presented.

When one considers how emotional expressions occur in the real world, ebbing and flowing with the tide of possible emotional elicitors, it is fairly surprising and somewhat disconcerting that so many studies investigating such a crucial social cognitive process have used stimuli devoid of movement. While few and far between, studies have begun to use dynamic stimuli when presenting emotional facial expressions when investigating capacity for recognizing emotions in this population. Given that there is some evidence that dynamic emotional facial expressions are more readily identified than static (Harwood, Hall, & Shinkfield, 1999; Weyers, Muhlberger, Hefele, & Pauli, 2006), one might expect that individuals with schizophrenia would display a similar advantage when presented with more ecologically valid stimuli. Such a case can be made because there is some evidence that dynamic expressions may engage predictive visual mechanisms (Kaufman & Johnston, 2014). Using a visual cuing paradigm, Kaufman and Johnston (2014), found that participants' response time was reduced when they were cued with a dynamic facial expression that was congruent, versus incongruent, to the probe stimulus. The authors argued that the dynamic nature of the stimuli may be engaging simulation processes that might underlie the recognition of other's emotional expressions. Such a possibility will be discussed in greater detail in the final section of this chapter. To my knowledge, there has been only one study that directly compared emotion recognition performance on static and dynamic emotional facial expressions in individuals with schizophrenia and this study did not find a facilitative effect on performance in the dynamic condition (Johnston et al., 2010). Other studies have used dynamic emotional facial expressions and have found performance deficits in individuals with schizophrenia compared to controls (Archer, Hay, & Young, 1994). Given the paucity of studies exploring emotion recognition capacity in this population using dynamic stimuli, further study is greatly warranted.

A common feature of these visual scanning studies presented previously, is the use of static images of emotional expressions. As noted earlier, facial expressions of emotion are dynamic across time and the movements of the different regions of the face provide us with direct clues for decoding the emotion. Moreover, each region of the face captures the viewer's attention at different points in time depending on how they move. Such dynamic information from different areas of the face is lost when one uses a static image as the target stimuli. What is left is a stimulus that treats each component of the face as equal, vying for the perceiver's gaze. Motion onset has been shown to capture attention (Abrams & Christ, 2003), therefore by removing the motion component in facial expressions, we remove the built-in advantages for attentional capture by the regions of the face rich in emotional information. This forced equivalence between the different features of the face may be inducing these aberrant visual scanning patterns in individuals with schizophrenia. To our knowledge, no study has examined visual scanning patterns of dynamic facial expressions in individuals with schizophrenia. By foregoing the use of more naturalistic stimuli, the current interpretations of the emotion recognition deficits found in schizophrenia are incomplete.

Telegraphing Social Information: Cues from the body

Perceiving and recognizing social cues expressed in body movement is an important component of effective social functioning. One can perceive another's gender (Troje, Sadr, Geyer, & Nakayama, 2006), identity (Troje, Westhoff, & Lavrov, 2005), emotional state (Atkinson, Dittrich, Gemmell, & Young, 2004; Dittrich, Troscianko, Lea, & Morgan, 1996; Roether, Omlor, Christensen, & Giese, 2009), and health (Kramer, Arend, & Ward, 2010) based on the way in which a person moves his/her body. Some of this information comes from the biological constraints of sexual dimorphism, as is the case in perceiving gender. On average, men have greater shoulder-to-hip ratio, whereas women, on average exhibit an equal or reduced shoulder to hip width (Murray, Drought, & Kory, 1964). These structural differences lead, in part, to differences in the movement (e.g. swaying hips in female gait) that provide us with cues for determining gender. In fact, it is this stereotypic movement found in male and female gait that provides us with clues into far more complex social information. Sexual orientation can be discerned from others' gaits insofar that the individual's gait violates the stereotypic movement of his/her gender (Johnson, Gill, & Reichman, 2007). This was confirmed both through the presentation of LGBT individual's gaits (both males and females) to naïve participants as well as through manipulation of computer generated point-light displays (PLDs;

Johansson, 1976) that were adjusted for their hip sway while shoulder-to-hip width ratio was kept constant.

Social information extracted from the body is important in deciding how to engage with potential social partners (or not to engage at all). In fact, such initial and basic social information processing influences our interpretation of more complex features such as social traits (Thoresen, Vuong, & Atkinson, 2012). Even when bodily cues are obtained from very sparse or impoverished stimuli such as PLDs (Johansson,

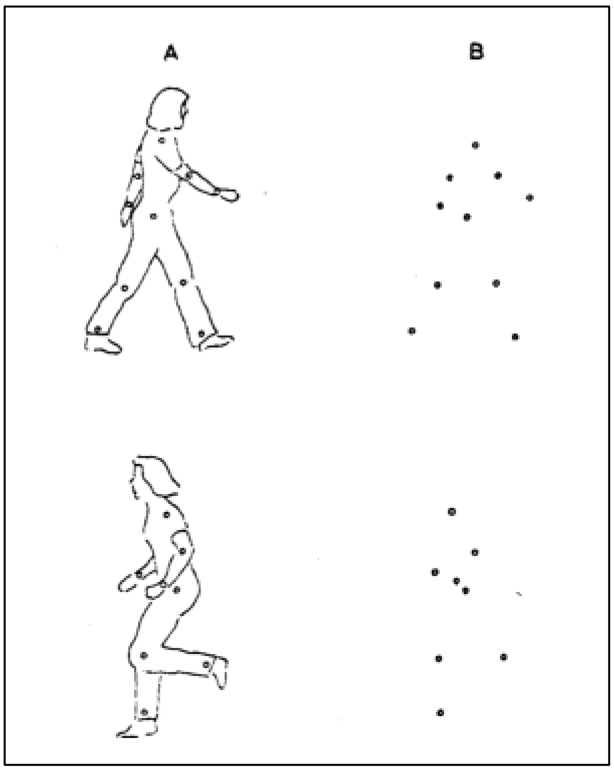

Figure 1. Adapted from Johansson (1976) the figures in under A show the positioning of the reflective diodes on the human that, when moving, provide the percept of a person moving. As can be seen in the figures under B, the human form can be difficult to discern when static.

1976), social traits can be accurately extracted from gait. Accurate identification of social and emotional information from body movement allows for response preparation at a distance; invaluable in determining whether to approach or withdraw, long before the face becomes accessible at which point it might be too late to make a decision. Imagine being in a dark alley and someone begin to approach you. By having the ability to recognize your friend by their characteristic gait, your response to their approach is drastically different than if you had to wait until their face was visible. It is for reasons like these and more that the ability to perceive social cues from body movement is so important.

More recently, some researchers have begun to examine social information processing using bodily cues with the PLDs (Johansson, 1976). Both generalized and specific deficits in emotion recognition from the body were found in individuals with schizophrenia. Henry and colleagues (2010) reported a selective deficit for the recognition of fear presented with PLDs. Couture and colleagues (2009) found that individuals with schizophrenia showed impairment in recognizing a number of emotions presented in body movement but unlike the findings of Henry and colleagues (2010), they did not find specificity of emotion recognition deficits (Couture et al., 2009). Individuals with schizophrenia showed impairment in the recognition of happiness, anger, fear, and sadness when presented with PLDs. This result diverges somewhat from the results of studies that used static faces (i.e. they report more deficits of negative emotion recognition). Typically, individuals with schizophrenia show less impairment in recognizing positive emotions in facial expressions. As noted previously, this “specific deficit for negative emotions” may be an artifact of how the task is constructed (Johnston et al., 2006). Given the importance of the upper parts of the body for expressing emotional states across both positive and negative emotions (Roether et al., 2009), the methodological artifact found in other emotion recognition studies using faces may be ameliorated with dynamic body stimuli. Peterman and colleagues (2014) also found that not only were individuals with schizophrenia less sensitive to the perception of emotional gaits, they were also impaired in perceiving other important social information like gender. Furthermore, the "intensity" of the social information in the gait, while providing a significant boost in performance in the patient group, did not erase the significant impairment seen compared to healthy individuals. This suggests that individuals with schizophrenia are potentially able to pick up on the social cues of others when exaggerated or less ambiguous but that there is still a gap in understanding what is being expressed by others.

Emotion recognition deficits have also been found using static images of emotional body postures (Bigelow et al., 2006; Van den Stock, de Jong, Hodiamont, & de Gelder, 2011). In a study comparing individuals with schizophrenia and healthy controls on emotion recognition performance using both PLDs and static posture stimuli, Bigelow and colleagues (2006) found a greater performance deficit on the postural task than the PLD task. Van den Stock and colleagues (2011) used a target-matching paradigm with static postural images whereby one image was the target and participants had to choose from two other images which one matched the expressed emotion in the target image. A control task was used in which participants were asked to match instrumental full-body actions (e.g. putting on pants). Individuals with schizophrenia were more impaired in matching the emotional postures than individuals with affective psychosis and healthy controls. Therefore, there is growing evidence of emotion recognition deficits when the body is used as the target stimuli.

As noted previously, in addition to being able to recognize the emotional states of others from a number of different channels (e.g. face, voice, and body) one needs to be able to make accurate social attributions about others in their environment. When deciding to interact with a potential social partner, we not only make judgments on their emotional state but also on whether they are approachable (Campbell, Neuert, Friesen, & McKeen, 2010), attractive (Koppensteiner & Grammer, 2011), or threatening (Heberlein, Adolphs, Tranel, & Damasio, 2004). Furthermore, such judgments are likely made from a distance, using cues from body movement, so that one may make a decision of engaging with conspecifics or not. There have been a number of studies investigating social trait perception in individuals with schizophrenia but few have used body movement as the principal stimulus (Bigelow et al., 2006; McIntosh & Park, 2014; Trémeau et al., 2016). Detection trustworthiness from static faces has been examined frequently in individuals with schizophrenia partly because of its potential impact on paranoia and social interactions. Findings have been mixed. Some studies found that individuals with schizophrenia rated other people's faces as less trustworthy than did health participants (Pinkham, Hopfinger, Pelphrey, Piven, & Penn, 2008). In contrast, other investigators have obtained higher ratings of trustworthiness from individuals with schizophrenia than healthy controls (Baas, van't Wout, Aleman, & Kahn, 2007; Trémeau et al., 2016). Lastly, some studies have reported no difference in trustworthiness ratings between the two groups (McIntosh & Park, 2014). When more complex social stimuli such as social vignette videos were used by researchers to examine perception of trustworthiness, the ratings provided by the patient group were positively associated with their current degree of positive symptoms (McIntosh & Park, 2014). In other words, the more psychotic patients tended to give more positive trustworthiness ratings. Such mixed findings suggest there needs to be more systematic research to understand the relationship between social trait judgments and symptomatology in individuals with schizophrenia.

Emotional Functioning in individuals with schizophrenia

Appropriate emotional responses within an ongoing social context are crucial to navigating interpersonal relationships but in schizophrenia, components of emotional responses such as subjective experiences, expression and physiological arousal may be fragmented rather than cohesively integrated. In general, subjective emotional experiences in-the-moment appear to be either intact or even exaggerated in schizophrenia whether in the laboratory (Kring & Neale, 1996; Herbener et al., 2008; Cohen & Minor, 2010; Folley & Park, 2010; Cumming et al., 2011), or in daily life (Myin-Germeys & Delespaul, 2000), but the outward expression of emotions may be compromised. Facial expressions of emotion are reduced in schizophrenia even when they report experiencing an emotion (Berenbaum & Oltmanns, 1992; Earnst & Kring, 1999; Kring & Moran, 2008). Similarly, production of emotional prosody in speech has been shown to be impaired in schizophrenia (Borod et al., 1989).

While overt facial expressions are reduced in schizophrenia, recruitment of facial muscles involved in the production of emotional expressions may be intact, as detected by facial electromyography (fEMG) (Kring et al., 1999). In general, increased zygomatic activity corresponds to positive/pleasant stimuli and increased corrugator activity to negative/aversive stimuli. Facial electromyography data suggest that although overt facial expressions may be imperceptible to the observer, individuals with schizophrenia may be engaging the facial muscles associated with these expressions, albeit at an attenuated level. (Mattes, Schneider, Heimann, & Birbaumer, 1995; Wolf, Mass, Kiefer, Wiedemann, & Naber, 2006).

Several studies have investigated perception and production of prosody in individuals with schizophrenia across different emotion-induction paradigms. Affective prosody in speech appears to be reduced in those with schizophrenia (Cohen, Kim, & Najolia, 2013; Cohen, Mitchell, & Elvevåg, 2014; Martínez-Sánchez et al., 2015). Using automated acoustic analysis, Martinez-Sanchez and colleagues (2015), found that individuals with schizophrenia displayed flatter intonations and reduced variability in trajectory of speech. By using automated analysis, the authors were able to eliminate potential biases in subjective coding or ratings. Importantly, this study employed the use of a neutral text as the stimulus participants read rather than an emotionally laden piece or emotional prompts for self-generated prose. The argument for this was based on idea that typically, one rarely speaks on discrete, high intensity emotional topics and that a more ecologically valid assessment is to investigate the natural prosodic variation in everyday speech.

Emotional responses are accompanied by physiological changes that indicate valence and arousal (Keltner & Gross, 1999; Levenson, 1992). Autonomic arousal in response to emotional stimuli can be assessed with the galvanic skin response (GSR) but the findings are mixed. GSR to emotional stimuli in schizophrenia has been reported to be increased (Kring & Neale, 1996), reduced (Venables & Wing, 1962) or unchanged (Hempel, Tulen, van Beveren, Mulder, & Hengeveld, 2007; Hempel et al., 2005). One reason for these contradictory findings may be that GSR is influenced by multiple factors including attentional orienting, as well as the social significance, salience and relevance of the stimulus. Socially relevant stimuli are known to enhance attentional orienting (Öhman et al., 2001; Schuller & Rossion, 2004) regardless of valence and the ability to orient to social stimuli is closely related to shared attention mechanism that facilitates social interactions (Dawson et al, 1998; Langton & Bruce, 1999).

Emotional experiences can change significantly depending on the social context. Nonsocial emotions are associated with appetitive or aversive stimuli with direct biological or survival relevance (e.g., food, weapon), whereas social emotions such as joy or sadness are thought to arise in the context of human interactions or relationships, but these two types of emotion are not independent, can co-exist, and recruit overlapping and distinct neural networks. Indeed, a number of studies investigating the role of sociality in emotional responses in the healthy population suggest that our responses to emotional events are intimately tied to their social context (Britton, Phan, Taylor, Welsh, Berridge, & Liberzon, 2006a; Britton, Taylor, Berridge, Mikels, & Liberzon, 2006b; Norris, Chen, Zhu, Small, & Cacioppo, 2004). In one of the first studies to directly investigate the interplay of social and emotional content in the brain, Norris and colleagues (2004), found significant overlap in the activation of brain areas implicated in the processing of emotional and social information (e.g. IAPS images) such as the inferior frontal gyrus, medial prefrontal gyrus, and the amygdala. In some instances, brain activation pattern for social stimuli depended on the emotional nature of the stimuli; the superior temporal sulcus, occipito-temporal sulcus, and thalamus showed greater activation for emotionally-valenced social images than neutral social images, suggesting that there is greater recruitment of the regions when social situations are of an emotional nature. An additional finding, and unexpected finding was that participants rated the emotional social images as being more extreme than the emotional non-social images, a finding that was also seen in a later study of subjective and physiological responses to social and non-social emotional scenes (Britton, Taylor, Berridge, Mikels, & Liberzon, 2006b; Norris et al., 2004).

In schizophrenia, differential physiological responses to social and nonsocial stimuli have been observed using the post-auricular reflex paradigm, which indexes automatic response to pleasant stimuli (Aaron et al., 2013). The postauricular reflex was enhanced for positively valenced social scenes from the International Affective Pictures System (IAPS; Lang et al., 2008) (e.g. erotica and nurturing scenes containing humans), but not for pleasant non-social pictures (e.g. beautiful nature). Importantly, if the sociality factor had not been examined, the authors would have concluded that the physiological responses in individuals with schizophrenia to pleasant emotional stimuli were reduced overall, missing this crucial interaction. The role of sociality in emotional images and their effect on emotional responses has also been investigated in psychometrically identified at-risk individuals who showed intact modulation of the startle eye blink response when presented with positively, negatively, and neutrally valenced images (Gooding, Davidson, Putnam, & Tallent, 2002). Furthermore, there were no differences between the groups when the researchers looked at the role of sociality in startle eye blink modulation. Given that the groups did not differ in their responses, both groups were pooled together which did indicate that there was greater attenuation of the startle eye-blink magnitude when viewing positively-valenced social images (Gooding et al., 2002). These findings underscore the importance of examining sociality dimension in emotion tasks.

Shared representation in individuals with schizophrenia

William James (1932) placed the body firmly at the center of emotional experience. He argued that we experience changes to our physical state and then interpret these changes as emotional states. In other words, according to James, "we feel sorry because we cry, angry because we strike, afraid because we tremble, and [it is] not that we cry, strike, or tremble, because we are sorry, angry, or fearful, as the case may be" (James, 1884).

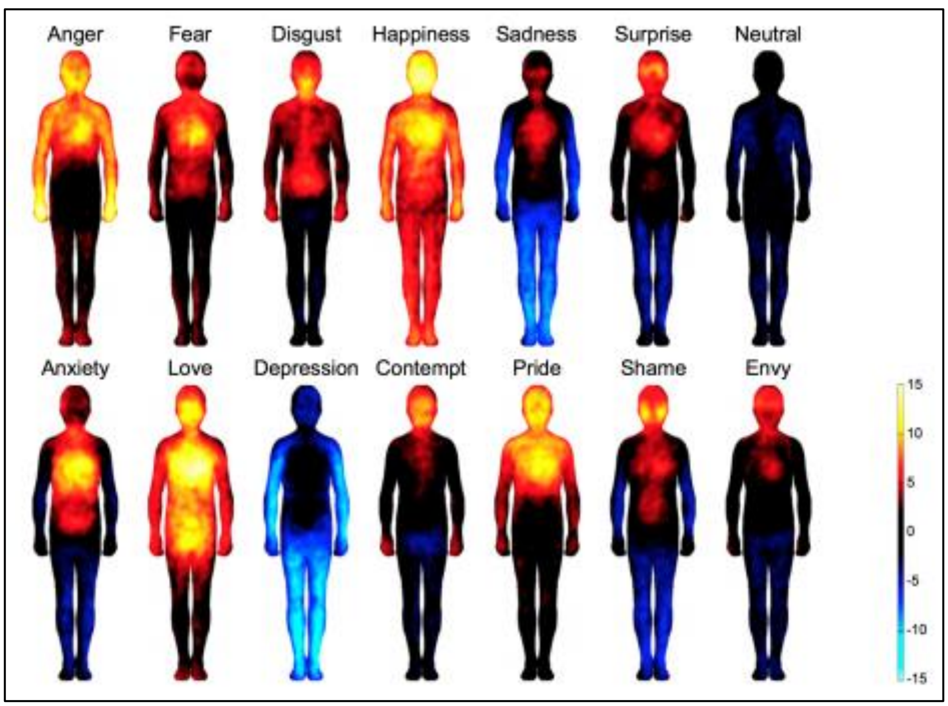

Figure 2. Adapted from Nummenmaa et al. (2014). Examples of the topographical maps showing differential distributions of bodily sensations when experiencing different emotions.

Interestingly, emotional responses seem to be experienced in the body in similar ways across different cultures, suggesting the universality of bodily responses that give rise to emotions (Nummenmaa et al, 2014). Whether it's the butterflies one feels when in love or the muscle tension another feels in rage; subjective emotional experiences are coupled with somatovisceral responses. Nummenmaa and colleagues (2014) generated average maps of subjectively felt bodily sensations (see figure 2) that are associated with different emotions from a very large sample (n=701), using a topographical self-report method. Participants were asked to color the regions of the body corresponding to increasing or decreasing sensations while viewing emotional stimuli. Across different cultures, different emotions were consistently associated with statistically separable bodily sensation maps regardless of the stimulus types.

There is strong evidence for the importance of the bodily experiences in emotions processing. For decades, there have been compelling arguments for the role of facial expressions in not only expressing our emotional states to others but facilitating our understanding of other's emotional states (Adelmann & Zajonc, 1989; Niedenthal, Mermillod, Maringer, & Hess, 2010). In some instances this has been correlational, studies finding that those who show greater facial mimicry reporting greater levels of empathy (Dimberg & Andréasson, 2011), but has also been found in experimental manipulation of participants' facial musculature. When facial musculature are injected with BOTOX, a muscle paralytic, reductions in both emotion recognition accuracy (Neal & Chartrand, 2011) and self-reported emotional experience are found (Davis et al., 2010). By manipulating the afferent signals provided by the facial musculature involved in the expression of a given emotion, modulation of visual perception for that emotion occurred (Neal & Chartrand, 2011). Furthermore, subjective emotional experience in response to emotionally evocative scenes was reduced when individuals were prevented from engaging facial musculature associated with their internal emotional experience (Davis et al., 2010). In a study looking at facial mimicry in individuals with schizophrenia during an emotion recognition task, those individuals showed reduced recruitment of congruent musculature during viewing of static emotional faces (e.g. happy and sad expressions) which the authors interpreted as being evidence for a reduced empathic capacity (Varcin, Bailey, & Henry, 2010). A more recent study, using dynamic stimuli found contrary evidence, specifically that individuals with schizophrenia showed intact recruitment of the corrugator muscle during presentation of sad stimuli but reduced or inadequate recruitment of the zygomatic muscle during presentation of positive stimuli (Sestito et al., 2013). Interestingly though, Sestito and colleagues (2013) did not find deficits in the recognition of the emotions presented in the patient group, although, the stimuli used were either videos of individuals laughing or crying and participants were required to judge the valence rather than discrete emotion presented. Thus, in the healthy population, there is compelling evidence for the reciprocal nature of facial mimicry in the experience of one's own emotions and the understanding of other's emotions and how this plays out in individuals with schizophrenia is still open to exploration.

The theory of embodied emotion provides a unifying framework for the interplay between the physical experience and mental processing of emotional stimuli. Niedenthal (2007) argues that the experience of emotions in response to an evoking stimulus and recollection of that evocative stimulus engage similar representations in the brain (see figure 3 for an example of these processes). When applied to perception of other's

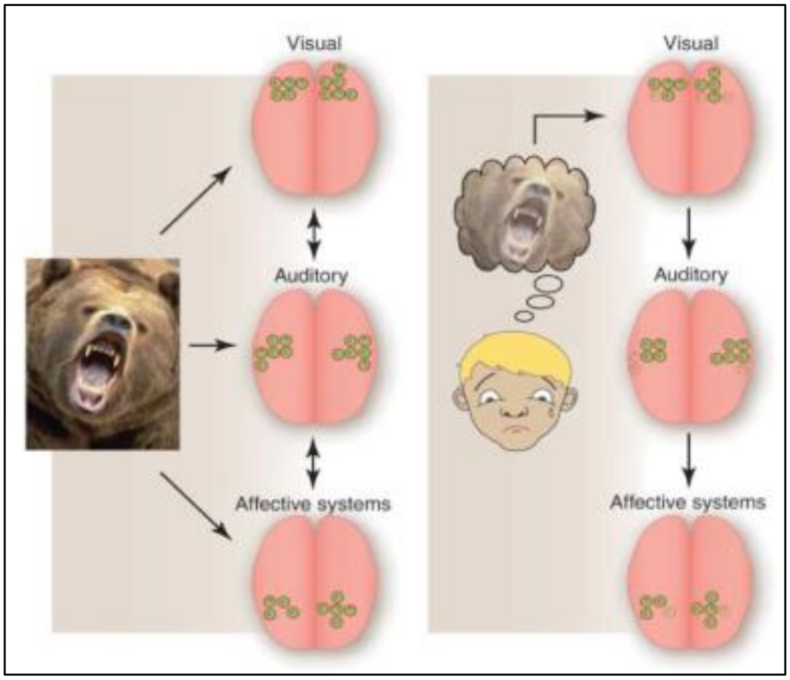

Figure 3. Adapted from Niedenthal (2007) this figures provides an example of what is believed to be occurring during both the actual experience of the emotion of fear when faced with an evocative stimulus (e.g. a snarling bear) and what occurs neurally when we re-imagine that experience. The same visual, auditory, and affective systems engaged when in the presence of the bear are reactivated, to a degree, during our recollection of emotionally evocative events.

emotional expressions, a similar engagement process occurs. Rather than engaging in abstract pattern matching of an individual's emotional expression to a stored exemplar of that emotion, embodied emotion theory posits that the visual percept of the expression activates the associated affective systems involved in experiencing the perceived emotional expression. Indeed, studies have shown that we engage in spontaneous mimicry of other's emotional expressions during interactions and this mimicry is correlated with self-report of empathic tendencies (Chartrand & Bargh, 1999; Niedenthal et al., 2005). Connectedness with others and their emotional experiences may thus result from the 'mirroring' of their expressions. The adage of "walking a mile in another's shoes" is a particularly apt description in this context.

If processing other's emotional expressions is facilitated by the matching of a percept (usually visual or auditory) to internal experience, then one would expect that this mirroring to occur on a neural level. Originally discovered in the premotor cortex of non-human primates, there are populations of neurons that fire during the observation of an action and the execution of the same action (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Fabbri-Destro & Rizzolatti, 2008; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). Functional neuroimaging in humans has provided evidence for the presence of mirror mechanism in humans as well (Iacoboni, 1999; 2005). The mirror neuron system provides a mechanism by which the perception of an action can be matched to the motoric production of the action. Action perception is mediated by the posterior superior temporal sulcus (Grossman & Blake, 2002; Iacoboni, 2005) and transformed to motor plans via the inferior parietal lobule (Buccino et al., 2008; Iacoboni, 1999). The goal of the action is then represented in the inferior frontal gyrus (Iacoboni et al., 2005). This network of temporo-parietal and prefrontal regions supports social information processing through which we internally model the external world in order to understand other people's actions without having to actually perform the same act. (See figure 4 from Thakkar et al, 2014). Thus, we are able to understand the world through internal simulation.

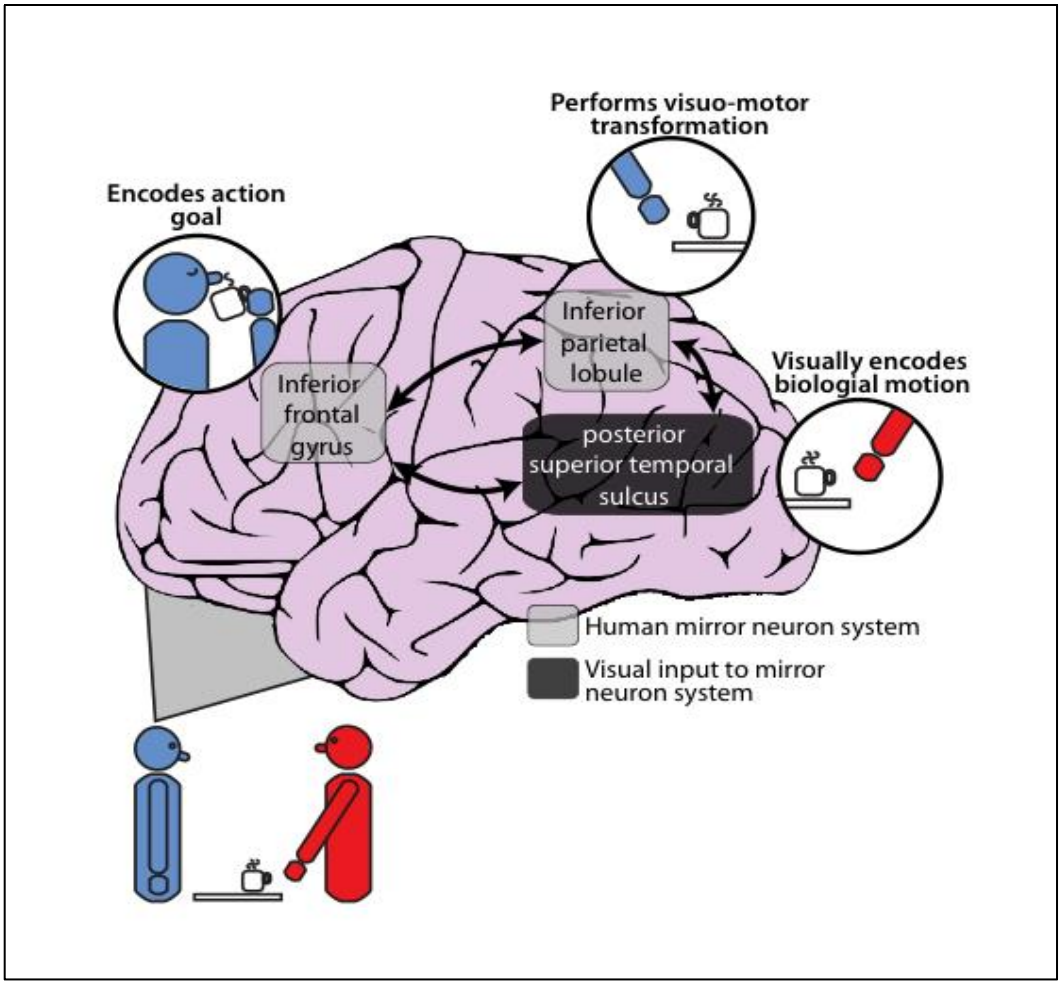

Figure 4. Schematic of the core components of the mirror neuron system. Visual information comes into the pSTS where it is then sent through the inferior parietal lobule, which translates the visual information into a motor plan. This information is then sent to the inferior frontal gyrus where the goal of the action is coded (Adapted from Thakkar, Peterman, & Park, 2014).

Further support for the role of embodiment in the processing of other's emotional expressions comes from neuroimaging studies that showed common brain regions that increase activity when perceiving other's emotions and experiencing emotions. Wicker and colleagues (2003) showed that areas of the insula display overlapping regions of activation during the experience of disgust and the perception of other's disgust expressions. Brain activation associated with presentation of noxious odorants was compared to activation during viewing of disgusted faces. The anterior insula increased activation for these two conditions, suggesting a mapping of the external (visual) world with the internal (experiential) world. Additionally, Carr and colleagues (2003) have shown engagement of the anterior insula and the inferior frontal gyrus during viewing and imitation of emotional facial expressions. It remains to be seen if the anterior insula displays mirror-like activity similar to the inferior frontal gyrus and inferior parietal lobule. What does seem clear is that perception of other's expressions engages the same neural circuitry involved in the experience of emotion.

This mirror mechanism in individuals with schizophrenia has been studied both behaviorally and with functional neuroimaging. Thakkar and colleagues (2014) found that activity in parietal areas involved in the translation of visual information into motor plans was altered in individuals with schizophrenia. Indeed, individuals with schizophrenia display deficits in imitation of manual gestures, facial expressions and mouth movements (Matthews, Gold, Sekuler, & Park, 2012; Park, Matthews, & Gibson, 2008). Thus deficits in emotion recognition of schizophrenia patients could be due to a disruption in the seemingly automatic process of simulating other's expression (Kupper, Ramseyer, Hoffmann, Kalbermatten, & Tschacher, 2010). Without this mirroring of the external and internal world, individuals with schizophrenia may need to rely more on top-down processing (e.g. excessive use of the theory-of-mind or hyper-mentalizing) to understand other people's actions, intentions, and feelings. Hyper-mentalizing can lead to social information processing errors, which then may lead to delusions. Thus disruptions in the simulation and embodiment of emotional expressions may underlie social deficits and associated clinical symptoms (e.g. paranoia) in schizophrenia.

The nature of emotion recognition deficits in schizophrenia may be best described then as a problem of looking but not seeing. Rather than the observed deficits being the result of inattention to emotionally expressive areas of the face and body, a breakdown in the simulation of other's expression may be the culprit. If individuals with schizophrenia are not able to accurately translate the visual input into motor plans, the interpretation of these expressive gestures will be more difficult. Both neuroimaging and behavioral evidence suggest abnormalities in this mirroring process (Matthews et al., 2012; Park et al., 2008; Thakkar, Peterman, & Park, 2014). Deficits in internal simulation via mirror mechanism could result in compensatory hypermentalizing in an attempt to interpret the intentions, actions, and emotions of others in the absence of high fidelity embodied input. Such effortful process may often result in incorrect interpretation of the external social world.

Summary and Aims of the Studies

Social functioning impairment is an intractable feature of schizophrenia and has been shown to be related to the individual's social cognitive ability (Couture, 2006; Kohler et al., 2010; Sergi et al., 2006). Our understanding of the social cognitive deficits has been informed, to a degree, by investigations that do not fully capture the richness of social displays, either in an expressive capacity of emotional states, or by the use of stimuli that can more accurately capture the socio-emotional milieu. Thus the studies presented herein, attempt to expand our understanding of these social cognitive deficits by probing them in new and novel ways. As has been enumerated, the human body can provide a wealth of socially relevant information, at times even surpassing the face in its expressive capacity (Aviezer, Trope, & Todorov, 2012). There is preliminary evidence that the information contained therein is not as readily accessed by individuals with schizophrenia than by the healthy population (Bigelow et al., 2006; Couture et al., 2009; Peterman, Christensen, Giese, & Park, 2014; Van den Stock et al., 2011). Such investigations have typically been conducted with stabilized outpatients and thus may not fully capture the interplay of symptomatology and social information recognition. Therefore, the first study investigates the social cognitive performance of individuals with schizophrenia-spectrum disorders who are currently psychiatric inpatients in order to possibly capture the relationship between psychotic symptoms of recognition of social information from body movement.

The second study tests the hypothesis that emotion recognition deficits in schizophrenia are the result of inattention to regions of emotional salience on a person. While a number of studies have found that individuals with schizophrenia display reduced visual fixation and shorter duration time towards areas of the face that are involved in expression emotions (Loughland, 2004; Loughland, Williams, & Gordon, 2002a; 2002b; Williams, Loughland, Gordon, & Davidson, 1999), the limitations of these studies, specifically the lack of actual expressive motion in the emotional expressions displayed, reduce the confidence one can have in the conclusions. Thus we presented individuals with schizophrenia, dynamic emotional displays using walking avatars in order to probe the inattention hypothesis of emotion recognition deficits.

While investigating the nature and underlying cause of emotion recognition deficits in schizophrenia is the focus of the first two studies, the second two attempt to examine the possible interplay between the internal experience of one’s emotions and the understanding of other's emotional states. This interplay, in healthy individuals, has been shown to recruit overlapping neural regions in the brain (Carr et al., 2003; Wicker et al., 2003), and some have argued that our processing of other's emotional states is accomplished in part through a "shared representation" of the other individual's emotional state (Decety & Chaminade, 2003; Decety & Sommerville, 2003; Gallese, Keysers, & Rizzolatti, 2004). First, by examining the emotional response of individuals with schizophrenia to social and non-social emotional scenes, we can determine whether individuals with schizophrenia and healthy individuals are coming to social interactions and shared representations "from the same place". Exploring the aspect of sociality is crucial given that there is some preliminary evidence that individuals with schizophrenia react physiologically differently towards socially salient emotional stimuli than non-socially salient stimuli (Aaron et al., 2013), and that healthy individuals show differential physiological and subjective responses to emotionally-valenced social scenes (Britton, Taylor, Berridge, Mikels, & Liberzon, 2006b).

Finally, the last study investigates the role of shared representations indirectly through the use of electromyographical measurement during viewing of emotionally dynamic facial expressions. As previous research has shown, spontaneous mimicry of other's emotional expressions is related to self-reported empathy (Chartrand & Bargh, 1999; Niedenthal et al., 2005), and that prevention of facial mimicry to emotional expressions actually reduced the accuracy of healthy individuals in an emotion recognition task (Neal & Chartrand, 2011). Given the presence of flat affect in individuals with schizophrenia, as indexed in structured symptom interviews by the rater's observation of a lack of emotional expression both facially and vocally, one could expect that a lack of spontaneous facial musculature recruitment during an emotion recognition task could be related to a breakdown in the recruitment of the shared representation process as indexed by the breakdown in the mirror neuron system (Stegmayer et al., 2016; Thakkar et al., 2014).

Altogether, these studies contribute to extending the boundaries of our understanding of the complex nature of social cognition in schizophrenia. Investigations that are focused on exploring this process in new and dynamic ways is sorely needed as we, as a field, work towards improving the lives of individuals who experience social isolation and social rejection acutely.

CHAPTER III

SOCIO-EMOTIONAL RECOGNITION FROM DYNAMIC GAIT IN INPATIENTS WITH SCHIZOPHRENIA SPECTRUM DISORDERS

In the first of four studies, the ability to recognize emotional states and socially-relevant information (e.g. gender) is evaluated in inpatients diagnosed with a schizophrenia-spectrum disorder. To my knowledge, the exploration of this ability has not been investigated in inpatients using gait-oriented stimuli. As we approach others, or are approached by others, we must prepare to engage with others in a way that is congruent with how they present themselves. Such decisions cannot be made based on facial expressions until the individual is much closer. Therefore, the ability to evaluate others' emotional states, at a distance, is functionally adaptive. To better understand this process in individuals with schizophrenia, the ability must be probed across the disease course so that we may be able to develop interventions that target the nature of the deficits present.

In addition to investigating the integrity of recognizing others emotional states, which is directly related to social competency (Billeke & Aboitiz, 2013; Horan et al., 2012), the nature of social trait judgments based on gait is also investigated. Knowing the emotional states of others, and who it is we are going to engage with, are just part of the process of adaptive social functioning. Our ability to make judgments about others with regard to their approachability, trustworthiness, or attractiveness, is also a crucial aspect of how we prepare to interact with others (Ambady & Rosenthal, 1993; Koppensteiner & Grammer, 2011; Sebanz & Shiffrar, 2009). The nature of social trait judgments has been investigated in individuals with schizophrenia, to a degree, and the results so far have been mixed. For example, some have found increased ratings of trustworthiness (Baas et al., 2007; Trémeau et al., 2016), no difference between outpatients and controls (McIntosh & Park, 2014), or reduced trustworthiness ratings (Pinkham et al., 2008). Exploring a range of social traits, in inpatients whose active symptomatology may interact with their judgments of others' gaits can provide insight into how disruptions in social interaction with others occurs.

Methods

Participants

Sixteen individuals with diagnoses of schizophrenia spectrum disorders (14 individuals with a diagnosis of schizophrenia and 2 individuals with a diagnosis of first-episode psychosis) were recruited from an inpatient psychiatric unit in a hospital in Victoria, Australia. Recruitment of participants was done by review of medical charts in conjunction with the treating psychiatrists. Diagnoses were confirmed upon discharge of the participant from the hospital. All diagnoses were established according to the Diagnostic and Statistical Manual 4th Edition-Text-Revised (DSM-IV TR; American Psychiatric Association, 2000). Clinical symptoms were assessed at the time of testing using the Positive and Negative Symptom Scales (Kay, Fiszbein, & Opfer, 1987).

Sixteen healthy controls were recruited from the community using advertisements in Nashville, Tennessee. All controls were screened for current and prior history of Axis I disorders using the SCID (First et al, 2002) and a history of psychosis in their first-degree relatives.

Exclusion criteria were the following: IQ score lower than 85, history of head trauma, loss of consciousness, or neurological disorder.

Intelligence (IQ) was assessed using the National Adult Reading Test-Revised (NART-R; Blair & Spreen, 1989). A native Australian conducted the NART-R for the inpatients in order to control for any pronunciation differences due to accent. All participants were assessed to be of at least average intelligence. Years of education were also assessed. All participants had normal or corrected to normal vision.

Participants were matched on age, gender, and IQ. See Table 1 for demographic information and clinical information.

Table 1. Demographics and clinical information.

	Schizophrenia Mean (SD)	Controls Mean (SD)	Statistical test	p-value
Age	35.9 (11.0)	39.2 (12.3)	$t = -0.79$	0.44
Gender	3 F / 13 M	4 F / 12 M	$Chi^2 = 0.18$	0.67
IQ	104.5 (10.0)	109.6 (7.4)	$t = -1.58$	0.12
PANSS-Positive	19.1 (5.8)	N/A	N/A	N/A
PANSS-Negative	16.2 (5.7)	N/A	N/A	N/A
SPQ		11.9 (12.3)		
Cognitive	N/A	1.92 (2.9)	N/A	N/A
Interpersonal		3.67 (2.2)		
Disorganized		2.92 (3.9)		

IQ, intelligence estimated by the National Adult Reading Test-Revised (NART-R); PANSS, Positive and Negative Symptom Scales; SPQ, Schizotypal Personality Questionnaire; N/A, not applicable.

Apparatus and Stimuli

The stimuli used in the current study have been used in previous investigations into the perception of emotion and gender from gait (Roether et al, 2009; Peterman et al, 2014). Stimuli were presented on a 1280 x 800 screen. The stimuli were presented in the middle of the screen with a vertical visual angle of 14.37°. In the Emotion Recognition task, three emotions (Happy, Angry, and Sad) and a Neutral or "no emotion" avatar were used. For the emotional avatars, parametrically adjusted stimuli were used to display attenuated (50%), typical (100%), and exaggerated (150%) intensities of the emotions. Similarly, in the Gender Recognition task, Male and Female avatars were used with parametrically adjusted stimuli displaying the attenuated, typical, and exaggerated gendered movements. Finally, in the Social Traits Judgment task, the "typical" or 100% intensity stimuli were used and all stimuli (Male, Female, Happy, Angry, Sad, and Neutral) were presented. See Figure 5 for an example of the stimuli used.

Figure 5. Examples of the four emotions used in the study. The 100% intensity avatars are presented.

Procedure

Participants were administered the three tasks (Emotion Recognition Task, Gender Recognition Task, and Social Traits Judgment Task) in a randomized order so as to control for possible order effects.

In the Emotion Recognition Task, participants viewed the avatar walking for three seconds, after which the avatar disappeared from the screen and the participant was required to indicate which emotion they believed was being expressed in the avatar's gait. Responses were recorded via the keyboard with "C" indicating Happy, "V" indicating Angry, "B" indicating Sad, and "N" indicating neutral or no emotion. Stickers were placed on the keys with the emotion words in order to reduce working memory load when choosing a response. One hundred and sixty trials were administered in eight blocks (20 trials per block). Ten practice trials were administered at the start of the task in order to orient the participant to the task and were not included in the analyses. Each individual stimulus was presented an equal number of times per block in a randomized order. At the beginning of the task, participants were instructed to watch the walking avatar and choose, out of the possible options provided, which emotion best identified which emotion they believed was being expressed in the avatar's walk.

In the Gender Recognition Task, participants viewed the walking avatars for three seconds and upon the avatar disappearing from the screen, indicated whether they believed the avatar's gait indicated it was male or female. Responses were recorded via the keyboard with the "A" key indicating Female and the "L" key indicating Male. One hundred and forty-four trials were administered across eight blocks (18 trials per block). Six practice trials were presented at the start of the task and were not included in the analyses. All gendered stimuli were presented an equal number of times, randomly, within each block. Participants were instructed at the beginning of the task, to watch the avatar walk and then when the avatar disappeared, decide whether the avatar's movement would indicate if it was a male or female.

In the Social Traits Judgment Task, four social traits (Approachability, Attractiveness, Threatening, and Trustworthiness) were selected based on previous literature investigating social trait judgments in schizophrenia (e.g. (Baas et al., 2007; McIntosh & Park, 2014). For each trait, each of the "typical" avatars (Male, Female, Happy, Angry, Sad, Neutral) were presented once for five seconds in randomized order. The social traits were presented in a nonrandomized order which was: Threatening, Approachability, Attractiveness, and Trustworthiness. After the avatar was presented, participants indicated the degree to which they believed the avatar's walk was indicative of that trait, using the 1-5 numerical keys. After the avatar, a Likert scale would appear on the screen asking them to indicate their response with "1" representing the complete lack of the trait and "5" representing the trait being highly present in the gait. The particular trait being rated always appeared at the top of the Likert scale so that the participants would not need to hold which trait was being rated in mind. For example, during the Threatening block, after viewing the Angry avatar, a participant may respond with a "5" indicating that the Angry avatar's walk was highly threatening. At the beginning of the task, participants were instructed that they would be viewing walking avatars and that they would be asked to rate them on various social traits.

Data Analysis

For the Emotion Recognition Task, an initial mixed repeated measures ANOVA was conducted investigating whether inpatients with a schizophrenia spectrum disorder performed differentially worse than healthy controls for the four emotions presented. Therefore, group (CO, SZ) served as the between group factor and emotion (Happy, Angry, Sad, Neutral) served as the within group factor. Due to the Neutral stimulus being presented at only one intensity, it was removed from subsequent analysis investigating the effect of stimulus intensity on the recognition of emotion between the two groups. A mixed repeated measures ANOVA was run with group (CO, SZ) as the between group factor and stimulus intensity (50%, 100%, 150%) and emotion (Happy, Angry, Sad) as the within group factors. Finally, when possible, examination of the possible pattern of errors displayed on Neutral trials was investigated in order to determine whether the two groups differed in their misappraisal of the Neutral stimulus.

For the Gender Recognition Task, a mixed repeated measures ANOVA was performed to determine the performance profiles of the two groups when discriminating male and female gaits at different intensities. Group (CO, SZ) served as the between group factor, and stimulus intensity (50%, 100%, 150%) and gender (Male, Female) served as within group factors.

For the Social Trait Judgment Task, each social trait's ratings were submitted to a mixed repeated measures ANOVA where group (CO, SZ) was the between group factor and Stimulus (Happy, Angry, Sad, Neutral, Male, Female, Neutral) was the within group factor.

Tukey's Honestly Significant Difference were used to explore post-hoc differences when the repeated measures ANOVA indicated a significant multi-level effect. Non-parametric correlations were conducted to investigate possible associations between recognition performance, social trait judgments, and current symptomatology.

Results

Emotion Recognition Task

See Figure 6 for results. A mixed repeated measures ANOVA was conducted and revealed a main effect of group whereby the SZ group performed worse on the task than the CO group ($F(1,30) = 15.79$; $p = 0.0004$). There was also a main effect of emotion ($F(3,90) = 13.65$; $p < 0.0001$). Post-hoc Tukey's HSD analyses revealed that, across both groups, the Neutral avatar was the most difficult to identify compared to all other emotions presented. Furthermore, the Anger avatar was significantly more difficult to identify than the Sad avatar. There was no group by emotion interaction ($F(3,90) = 0.86$; $p = 0.465$).

The Group x Intensity x Emotion rmANOVA revealed a nonsignificant main effect of group ($F(1, 30) = 2.87$; $p = 0.10$). There was a significant main effect of intensity ($F(2,60) = 189.49$; $p < 0.0001$) whereby Tukey's HSD revealed that across both groups and emotions, performance significantly improved from the 50% stimuli to the 100% stimuli, and from the 100% stimuli to the 150% stimuli. There was also a main effect of emotion ($F(2,60) = 10.04$; $p = 0.0002$). Participants were able to recognize the Sad stimuli significantly better than the Happy and Angry stimuli. There was no group x intensity interaction ($F(2,60) = 0.68$; $p = 0.51$). Both groups, across the different emotions, showed similar gain in performance as the stimulus intensity increased. There was no group by emotion interaction either (F(2,60) = 0.09; p = 0.91). There was a significant intensity x emotion interaction (F(4,120) = 10.69; p < 0.0001). With regard to performance on the Happy and Sad trials, performance significantly increased from 50% to 100% but did not significantly differ from 100% to 150%, suggesting a plateauing of performance, across both groups. However, for the Angry trials, performance significantly improved at each stimulus intensity.

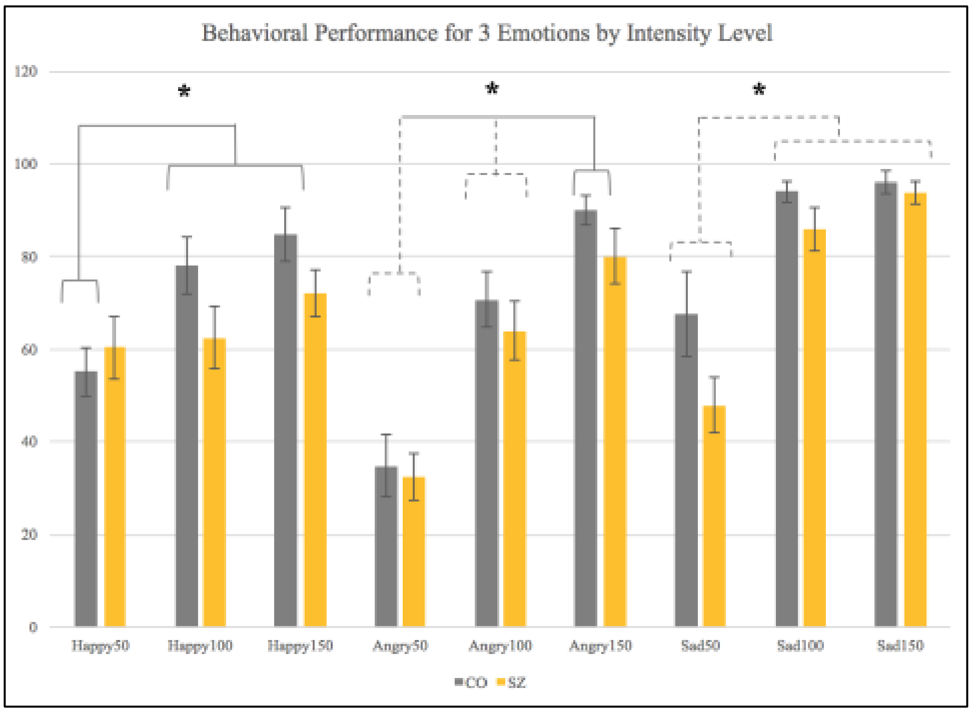

Figure 6. Performance on the three emotions presented by intensity level. Solid grouping lines indicate significance for only the control group and dotted lines indicate significance for both the schizophrenia group and control group. Overall, inpatients did not benefit to the same degree during the recognition task when the signal intensity of the emotion being expressed was increased.

Finally, there was a significant group x intensity x emotion interaction (F(4,120) = 3.88; p = 0.005). On Happy trials, CO showed improvement from 50% to 100% but then plateaued between 100% and 150%. In contrast, SZ showed virtually no improvement from the 50% to 100% and non-significant improvement from the 100% to 150%. For the Angry trials, CO displayed consistent and significant improvement at each increasing intensity level. Whereas, SZ only showed significant improvement from the 50% to 100% intensity level. Finally, for the Sad trials, both groups exhibited significant improvement from 50% to 100% but then plateaued from 100% to 150%.

Neutral Trials Error Analysis

Given the possibility of consistent errors in recognizing emotions in gait and possible biases in the error pattern when perceiving an ambiguous stimulus like the neutral avatar, analyses were conducted to compare the two groups' error trials for the neutral avatar in order to identify any potential patterns in response. The proportion of error trials was calculated per emotion endorsed out of the total number of neutral trials. The outpatient group had a significantly greater number of neutral trials incorrectly identified as angry ($t(30) = 2.06$; $p = 0.048$). They also trended towards a significantly greater number of neutral trials incorrectly identified as happy ($t(30) = 1.93$; $p = 0.063$). It was not possible for the neutral trials incorrectly identified as sad to be compared between the groups because the CO group never endorsed 'sad' for a neutral avatar.

Gender Recognition Task

See Figure 7 for results. A mixed repeated measures ANOVA revealed a significant main effect of group ($F(1,30) = 19.10$; $p < 0.0001$), as expected, SZ performed worse than CO on the task. There was a significant main effect of intensity ($F(2,60) = 61.25$; $p < 0.0001$). Across both groups and genders, performance significantly improved with each increasing intensity level. There was also a significant main effect of gender (F(1,30) = 5.13; p = 0.03), whereby across both groups and intensity levels, the male avatars were recognized more easily than the female avatars. There was no significant group x intensity interaction (F(2,60) = 0.99; p = 0.38). There was a trend for a group x gender interaction (F(1,30) = 3.81; p = 0.06). Tukey's HSD analyses revealed that SZ showed significantly worse performance in recognizing the female avatar compared to CO. This differential in recognition performance between two groups is likely what is driving the significant group and gender main effects. There was a significant intensity x gender interaction (F(2,60) = 5.86; p = 0.005). Across both groups, recognition of the gendered avatars improved from the 50% to 100% intensity level but then plateaued from the 100% to 150% intensity level. Performance on the two genders though, significantly differed at the different intensity levels, whereby the male avatar was more easily recognized at the 50% and 100% intensity levels than the female avatar. Finally, there was no group x intensity x gender interaction (F(2,60) = 2.04; p = 0.14).

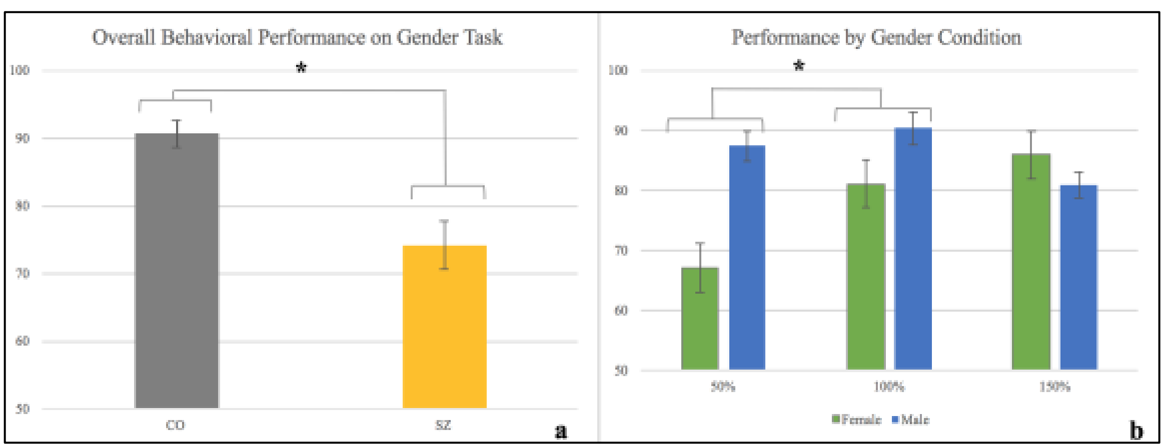

Figure 7. a) Overall performance for the two groups. Controls displayed significantly better performance on the task compared to inpatients. b) Across both groups, performance was significantly better when identifying the male avatar's gait than the female avatar's gait at the 50% and 100% intensity level.

Social Trait Judgment Task

See Figure 8 for the results of the social traits ratings.

Approachability

The mixed repeated measures ANOVA did not reveal a main effect of group ($F(1,30) = 2.33$; $p = 0.14$). There was a significant effect of avatar ($F(5,150) = 31.54$; $p < 0.0001$). Post-hoc Tukey's HSD analyses revealed a number of significant differences in the ratings of approachability between the Happy avatar and the other avatars. Unsurprisingly, the Happy avatar was rated as being more approachable than all other avatars, except for the Male avatar. The Sad and Angry avatars were rated as being significantly less approachable than all other avatars. Importantly, there was a group by avatar interaction ($F(5,150) = 3.76$; $p = 0.003$). Post-hoc Tukey's HSD analyses revealed that the SZ group displayed significantly different approachability ratings for the Happy and Angry avatars compared to the CO group. The SZ group rated the Angry avatar as being significantly more approachable than the CO group's Angry avatar ratings but the Happy avatar as significantly less approachable than the CO group's Happy avatar ratings. The CO group also rated the Male avatar as being significantly more approachable than the SZ group.

Attractiveness

There was a trend for a main effect of group whereby the SZ group trended towards rating the avatars as generally more attractive than the CO group ($F(1,30) = 3.20$; $p = 0.084$). There was a significant main effect of avatar ($F(5;150) = 19.81$; $p < 0.0001$).

Post-hoc Tukey HSD analyses indicate that the Sad and Angry avatars were rated as significantly less attractive than all the other avatars. There was a trend for a group by avatar interaction ($F(5,150) = 2.20$; $p = 0.057$). Post-hoc Tukey HSD analyses did not reveal any significant pairwise group comparisons by avatar.

Threat

There was a trend for a main effect of group whereby the SZ group trended towards rating the avatars as more threatening compared to the CO group ($F(1,30) = 4.069$; $p = 0.053$). There was a significant effect of avatar ($F(5,150) = 21.32$; $p < 0.0001$). Post-hoc Tukey HSD analyses indicate that this effect was driven by the Anger avatar being rated as significantly more threatening compared to all other avatars. There was no group by avatar interaction ($F(5,150) = 1.68$; $p = 0.142$).

Trustworthiness

There was no main effect of group ($F(1,30) = 0.19$; $p = 0.670$). There was a significant main effect of avatar ($F(5,150) = 27.11$; $p < 0.0001$). Post-hoc Tukey HSD analyses indicate that the Sad and Anger avatars were rated as being significantly less trustworthy than the other avatars. There was no group by avatar interaction ($F(5,150) = 1.09$; $p = 0.371$).

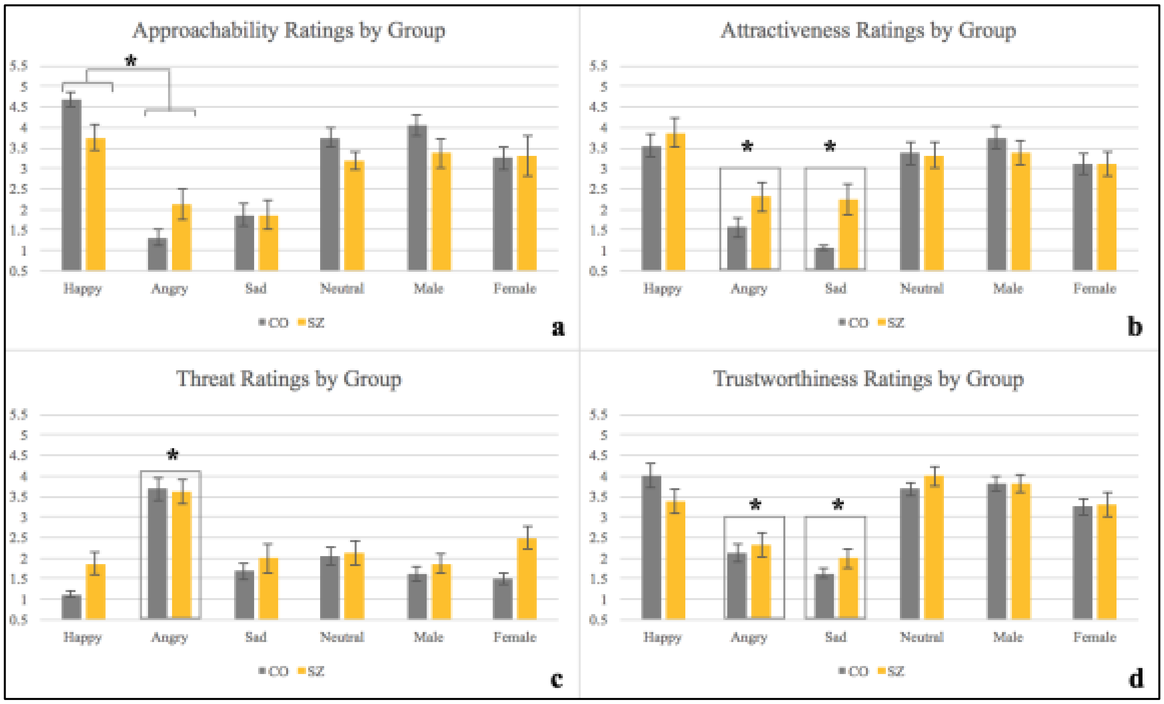

Figure 8. a) Inpatients rated the Angry avatar as being more approachable and the Happy avatar as being less approachable, compared to controls. b) Both groups rated the Angry and Sad avatars as being less attractive. c) Both groups rated the Angry avatar as being more threatening. d) Both groups rated the Angry and Sad avatars as being less trustworthy than the other avatars.

Correlations

Controls

Self-report of schizotypal traits was associated with a number of the social trait judgments made. Overall SPQ score was negatively associated with the rating of attractiveness for the female avatar ($r_s = -0.68$; $p = 0.007$), suggesting that greater endorsement of schizotypal personality traits correlated with finding the female avatar's gait to be less attractive. The Cognitive/Perceptual subscale of the SPQ was negatively associated with CO ratings of approachability of the happy avatar ($r_s = -0.59$; $p = 0.04$), suggesting that those who endorsed greater attenuated positive symptomatology also found the happy avatar to be less approachable. For the Interpersonal subscale, greater endorsement of interpersonal difficulties was associated with finding the sad avatar less approachable (r_s = -0.81; p = 0.002) as well as finding the female avatar less threatening (r_s = -0.60; p = 0.04). With regard to the Disorganized subscale, those who endorsed a greater number odd behaviors and speech also found the female avatar to be less attractive (r_s = -0.63; p = 0.03) and less threatening (r_s = -0.70; p = 0.01).

Inpatient

Ratings of current symptomatology were found to be significantly associated with a number of the social trait judgment ratings and emotion recognition performance. The PANSS Positive aggregate score was positively associated with ratings of approachability for the female avatar (r_s = 0.69; p = 0.004) and the neutral avatar (r_s = 0.73; p = 0.002). Additionally, PANSS Positive aggregate score was positively associated with threat ratings for the sad avatar (r_s = 0.56; p = 0.03) but negatively associated with threat ratings for the neutral avatar (r_s = -0.59; p = 0.02).

The PANSS Negative aggregate score was also negatively associated with threat ratings for the sad avatar (r_s = -0.53; p = 0.04), the trustworthiness rating for the neutral avatar (r_s = -0.56; p = 0.03) and the approachability rating for the neutral avatar (r_s = -0.59; p = 0.02). It was also positively associated with the ratings of approachability for the happy avatar (r_s = 0.53; p = 0.04). Finally, it was negatively associated with recognition of the Happy 150% avatar (r_s = -0.58; p = 0.02) and the Sad 100% avatar (r_s-0.61; p = 0.02).

Discussion

This first study investigated the ability to recognize gait-presented socio-emotional information in an inpatient population of individuals diagnosed with schizophrenia-spectrum disorders. As has been seen previously in outpatient populations (Bigelow et al., 2006; Couture et al., 2009; Peterman et al., 2014), in the current study, inpatients showed significantly poorer performance in recognizing emotion when it was presented in gait. Furthermore, inpatients with schizophrenia spectrum disorders also displayed performance deficits in recognizing other important social information in gait (e.g. gender) as well as dystonic social trait judgments of emotionally-laden stimuli.

While findings of emotion recognition deficits are consistent with previous research, when performance was examined in finer detail, a number of interesting outcomes were identified. Contrary to previous studies suggesting a specific deficit for recognition of negative emotions (Dickey et al., 2011; Hooker & Park, 2002; Kohler et al., 2003), both inpatients and controls displayed significantly better performance when identifying the sad gait than when identifying both happy and anger in gait. This facilitation of performance in recognizing was likely driven by the velocity differential in movement of the stimuli. In the current study, the stimuli were not matched across speed as they had been in a previous investigation (see (Peterman et al., 2014), thus performance was likely informed not only by the position of the body during movement (Roether et al., 2009), but also by the speed at which the stimuli moved.

Additionally, across the different emotions, neutral was the most difficult to identify, suggesting that it may be more difficult to identify the absence of affect than the presence. While the two groups did not significantly differ in their accuracy in recognizing when there was no emotion present in the gait of the avatar, inpatients were found to misidentify the neutral avatar as being angry or happy at a greater rate than the healthy individuals. Kohler and colleagues (2003) also found that individuals with schizophrenia have a particular difficulty in recognizing neutral facial expressions, misidentifying them as disgusted at a higher rate than healthy individuals. Such misidentification could significantly impact one's ability to accurately gauge others' emotional states, leading to engagement with others under faulty social premises. Indeed, previous research has indicated that individuals with schizophrenia display a bias in interpreting the gaze of other individuals as being directed towards them when it is in fact averted (Hooker & Park, 2005), suggesting that these individuals may infer that others are evaluating them for social interaction when in fact they are not.

The role of emotional expression intensity in augmenting the performance on this task was partially in line with previous studies displaying enhancement of performance as "signal" intensity increased (Kohler et al., 2003; Peterman et al., 2014). The degree to which the signal intensity increase facilitated recognition of various emotions was not uniform between the two groups. In fact, inpatients' performance in recognizing happy in the avatar's gait was static across the three intensities, and only increased from the 50% intensity to 100% intensity for the other two emotions. This partial facilitation of intensity is counter to previous studies with outpatients, which found consistent facilitation across the three intensity levels (Peterman et al., 2014). Such a discrepancy may point to the possible role of current symptom status on performance and supports the idea that accurate emotion recognition performance is important for social function capacity (Couture, 2006; Green, Hellemann, Horan, Lee, & Wynn, 2012; Green, Horan,

& Lee, 2015). Indeed, in the current study, significant positive associations between performance and current negative symptomatology was found suggesting that the degree of symptom exacerbation, when of sufficient magnitude to require hospitalization may track with social cognitive performance.

With regard to the underlying cause of the impairment in emotion recognition in the current study, one might infer that it is analogous to what studies investigating emotion recognition via faces has shown which is an inattention to the salient aspects of those parts that are critical to emotion expression (Loughland, 2004; Marsh & Williams, 2006). It is possible that individuals with schizophrenia are not attending to the parts of the body that index emotional state via positional cues. For example, the flexion of the head, either dipped forward or tilted backward, has been shown to indicate a person moving in a way that is angry or happy, respectively (Roether et al., 2009). If individuals with schizophrenia are not attending to these cues when viewing the stimuli, they would likely not be able to respond optimally. Having said that, position of the body is not the only cue that feeds into our recognition of emotional state via gait, as noted previously, the speed at which one is moving can also serve as a salient signal. As such, in the current study, both groups showed improved performance in the recognition of sadness in gait likely due to this stark contrast in the speed of movement when compared to the speed of gait in the happy and angry condition. Parsing about the role of attention to the salient parts of the body during emotional movement is of great importance and is directly assessed in CHAPTER IV.

The current study is consistent with previous evidence indicating that individuals with schizophrenia have a difficulty in discriminating gender expressed via gait

(Peterman et al., 2014). Performance in the recognition of gender in schizophrenia has received less attention in the past, typically, even though one's gender affects the way in which individuals interact with one another (Campbell et al., 2010; Smoski & Bachorowski, 2003). Therefore, one's acuity in recognizing others' genders likely has an impact on the quality of their social functioning.

Judgment of others' social trait dispositions requires complex judgments that influence how and whether we engage with others. Such judgments are fairly stable across raters (Ambady & Rosenthal, 1993; Thoresen et al., 2012). Said judgments are also influenced by the emotional state of the individual being rated (Thoresen et al., 2012). Research on social trait judgments by individuals with schizophrenia have also found consensus, in some instances, with the ratings of healthy individuals (McIntosh & Park, 2014; Trémeau et al., 2016). In the current study, we found both consensus across the two groups, as well as disagreement with regard to the rating of approachability. Specifically, inpatients with schizophrenia spectrum disorders rated the Anger avatar as being more approachable than the healthy individuals did. Such a disconnect between emotional state and social trait judgment was also seen in the significantly lowered approachability rating for the Happy avatar compared to what the healthy controls rated. For the other social trait ratings, there were trends for inpatients to give higher ratings regardless of the stimulus being presented which would also possibly indicate a breakdown in making social trait judgments that are attuned to the emotional state of the individual being evaluated. Such findings are consistent with other findings of undifferentiated increased social trait ratings regardless of the valence of the face being presented (Trémeau et al., 2016).

Finally, social trait judgment ratings were significantly associated with both current symptomatology in the inpatient individuals as well as self-reported schizotypal traits in the healthy controls. Positive symptomatology as assessed by the PANSS Positive composite score was positively associated with ratings of approachability for the Female and Neutral avatars and ratings of threat for the Sad avatar. Except for the PANSS Positive composite score being negatively associated with ratings of threat for the Neutral avatar, these correlations are consistent with the findings of McIntosh and colleagues (2014) which found that higher scores on the Schedule for the Assessment of Positive Symptoms (Andreasen, 1984), was positively associated with higher social trait judgment ratings in stable, outpatient individuals with schizophrenia.

Amongst healthy individuals endorsing attenuated experience of schizotypal traits, different subscales of the SPQ were found to be, generally, negatively associated with social trait judgment ratings across both avatar type and social trait judgment rated. For example, those who endorsed items on the cognitive/perceptual subscale of the SPQ, gave lower ratings of approachability to the Happy Avatar. Again these findings are similar in tone to those found by McIntosh and Park (2014) which was that while, increased positively symptomatology in patients was positively associated with social trait judgments, indiscriminant of whether the trait being rated was positive or negative, healthy individuals endorsing schizotypal traits had their social trait judgments track with the valence of the trait being rated. In other words, increased cognitive/perceptual schizotypal experiences led healthy individuals to see a happy individual as being approachable or overall endorsement of schizotypal traits in healthy individuals tracking with finding the Female avatar as being less attractive. There appears to be more congruence in the social trait ratings and attenuated schizotypal experiences than in individuals who have fully converted to a psychotic disorder. This breakdown in contingency between the outward expression of others and the internal judgments of individuals with schizophrenia likely compounds the social functioning deficits in this population.

Finally, there are some limitations and concerns with the present study, specifically with regard to the respective populations from which the two groups were recruited. On the surface, one might suspect that cultural differences could partially explain the differences in performance between the Australian inpatient group and American healthy controls. Such a conclusion though would ignore findings of commonalities across cultures with regard to emotion recognition (Habel et al., 2000; Yan, Andrews, & Young, 2016) and the commonalities found in the present study in the inpatient group with previous research on individuals in the US (McIntosh & Park, 2014). Habel and colleagues (2000), investigated emotion recognition performance across three cultures (American, German, and Indian) and found commonalities across the cultures in terms of one's ability to discriminate facial emotions, although they did find that the ethnicity of the actor in the stimulus did affect performance to a degree. The current study avoids the influence of actor ethnicity due to the form of the stimuli being devoid of racial or ethnic visual cues. It is also important to note that the three cultures being assessed by Habel and colleagues (2000) are more diverse and unique than the two cultures being compared in the current study. Having said this, we cannot fully rule out the possible cultural differences in performance but given the similar trend in associations between symptomatology and social trait judgments between the Australian inpatient group in the current study and the American outpatient group in the study by McIntosh and Park (2014), such influences are likely minimal.

Taken together, this study provides important evidence for the breadth of socio-emotional recognition deficits in individuals with schizophrenia and offers further support for the incongruence of social trait judgments when evaluating others' expressing a range of emotional states. How this impairment in accurate recognition of emotional states from gait occurs is open to exploration and may potentially lie in the inability of individuals with schizophrenia to attend to the critical features of the body that give rise to the expression of emotion. While there is some evidence that the intensity of the emotional expression facilitates recognition performance, individuals with schizophrenia do not appear to be aided to the same degree as healthy individuals, suggesting that attention to the salient areas may only be part of the problem. In the next chapter, the role of visual attention in the recognition of emotion from gait will be directly assessed.

CHAPTER IV

LOOKING BUT NOT SEEING: VISUAL SCANNING BEHAVIOR OF EMOTIONAL GAIT IN SCHIZOPHRENIA

Clinically stable, outpatients with schizophrenia display deficits in the recognition of emotion and other socially relevant information when it is presented via gait (Bigelow et al., 2006; Couture et al., 2009; Peterman et al., 2014). As CHAPTER III showed, this ability is also impaired in symptomatically active, inpatients with schizophrenia spectrum disorders as well. Theories explaining this deficit, based on literature using static images of facial expressions, have put forth that an inattention to emotionally salient aspects of the face as the underlying cause of impairment (Loughland, 2004; Loughland, Williams, & Gordon, 2002a; Marsh & Williams, 2006; Williams et al., 2003). If this is indeed the case, then such a process could underlie the deficits seen in CHAPTER III and previous investigations into gait-presented emotion recognition deficits. Therefore, in the following investigation, the eye movements of outpatients with schizophrenia are evaluated while viewing avatars' gaits. Such an investigation will provide further insight in the nature of these deficits and direction in the development of interventions for ameliorating this deficit. Indeed, some behavioral interventions have already been developed based on the inattention hypothesis whereby individuals with schizophrenia engage in training focused on reorienting attention to the salient aspects of the face during emotional expression (Combs, Chapman, Waguspack, Basso, & Penn, 2011; Statucka & Walder, 2013).

Methods

Participants

Sixteen outpatients with schizophrenia (SZ) were recruited from private care facilities in Nashville, TN. Diagnoses were confirmed with the structured clinical interviews (SCID; First et al., 2002) according to the Diagnostic and Statistical Manual 4^{th} Edition-Text Revised (DSM-IV TR). Fifteen patients were taking atypical antipsychotic medication and one was on a typical antipsychotic drug**.** Mean chlorpromazine (CPZ) equivalent dose was 358.55 mg/kg/day (s.d.=193.11). Clinical symptoms were assessed using the Brief Psychiatric Rating Scale (BPRS; Overall & Gorham, 1962), the Scale for the Assessment Positive Symptoms (SAPS; Andreasen, 1984), and the Scale for the Assessment Negative Symptoms (SANS; Andreasen, 1984).

Sixteen healthy controls (CO) were recruited from the same community via advertisements. They were screened for Axis I disorders using the SCID (First et al., 2002) and a history of psychosis in their first-degree relatives.

Exclusion criteria for both groups were as follows: IQ score lower than 85, a prior history of head injury or neurological disorder or history of drug use in the year prior to the study.

Intelligence (IQ) was estimated using the National Adult Reading Test-Revised (NART-R; Blair & Spreen, 1989), an assessment tool measuring premorbid IQ. All subjects were assessed to be of at least average intelligence. Years of education were also assessed. Social functioning was assessed by calculating the Zigler Social Competence Score (SCS; Zigler & Levine, 1981), as expected, patients had significantly lower SCS than healthy controls ($t(30)=-7.98$; $p<0.0001$). All participants had normal or corrected to normal vision. Participants gave written informed consent as approved by the Vanderbilt Institutional Review Board. The two groups were matched on age, gender, estimated IQ, but not years of education. Ethnicity and socioeconomic status were not collected. Table 2 presents the demographic information.

Table 2. Demographic and clinical information.

	Schizophrenia Mean (SD)	Controls Mean (SD)	Statistical test	p-value
Age	41.9 (9.6)	43.6 (10.1)	$t = -0.50$	0.620
Gender	5 F / 11 M	7 F / 9 M	$Chi^2 = .54$	0.464
Education, years	13.5 (2.3)	15.3 (2.7)	$t = -1.96$	0.059
IQ	104.9 (9.7)	106.8 (9.5)	$t = -0.57$	0.572
Zigler Social Competence Score	0.89 (0.2)	1.68 (0.3)	$t = -7.98$	<0.0001
SAPS	17.1 (7.2)	N/A	N/A	N/A
SANS	24.6 (17.0)	N/A	N/A	N/A
BPRS	13.3 (7.2)	N/A	N/A	N/A
CPZ Equivalent dose (mg/kg/day)	358.55 (193.1)	N/A	N/A	N/A

IQ, intelligence estimated by the National Adult Reading Test-Revised (NART-R); SAPS, Scale for the Assessment of Positive Symptoms; SANS, Scale for the Assessment of Negative Symptoms; BPRS, Brief Psychiatric Rating Scale; CPZ, Chlorpromazine; N/A, not applicable.

Procedure

Materials and Equipment

The stimuli used in the current experiment have been used in previous experiments investigating perception of emotion in gait (Roether et al., 2009). The stimuli were presented on a 1280x1024 resolution screen. The stimuli were displayed in the center of the screen at a vertical visual angle of 10.36° and a horizontal visual angle of 8.35°. Construction of the stimuli used motion morphing (Giese & Poggio, 2000), which sampled 3 females and 3 males who exhibited the most expressive emotional gaits as rated in a previous standardization study (Roether et al., 2009) in order to produce a given emotional gait stimulus; see Figure 9 for an example of the stimuli. By combining both male and female emotional expressions, the stimuli depict emotional gaits independent of gender information. The emotions used in the current study were Happy, Angry, Sad, and Neutral.

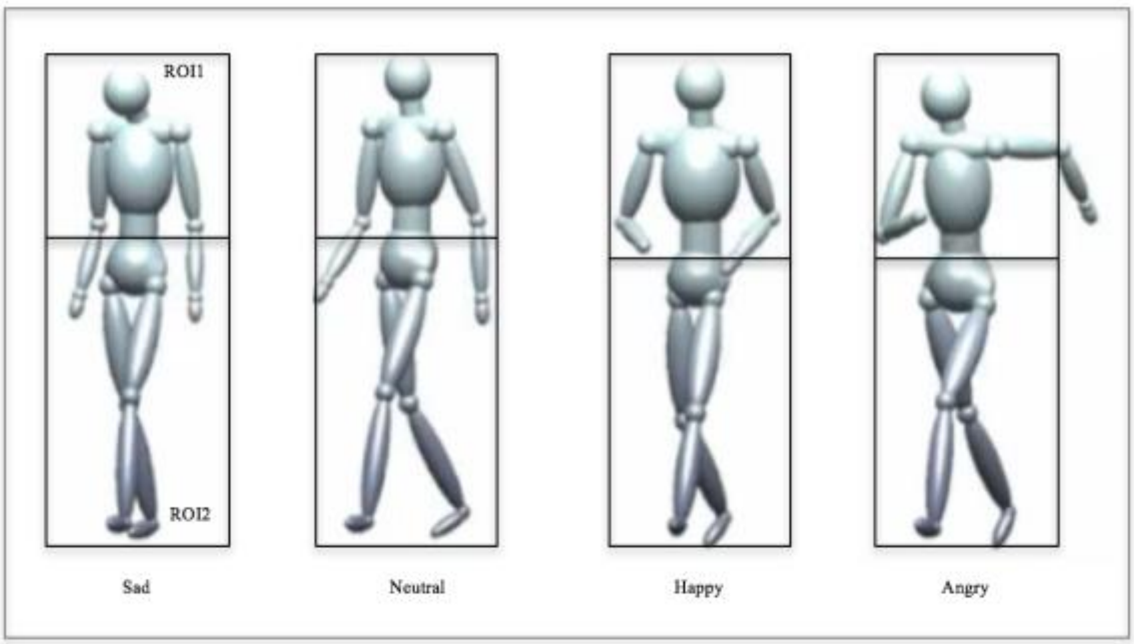

Figure 9. Examples of the avatars used in the study with the ROIs overlaid on top of them. ROI1 encompassed the avatar from the waist up. ROI2 encompassed the avatar from the waist down to the feet.

Behavioral Tasks

Participants completed two separate emotion recognition tasks, a four-choice task and a seven-choice task, that were counterbalanced in their presentation across all participants. The seven-choice task included 3 additional emotion responses (fearful, surprised, and disgusted), which were not present in the gait stimuli but introduced at the response stage as lures. Both tasks were programmed in Presentation (Neurobehavioral Systems; Berkeley, CA). The four emotional gait stimuli were randomly interleaved and presented 6 times each in both emotion recognition tasks for a total of 24 trials per task. During both tasks, participants viewed the stimuli walking in place in the center of the screen for 10 seconds. Participants were instructed to watch the stimuli and decide which emotion they believed was being expressed in the walker's gait. Then, participants were asked to select which emotion they thought was being presented in the walker's gait using the computer mouse. In the 4-choice emotion recognition task, participants selected their response out of the four emotions viewed (e.g. Happy, Angry, Sad, Neutral). In the seven-choice emotion recognition task, participants selected their response out of seven emotions; the 4 emotions that are actually present in the stimulus set and 3 catch emotions (Fear, Disgust, Surprise).

Eye Movement Data Processing

BeGaze 1.0 software from SMI was used to extract eye movement events (fixations, saccades, blinks). Fixations were defined as a period of time longer than 80msecs when gaze was stable within 1.5° visual angle. The upper and lower body regions of interest (ROIs) were defined with the waist of the walker as the cut point between the two regions so as to create two regions of interest with a natural demarcation of the body. Region of interest 1 (ROI1) (52.39mm x 45.24mm encompassed the head down to the waist of the avatar; region of interest 2 (ROI2) (52.39mm x 75.14mm) encompassed the pelvic region down to the feet. These regions were defined based on previous findings of the upper half of the body driving perception of emotional states in gait (Roether et al., 2009). Both the number of fixations as well as the duration of fixations (dwell time) was calculated for each region, summing across the 10sec stimulus presentation time.

Statistical Analyses

To measure emotion recognition performance, a 2x2x4 repeated-measures ANOVA on accuracy (% correct) with group (CO, SZ) as the between subjects factor and task condition (4-Choice, 7-Choice) and emotion (Happy, Angry, Sad, Neutral) as the within subjects factors was run.

For the eye tracking variables, initial analyses revealed no group differences for the raw number of fixations ($F(1,30)=0.67$, $p=0.42$); or raw dwell time, ($F(1,30)=1.36$, $p=0.25$). The two groups produced similar numbers of fixations and spent similar amounts of time fixating on the stimulus across all trials. Due to the limited trials per emotion, eye tracking variable analyses on error trials were unable to be performed. Therefore, all subsequent eye tracking variable analyses are performed using only the data from both groups' correct trials across both task conditions.

Accordingly, proportions of fixations and proportion of dwell time within each ROI by total ROI fixations were calculated to allow for between group comparisons given differing numbers of correct trials per emotion. Thus two repeated-measures ANOVAs were conducted with group (CO, SZ) as the between-subjects factor and Emotion (Happy, Angry, Sad, Neutral) as the within-subjects factor. The dependent variables were proportion of fixations and proportion of dwell time within ROI1. The upper part of the body is believed to convey the most information regarding emotional state (Roether et al, 2009) leading us to use ROI1 as the focus of our visual pattern analyses.

Spearman correlations were used to examine associations between performance and severity of symptoms. All tests were two-tailed unless otherwise specified.

Results

Behavioral Results

See Figure 10 for results. Mauchly's test indicated that the assumption of sphericity was violated for Emotion ($\chi^2(5)=13.09$, $p=0.023$), therefore degrees of freedom were corrected using the Greenhouse-Geisser estimates of sphericity($\varepsilon=0.787$).

There was a main effect of group; individuals with schizophrenia performed worse, overall, on the emotion recognition tasks compared to controls ($F(1,30)=9.37$; $p=0.005$, $\eta_p^2=0.24$). There was a main effect of condition indicating that, across both groups, participants performed better on the 4-choice condition compared to the 7-choice condition ($F(1,30)=11.46$; $p=0.002$, $\eta_p^2=0.28$). There was no main effect of emotion ($F(2.36,78.62)=0.635$; $p=0.558$, $\eta_p^2=0.02$). Interestingly, there was a condition-by-emotion interaction ($F(3,90)=3.58$; $p<0.017$, $\eta_p^2=0.11$). Follow-up analyses indicated that across both groups, performance significantly drops from the 4-choice condition to the 7-choice condition for Happy (4-choice: 84.4%; 7-choice: 75.5%) and Sad (4-choice: 94.3%; 7-choice: 75.5%). There were no other significant interactions.

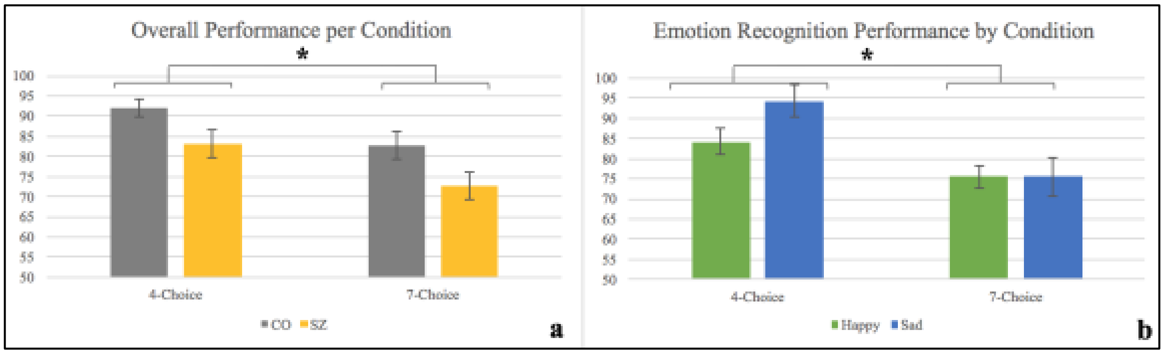

Figure 10. a) Across both conditions, controls performed better than outpatients. Overall though, participants performed better on the restricted choice (4-Choice) condition than the expanded (7-Choice) condition. b) Recognition of Happy and Sad from the avatars' gaits was negatively impacted by the expanded choice condition.

Eye Tracking Variable: Fixations

See Figure 10 for results. Mauchly's test indicated that the assumption of sphericity for the within-subjects factor of Emotion had been violated ($\chi^2(5) = 13.02$, $p=0.023$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon=0.755$).

There was no main effect of group ($F(1,30)=0.64$, $p=0.429$, $\eta_p^2=0.21$). Both groups allocated more than half of their fixations within ROI1 across all emotions. There was a main effect of Emotion ($F(2.26,67.93)=16.10$; $p<0.001$, $\eta_p^2=0.35$). Bonferoni-corrected post-hoc analyses indicated that, across both groups, the proportion of fixations within the Sad ROI1 (58.3%) was significantly lower than the those within the Happy ROI1 (71.6%), Angry ROI1 (68.3%) and Neutral ROI1 (68.7%) (all $p<0.005$).

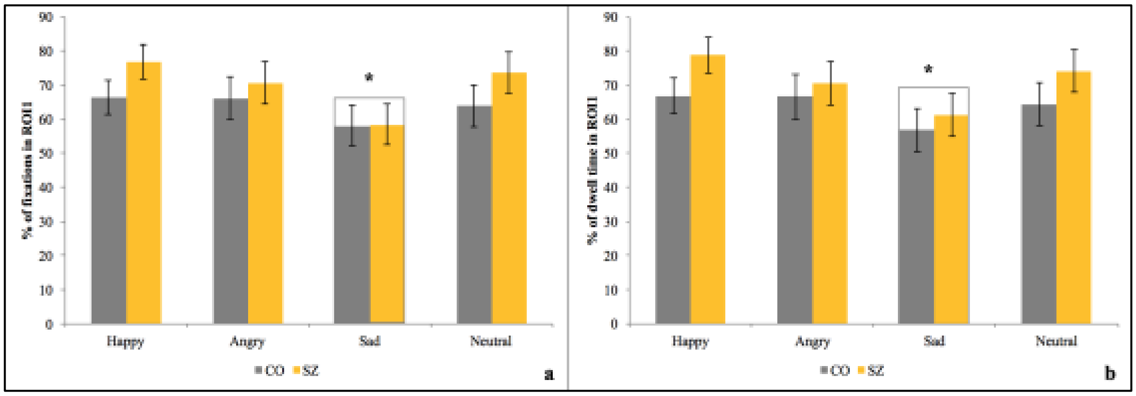

Figure 11. a) Across both groups, allocation of fixations was dependent upon the emotion being viewed. Specifically, more fixations were allocated to ROI2 (hips, legs, and feet) while viewing the Sad avatar. b) Dwell time tracked with the proportion of fixations whereby more time was spent looking at ROI2 when viewing the Sad avatar than the other emotional avatars.

There was a trend towards a Group x Emotion interaction ($F(2.26, 67.93)=2.29$, $p=0.069$, $\eta_p^2=0.08$). Given the trend towards significance and previous research indicating aberrant fixation patterns when viewing faces in individuals with schizophrenia (Loughland, Williams, & Gordon, 2002b; Streit et al., 1997), we were interested in investigating the pattern of the Group-by-Emotion interaction. Post-hoc analyses revealed that there were no group differences for proportion of fixations within a given Emotion ROI1 (all $p>0.15$).

Eye Movement Variable: Dwell Time

See Figure 11 for results. Mauchly's test indicated that the assumption of sphericity for the within-subjects factor of Emotion ROI1 had been violated ($\chi^2(5)=18.75$, $p=0.002$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon=0.685$).

The main effect of Group was not significant ($F(1,30)=0.845$, $p=0.365$, $\eta_p^2=0.03$). Overall, both groups allocated more than 60% of their dwell time to ROI1. The main effect of Emotion within ROI1 was significant ($F(2.05, 61.61)=13.34$, $p<0.001$, $\eta_p^2=0.31$). As was found with the fixation analyses, Bonferroni-corrected post-hoc analyses revealed that the proportion of dwell time in the Sad ROI1 (59%) was significantly lower than for the Happy ROI1 (72.8%), Angry ROI1 (68.5%), and Neutral ROI1 (69.2%). Finally, the interaction between Group and Emotion was not significant ($F(2.05, 61.61)=1.56$, $p=0.219$, $\eta_p^2=0.05$).

Correlational Analyses

Due to the significant effect of Task Condition on performance for both groups, correlational analyses between behavioral performance and eye movement variables were conducted for each task condition. Across both groups, in the 4-Choice Emotion Recognition Task, accuracy was positively associated with both proportion of ROI1 fixations ($r_s=0.40$, $p=0.022$) as well as the proportion of ROI1 dwell time ($r_s=0.42$, $p=0.016$). Thus greater and longer allocation of fixations to the upper half of the body (R0I1) was associated with better performance in the recognition of emotion from gait.

Performance on the 7-Choice Emotion Recognition Task was positively associated with the Social Competence Score ($r_s=0.61$; $p=0.01$). Unexpectedly, in the individuals with schizophrenia, BPRS was positively associated with behavioral performance on the 4-Choice Emotion Recognition Task ($r_s=0.54$, $p=0.037$). Neither SAPS nor SANS scores were significantly associated with behavioral performance on either emotion recognition task (all p-values>0.10).

Discussion

Emotion recognition from gait was evaluated in outpatient individuals with schizophrenia and healthy controls by examining task performance and visual scanning behavior. In accordance with previous studies (Henry, Hippel, Ruffman, Perry, & Rendell, 2010) Peterman et al., 2014), outpatients performed significantly worse than healthy controls, overall, on the emotion recognition tasks. Performance for both groups was negatively impacted by the inclusion of the three 'catch' emotion responses in the 7-choice condition, but this effect was limited to happy and sad stimuli. Follow-up evaluation of responses to the happy error trials in the 7-choice condition indicated that both groups disproportionately mislabeled the happy stimulus as neutral. Evaluation of the sad error trials in the 7-choice condition indicated that for both groups, the sad walker was predominantly misidentified as either portraying disgust or fear. When Roether and colleagues (2009), presented similar stimuli to participants and had them identify the emotion expressed in the gait, the sad stimulus, when misidentified, was predominantly reported to be expressing fear. Furthermore, when the stimuli were matched to the neutral stimulus speed of movement in that study, which was not the case in the present study, participants more often identified the sad stimulus as fearful than sad. Therefore, it is possible that the downward cast of the head of the sad walker could also be interpreted as portraying submissiveness or fear to the participant viewing the stimulus.

Interestingly, performance on the 7-Choice Emotion Recognition task, which was more difficult than the 4-Choice task based on the poorer performance across both groups, was positively associated with the Zigler social competence scores in the outpatients. Social competence score is calculated by assigning numerical values to different facets of an individual's life (e.g. educational attainment, marital status, employment status). Amongst the schizophrenia group, better performance in emotion recognition from gait was associated with better social competence scores. While, the social competence score is a broad and rough estimate of social functioning, our results suggest that social competency is related to greater proficiency in "reading" other people's body cues.

Counter to expectations, visual scanning behavior while viewing the emotional gait stimuli was intact in outpatients. Given the aberrant scan patterns while viewing emotional faces (Loughland, Williams, & Gordon, 2002b; Streit et al., 1997), the finding of normal visual scanning of emotional gait is puzzling, especially in light of the impaired behavioral performance and the observed association between the proportion of fixations, proportion of dwell time, and behavioral performance on the 4-choice condition.

The data suggest that intact visual scanning itself does not guarantee extraction of emotional cues from moving stimuli. Much of social understanding and interpretation of others' actions depend on our capacity for internal simulation of other's actions (Gallese, Keysers, & Rizzolatti, 2004; Park et al., 2008). Observing someone else's action or performing the same action activates a network of parietal and premotor areas, resulting in a match between internal and external worlds (Gallese et al., 2004). Such matching or mirroring of one's internal state to another's is believed to lie at the heart of social cognition (Gallese et al., 2004). Similarly, theories of embodiment suggest that perception and processing of emotional cues depend on one's bodily state (Niedenthal, 2007). If a breakdown in the process of sharing in another individual's emotional experience through the perception of their external emotional expression is, in part, responsible for the poorer performance seen in these individuals, then an exploration into what "internal information" individuals with schizophrenia are pulling from is an important next step.

Specifically, if a breakdown in the shared representation of others' emotional experiences is a possible mechanism for emotion recognition deficits, then this could potentially be caused by a breakdown in one of two ways. One possible issue could be the way in which individuals with schizophrenia emotionally respond to emotionally salient experiences. As was covered in CHAPTER II, the research on emotional experience in individuals with schizophrenia is complex and marked by conclusions running the gamut from reduced (Venables & Wing, 1962), intact (Hempel et al., 2005; 2007), or enhanced (Kring & Neale, 1996), as indexed by physiological arousal. Furthermore, the subcomponents of emotional responses in schizophrenia seem to be out of sync or at least disjointed in their deployment. For example, reduced facial expressivity (Berenbaum & Oltmanns, 1992; Kring & Moran, 2008), are present in the context of intact subjective emotional experience (Herbener, Song, Khine, & Sweeney, 2008; Myin-Germeys, Delespaul, & deVries, 2000). Such disconnects could impact these individuals' ability to draw accurate conclusions when responding to another individual's emotional displays.

Another possibility is that the mechanism through which one shares in the emotional experience of another, the mirror neuron network (Decety & Chaminade, 2003), could be compromised as seems to indeed be the case in this population. Indeed, individuals with schizophrenia have deficits in simulating and imitating another person's gestures or facial expressions (Matthews et al., 2012; Park et al., 2008; Thakkar et al., 2014). Moreover, individuals with schizophrenia showed altered activity in the mirror neuron network that includes the inferior parietal lobule which is involved in transforming the visual input into the associated motor plans of a given perceived action (Buccino et al., 2008; Thakkar et al., 2014). Impairment in the ability to simulate in schizophrenia would likely reduce their ability to identify emotional states in another person's body, regardless of how accurately they visually scan the gait stimuli. Furthermore, an inability to engage in this seemingly automatic process, as evidenced by unconscious imitation of others during social interactions (Chartrand & Bargh, 1999; Kupper, Ramseyer, Hoffmann, Kalbermatten, & Tschacher, 2010) would then require more effortful top-down processing of other's emotional expressions. Such compensatory efforts may lead to a higher number of recognition errors.

The next two chapters delve into these alternatives by investigating how individuals with schizophrenia emotionally respond to emotionally evocative stimuli. As has been done in previous studies investigating such processes in the general population (Britton, Phan, Taylor, Welsh, Berridge, & Liberzon, 2006a; Britton, Taylor, Berridge, Mikels, & Liberzon, 2006b), the emotionally evocative stimuli were selected to index emotional responses to both social and non-social stimuli. Such investigations have also been conducted in individuals believed to be at risk for the later development of schizophrenia (Gooding et al., 2002) which found, using a startle eye blink paradigm, commensurate modulation of the reflexive response to various emotional content. Furthermore, both groups showed greater attenuation of this response to socially-positive stimuli, similar to what was seen by Aaron and colleagues (2014) in their investigation of the post-auricular response to socially-positive stimuli. CHAPTER V builds on the work of these previous two studies by a priori selecting emotionally evocative images from a standardized set and matching the social and non-social images for both valence and arousal since the previous two studies did not do match their sets across sociality.

As explained previously, CHAPTER VI indirectly assesses the integrity of shared representations in individuals with schizophrenia by investigating the relationship between spontaneous mimicry to dynamic facial expressions during emotion recognition tasks. The relationship between spontaneous mimicry and emotion recognition performance has generally not been investigated in individuals with schizophrenia, rather previous studies either used passive viewing paradigms (Varcin et al., 2010) or more broadly dimensional emotional expressions (e.g. laughing and crying; (Sestito et al., 2013). If mimicry of other's expressions is associated with empathic capacity, as has been found previously (Künecke, Hildebrandt, Recio, Sommer, & Wilhelm, 2014; Neal & Chartrand, 2011), then it is possible that the degree to which an individual with schizophrenia spontaneously engages their facial musculature when performing an emotion recognition task could provide insight into how the breakdown in their understanding of others occurs.

CHAPTER V

COMPLEXITIES OF EMOTIONAL EXPERIENCE TO SOCIAL AND NON-SOCIAL SCENES IN SCHIZOPHRENIA

Emotions are evoked in a number of situations and circumstances. As humans, our emotional capacity has developed to not only experience emotions in response to unambiguous stimuli in our environment, (e.g. a snarling lion) but to ambiguous stimuli as well (e.g. a piece of music, a work of art). These emotional experiences can provide a framework on which we can engage with others. Sharing in emotional experiences is directly related to feelings of connectedness (Singer & Lamm, 2009; Sparks, McDonald, Lino, O'Donnell, & Green, 2010; Wicker et al., 2003) and is crucial to the maintenance of social relationships (Keltner & Kring, 1998). If the evocation of emotional experiences is reduced or distorted in an individual, as appears to the case in individuals with schizophrenia (Herbener et al., 2008), then this likely would have a negative impact on social functioning. Therefore, in this chapter, the emotional experience of outpatients with schizophrenia is investigated with regard to emotionally evocative stimuli that is either social or non-social in nature. Furthermore, the emotional experience is investigated across subdomains that comprises said emotional experience. Subjective experience, as indexed by self-report, physiological responsivity, indexed via galvanic skin response, and expressivity, indexed by facial electromyography, are analyzed concurrently in order to provide a comprehensive examination of how outpatient individuals with schizophrenia respond to emotional evocators. This chapter is presented, with permission, from *Frontiers in Psychology*. It was published as a manuscript (Peterman et al, 2015).

Methods

Participants

Twelve medicated outpatients with schizophrenia were recruited from private care facilities in Nashville, TN. Diagnoses were confirmed with the structured clinical interview for DSM-IV (SCID; First et al, 2002). Mean chlorpromazine (CPZ) equivalent dose was 359.63 mg/kg/day (s.d.=247.61). Symptoms were assessed using the Scale for the Assessment Positive Symptoms (SAPS; Andreasen, 1984), and the Scale for the Assessment Negative Symptoms (SANS; Andreasen, 1984).

Twelve healthy controls were recruited from the same community via advertisements. They were screened for current and prior history of Axis I disorders using the SCID (First et al, 2002) and a history of psychosis in their first-degree relatives.

Exclusion criteria for both groups were as follows: IQ < 85, a prior history of head injury or neurological disorder or history of drug use in the year prior to the study. Premorbid intelligence (IQ) was estimated using the North American Adult Reading Test (NAART) (Uttl, 2002). Current social functioning was assessed with the Social Functioning Scale, a semi-structure interview (Birchwood, et al, 1990). Schizotypy in controls was assessed using the Schizotypal Personality Questionnaire (Raine, 1991). All participants had normal or corrected-to-normal vision. Participants gave written informed consent as approved by the Vanderbilt Institutional Review Board. The two groups were matched on age, gender, estimated IQ, but not education. However, outpatients had at least high school education. See Table 3 for demographic information.

Table 3. Demographic and clinical information.

	Schizophrenia Mean (SD)	Controls Mean (SD)	Statistical test	p-value
Age	44.9 (9.9)	45.7 (9.4)	t = -0.21	0.83
Gender	6 F / 6 M	4 F / 8 M	$Chi^2 = 0.68$	0.40
Education, years	13.4 (2.1)	15.4 (2.2)	t = -2.2	0.03
IQ	107.1 (6.8)	106.4 (7.4)	t = 0.22	0.82
SAPS	12.9 (7.7)	N/A	N/A	N/A
SANS	24.5 (11.4)	N/A	N/A	N/A
SPQ		8.5 (8.1)		
Cognitive/Perceptual Interpersonal Disorganized	N/A	2.75 (4.1) 4.00 (3.8) 2.58 (3.8)	N/A	N/A
CPZ (mg/kg/day)	359.62 (247.6)	N/A	N/A	N/A

IQ, intelligence estimated by the North American Adult Reading Test (NAART); SAPS, Scale for the Assessment of Positive Symptoms; SANS, Scale for the Assessment of Negative Symptoms; BPRS, Brief Psychiatric Rating Scale; CPZ, Chlorpromazine; N/A, not applicable.

Stimuli and Equipment

The stimuli were selected from the International Affective Picture System (IAPS; Lang et al., 2008). To assess the effect of sociality on emotional responses, we selected social and non-social images from the positive, negative, and neutral images to create 6 categories of image blocks . Due to previous research indicating sex differences in self-reported valence and arousal ratings of some IAPS images, the stimulus sets for male and female participants differed slightly (Lang & Bradley, 2007). The selected IAPS images were as follows. Male set: 1274, 2200, 4599, 4601, 4651, 4700, 6212, 6250, 6510, 6560, 7006, 7140, 7190, 7235, 7270, 7350, 7460, 7480, 7550, 7620, 9140, 9210, 9290, 9300. Female set: 1274, 2200, 4599, 4601, 4640, 4700, 6212, 6250, 6560, 7006, 7140, 7190, 7235, 7270, 7350, 7460, 7480, 7550, 9140, 9210, 9290, 9373.

Importantly, across genders the average valence and arousal ratings, based on those provided in the IAPS database did not significantly differ for any of the image categories. Furthermore, the average valence and arousal ratings did not significantly differ between social and non-social valence categories.

Stimuli were presented on a 24" monitor (1024x768 resolution) 70-80cm from the participant using Unity3D (Unity Technologies, CA). Stimuli were shown in category blocks of four images, at 10 seconds per image (40s per block). Immediately after a block, participants were asked to indicate, with a mouse, their valence and arousal ratings using the *Self-Assessment Mannikin Scale* (SAM; Lang, 1980). The far left SAM indicated very negative or very unarousing and the far right SAM indicated very positive/pleasant or very arousing (see Figure 12). Then, participants selected the emotion they were experiencing out of 6 choices (happy, angry, afraid, sad, disgusted, neutral). There were 6 blocks, one for each category (social positive, social negative, social neutral, nonsocial positive, nonsocial negative, nonsocial neutral).

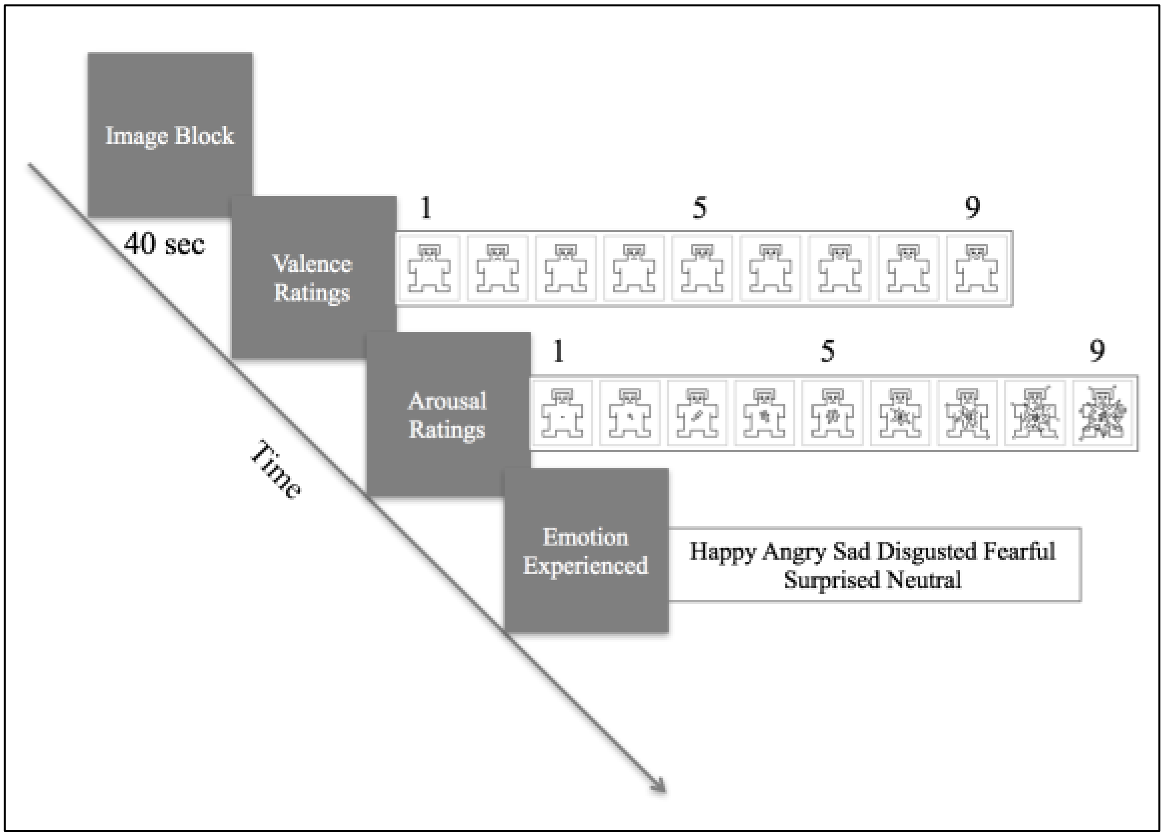

Figure 12. Schematic of the task design. Participants viewed an IAPS image block for 40sec, then rated the valence and arousal using the SAM Scales and then identified which emotion they might be experiencing. Throughout the task, physiological responsivity is recorded to be processed offline.

Physiological Monitoring and Processing

A wireless Bionomadix (BIOPAC Systems Inc., CA) physiological monitoring system was used to record 3 channels, sampled at 1000 Hz: galvanic skin response (μS; GSR) and 2 electromyograms (mV; EMG; corrugator supercilli and zygomaticus major). Physiological signals were post-processed for analysis. After filtering to reject outliers and artifacts, they were standardized (Mean=0, S.D.=1).

Procedure

Wireless sensors were placed on the participant's face and non-dominant hand. The sensors measuring corrugator activity were placed above their left eyebrow with one of the sensors aligning to the pupil when looking straightforward and above the tear duct. The sensors measuring zygomatic activity were placed about a third of the distance from the left-side corner of the mouth and the lower crease where the ear attaches to the head. The GSR sensors were placed on the index and ring fingertips of the hand.

After all the sensors were placed and checked for signal strength, participants sat for 3 minutes quietly to allow for settling of physiological responses and collection of baseline responses. After the collection of baseline data, participants performed the IAPS viewing task. GSR and fEMG were recorded during the image blocks. Each trial began with participants viewing a block of 4 stimuli sequentially (10s per picture). These 4 images belonged to the same category (i.e., social positive, social negative, social neutral, nonsocial positive, nonsocial negative or nonsocial neutral). Immediately after the presentation of the block, they indicate how positive or negative the image block made them feel (valence rating), and how aroused they feel (arousal rating) with the SAM using a mouse. After these ratings, they indicated which emotion they felt by selecting from 6 words on the computer screen with the mouse. (see Figure 1). Then, the next image block was presented and the task repeated until all six categories of image blocks were rated.

Data Analysis

To assess group differences in self-reported valence and arousal, 2x2x3 mixed repeated-measure ANOVAs were conducted for both variables with group (SZ, CO) as the between-group variable and sociality (Social, Non-Social) and valence of the image (Positive, Negative, Neutral) as the within-group variables. Specifically, we were interested in the following interactions: group-by-valence, sociality-by-valence, and group-by-sociality-by-valence. To test group differences in self-reported emotion label, chi-square analyses were conducted for the 6 category blocks and the participants' choice of emotion words.

To assess differences in physiological response to the social and nonsocial images, a repeated-measures multivariate analysis of variance (MANOVA) was conducted on the percent change from baseline for the GSR. To assess differences in facial expressivity response to the social and nonsocial images, repeated-measures MANOVAs were conducted on the % change in activity from baseline for the fEMG recordings.

All analyses are two-tailed unless otherwise specified and trends will be reported if $p < 0.10$. Effect sizes are reported for all significant and trend analyses with partial eta-squared.

Results

Self-Report Findings

See Figure 13 for the self-report results.

Self-Reported Valence

SAM ratings were converted a numerical scale ranging from 1 (far left SAM) to 9 (far right SAM). There was a main effect of group ($F(1,22) = 4.5$; $p = 0.05$; $\eta_p^2 = 0.17$). Overall, SZ rated the images more pleasant (positive) than CO. The main effect of valence was significant ($F(2,44) = 56.30$; $p < 0.0001$; $\eta_p^2 = 0.72$). Both groups rated positive images were as more pleasant (SZ: 8.1; CO: 7.2) than the neutral (SZ: 6.4; CO: 5.2) and negative images (SZ: 3.5; CO: 2.6). The group-by-valence interaction ($F(2,44) = 0.054$; $p = 0.95$), and sociality-by-valence interaction ($F(2,44) = 0.65$; $p = 0.52$) were not significant. Valence ratings for the social and non-social images did not differ across groups. Finally, the group-by-sociality-by-valence interaction was not significant ($F(2,44) = 0.59$; $p = 0.56$).

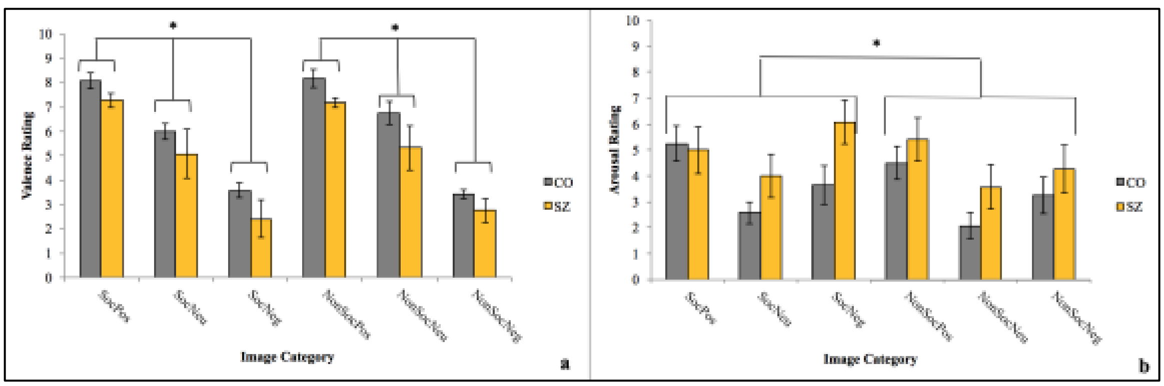

Figure 13. a) As expected, valence ratings were dependent upon the valence of the images with the positive images being rated as more positive than the neutral images which in turn were rated as more positive than the negative images. b) Unexpectedly, the social positive and negative images were rated as more arousing than the nonsocial positive and negative images.

Self-Reported Arousal

SAM ratings were converted a numerical scale ranging from 1 (far left SAM) to 9 (far right SAM). There was no main effect of group ($F(1,22) = 2.29$; $p = 0.14$), but there was a main effect of sociality on the arousal ratings ($F(1,22) = 4.39$; $p = 0.05$; $\eta_p^2 = 0.17$). Regardless of valence, the social image blocks were rated as more arousing than the non-social images. The main effect of valence was significant ($F(2,44) = 7.60$; $p = 0.001$; $\eta_p^2 = 0.26$). The positive and negative images were rated as more arousing than the neutral images, but they did not differ from each other. The group-by-valence interaction was not significant ($F(2,44) = 1.02$; $p = 0.37$). The sociality-by-valence interaction was not significant ($F(2,44) = 1.04$; $p = 0.36$); the presence of social context did not appear to have an effect on valence-specific ratings of arousal, across both groups. Finally, the group-by-sociality-by-valence interaction was not significant ($F(2,44) = 1.83$; $p = 0.17$).

Self-Report of Experienced Emotion

There were no significant group differences for the self-reported emotional experience (i.e., happy, angry, afraid, sad, disgusted, neutral) across all social and nonsocial IAPS image categories. ($chi^2 = 1.4\text{-}4.5$; $p > 0.20$). The two groups were in agreement with respect to labeling the emotions evoked by IAPS stimuli.

Physiological Reactivity

Tonic Galvanic Skin Response

There was a main effect of group; outpatients showed a stronger GSR overall compared to controls ($F(3,42) = 2.82$; $p = 0.05$; $\eta_p^2 = 0.17$), which is interesting since the two groups did not differ in their self-reported arousal; see Figure 14. There was no main effect of sociality; both groups showed similar GSR to social and nonsocial images

(F(3,42) = 0.68; p = 0.57). Finally there was no group-by-sociality interaction (F(3,42) = 0.36; p = 0.78).

Galvanic Skin Response

There was no main effect of group (F(3,42) = 0.59; p = 0.62). There was no main effect of sociality (F(3,42) = 0.28; p = 0.84). However, there was a significant group-by-sociality interaction (F(3,42) = 2.88; p = 0.05; $\eta_p^2 = 0.17$). Post-hoc analyses indicate that for neutral pictures, the two groups did not differ on the GSR to social stimuli (t(22) = -0.66; p = 0.52) but for nonsocial pictures, physiological arousal was significantly elevated in outpatients compared to controls (t (22) = 2.31; p = 0.03). Thus, abnormally high arousal to nonsocial neutral stimuli in outpatients is driving the group-by-sociality interaction.

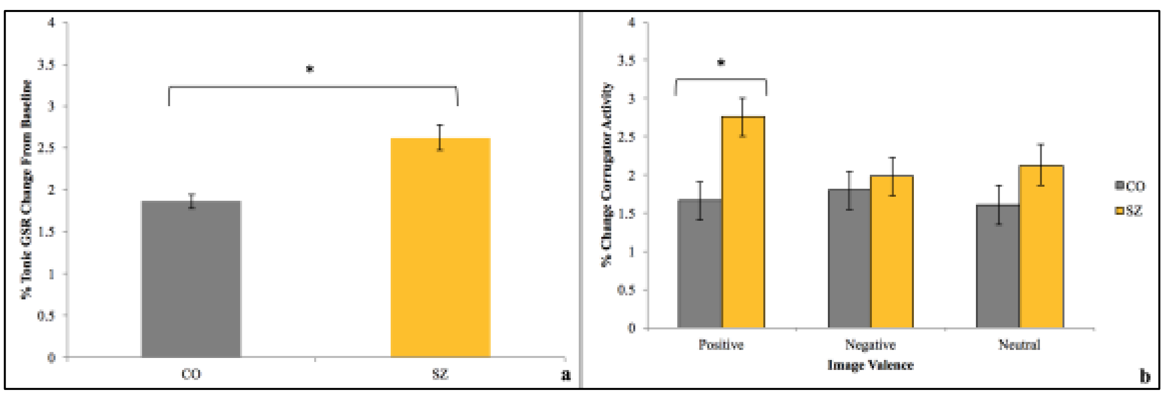

Figure 14. a) Outpatients exhibited stronger overall GSR response throughout the entire task regardless of the IAPS image block being viewed. b) Counter to what would be expected, outpatients showed greater corrugator activity while viewing positive images.

EMG Analyses

Zygomaticus Major

There was a trend for a main effect of group ($F(3,42) = 2.45$; $p = 0.08$; $\eta_p^2 = 0.15$). Post-hoc analyses indicate there was a trend for outpatients to show greater activity of the zygomatic muscle during viewing of positive images compared to controls ($F(1,44) = 3.49$; $p = 0.07$). There was no main effect of sociality ($F(3,42) = 0.34$; $p = 0.80$). The group-by-sociality interaction was not significant ($F(3,42) = 0.08$; $p = 0.97$).

Corrugator

There was a main effect of group ($F(3,42) = 3.99$; $p = 0.01$; $\eta_p^2 = 0.22$). See Figure 13. Specifically, outpatients showed greater corrugator response during viewing of positive images compared to controls ($F(1,44) = 9.59$; $p = 0.003$; $\eta_p^2 = 0.18$). There was no main effect of sociality ($F(3,42) = 0.23$; $p = 0.88$). There was no group-by-sociality interaction ($F(3,42) = 0.13$; $p = 0.94$).

Correlations with Clinical Variables.

There were no significant correlations among the self-report ratings, arousal, and fEMG across both groups. We report within-group associations below.

Outpatients: Self-reported arousal during viewing of Neutral Social images was positively correlated with SAPS ($\rho = 0.79$; $p = 0.002$). Thus, increased positive symptoms severity was associated with greater arousal for neutral social stimuli. SANS was negatively associated with mean EMG activity in the corrugator during viewing of negative social images (ρ = -0.62; p = 0.03), and mean EMG activity in the zygomatic muscle during viewing of positive nonsocial images (ρ = -0.71; p = 0.01).

Controls: The disorganized subscale of the SPQ was positively associated with arousal ratings during viewing the neutral social images (ρ = 0.60; p = 0.04); those with elevated schizotypal traits tended reported greater arousal while viewing neutral social images. The disorganized subscale of the SPQ was negatively associated with self-reported valence ratings for the negative social images (ρ = -0.80; p = 0.002) and the negative nonsocial images (ρ = -0.70; p = 0.003); those with elevated schizotypal traits tended to give lower ratings for negative images.

Discussion

A comprehensive assessment of the emotional response to visual images in outpatients with schizophrenia and matched healthy controls was conducted, by collecting self-reported valence and arousal ratings, as well as measuring physiological arousal and fEMG.

Labeling of emotion experience seems to be intact in outpatients, as both groups generally indicated experiencing the same emotions when asked to select a word that matched what they felt upon viewing IAPS stimuli. With respect to valence, outpatients rated stimuli to be more pleasant than healthy controls, which replicates previous findings of elevated positive ratings of affective stimuli (Doop & Park, 2006; Cumming et al, 2010; Folley & Park, 2010), and not inconsistent with findings of intact pleasantness ratings of IAPS stimuli (Heeny & Gold, 2007; Herbener et al, 2007).

Previous research has indicated that outpatients and healthy controls report experiencing similar levels of emotion when presented with affective stimuli (Kring & Neale, 1996; Kring, Kerr, Smith, & Neale, 1993; Myin-Germeys et al., 2000). In our study, both groups reported experiencing similar levels of arousal, but one physiological index of arousal, the GSR, told another story. GSR was increased in SZ, which perhaps hints at altered awareness or calibration of internal states. Emotional awareness may depend on integrating sensorimotor and interoceptive information with an interpretation of the external situation in real time (Terasawa et al, 2013). The role of bodily sensations and interoceptive awareness in emotion experience is unclear but since interoception and somatosensory processing are compromised in the schizophrenia-spectrum (Chang & Lenzenweger, 2005; Peled et al, 2003; Linnman et al., 2013), future research should further elucidate the dysconnectivity between self-reported emotions and internal states in schizophrenia.

For both groups, self-reported arousal was influenced by the presence of social components in stimuli. This finding was unexpected given that we had carefully matched for normative valence and arousal ratings (Lang et al, 2008) across the social and nonsocial images. Nonetheless, participants reported that the social images (i.e., containing humans) were more arousing than non-social images. This finding underscores the importance of social context in emotional experience (Keltner & Haidt, 1999). Moreover, in terms of physiological arousal, there was a curious interaction between group and sociality on the GSR. The GSR rate of the two groups do not differ on social neutral images but for nonsocial images, it was elevated for outpatients compared to healthy controls. One possibility is that the social and nonsocial boundary may be blurred in schizophrenia. Inanimate objects are considered nonsocial but there are conditions under which they acquire animistic and social qualities, notably during hallucinations and after prolonged social isolation (see Hoffman, 2007). It might be important to re-examine our conceptualization of 'social vs. nonsocial' categories in the context of psychosis.

With respect to EMG, interesting differences emerged between outpatients and healthy controls. While the finding of reduced *overt* facial expressions in SZ is relatively consistent (Kring & Moran, 2008), studies analyzing the muscular activity of the face has been more variable (Kring, Kerr, & Earnst, 1999; Mattes et al., 1995; Wolf et al., 2006). In this study, the activity of the corrugator muscle in outpatients was significantly greater than that in healthy controls, especially for positive images. Since corrugator muscles are implicated in the expression of negative emotions (e.g., frown), the fact that pleasant images increase corrugator activity is counterintuitive. However, mixed emotions do exist and increase with age (see Carstensen et al, 2000; Ong & Bergeman, 2004). Although outpatients and healthy controls did not differ significantly in their self-reported emotions, their responses were artificially constrained by the task requirement (i.e., selection of one out of six emotion words). Therefore, it is not possible to determine whether the experienced emotions were 'pure', undifferentiated or mixed. In this context, the insightful observation that in persons with schizophrenia, positive and neutral stimuli may "co-activate hedonic and aversive emotions" seems particularly relevant (Cohen & Minor, 2010).

Pleasant, positive images elicited somewhat greater zygomatic activity in outpatients than healthy controls. Given the previous findings of reduced overt facial expression in schizophrenia compared with healthy controls (see Kring & Moran, 2008), it is puzzling as to why the activity of the muscles underlying overt facial expressions is enhanced in the outpatients in our study. Outpatients did not differ from healthy individuals in their choice of labels for the emotions experienced so at least forced-choice labeling emotions seems to be intact. However, our fEMG data suggest that embodied simulation of those emotions and/or the expression of these emotions may be dissociated from the subjective, experiential component.

Within the patient group, EMG activity was negatively associated with the severity of negative symptoms; reduced fEMG in those with elevated negative symptoms may be manifested as flat affect. In controls, disorganized schizotypy was associated with increased arousal to neutral social images, which seems maladaptive; since neutral scenes are supposed to lack emotional content (e.g., a person standing under an umbrella), they should be least arousing compared with positive and negative stimuli.

With respect to the physiological indices of emotion experience, GSR data indicated areas of difference between outpatients and healthy controls. Specifically, outpatients showed stronger GSR than healthy controls. Heightened physiological arousal has been reported in a subset of SZ who are more socially withdrawn (Venables & Wing, 1962). In our study, outpatients reported lower social engagement and more time spent alone than healthy individuals, as indicated by the SFS (Birchwood, Smith, Cochrane, Wetton, & Copestake, 1990). Thus, increased physiological arousal may have been driven by social isolation in the outpatient group.

Lastly, discussion of the potential role of sociality in emotion processing in schizophrenia is warranted. Although self-reported arousal was increased for social images for both groups, physiological responses to the nonsocial images diverged. In outpatients, physiological arousal was elevated for nonsocial images compared with healthy individuals. Given the mundane and non-emotional content of the nonsocial images, greater arousal in outpatients suggests over-interpretation of external stimuli that could eventually lead to delusions, and/or miscalibration of internal states. Interestingly, self-reported arousal ratings for the social neutral images were significantly related to positive symptoms in outpatients. More psychotic patients found neutral social scenes more arousing. The very boring nature of the social neutral images (e.g. man sitting at a computer, a person standing under an umbrella) render certain ambiguity, which may then trigger greater elaboration and interpretation of these scenes. This may partly explain increased threat sensitivity in schizophrenia (Henry et al., 2010). A similar pattern was also observed in healthy individuals. Elevated SPQ-disorganized syndrome and arousal ratings for the social neutral images were correlated. These results imply that so-called ‘neutral’ images are not necessarily emotion-less and we must carefully consider individual differences in the top-down processing of standardized emotional stimuli. Future studies should investigate the process of interpretations that contribute to emotional experience when presented with ambiguous stimuli.

There are limitations to the study. The sample size was small but this study is one of the very few to examine subjective emotional experience, physiological index of arousal (skin conductance), and fEMG within the same experiment in demographically-matched individuals with schizophrenia and healthy controls. Another limitation is the use of static images for evoking emotional responses. While IAPS stimuli have shown to be sufficient in a wide range of emotion studies (see Bradley, Codispoti, Cuthbert, &

Lang, 2001), their ecological validity is circumscribed. We live in a dynamic and ever-changing world, which engages our emotions in a similarly dynamic way.

In summary, pockets of intact and anomalous indices of emotional processes in outpatient individuals with schizophrenia were found, with dissociation of self-reported emotions from the physiological and expressive indices emotion. Such splitting of subjective feelings from internal signals perhaps reflects what Eugen Bleuler meant by schizophrenia.

CHAPTER VI

SPONTANEOUS FACIAL MIMICRY AND EMOTION RECOGNITION IN SCHIZOPHRENIA

As the previous chapters have elucidated, emotion recognition and emotional experience are disrupted in individuals with schizophrenia. CHAPTERS III and IV demonstrated that both inpatients and outpatients with schizophrenia do not recognize emotion presented in gait to the same degree that healthy individuals do. Furthermore, this deficit does not appear to be due to an inattention to the emotionally relevant aspects of the body during movement, at least this is the case with clinically stable outpatients. Outpatients with schizophrenia also display aberrant emotional responses to social and non-social stimuli, displaying overall increased arousal regardless of the content presented and exhibiting emotionally incongruent recruitment of facial musculature. Yet, outpatients reported experiencing similar emotions and commensurate rating valence and arousal. How these two processes interact, emotion recognition and emotional experience, is investigated, albeit indirectly to a degree, in the following study. Measurement of spontaneous facial mimicry is conducted in association with an emotion recognition task using dynamically expressive avatars displaying emotional facial reactions. If facial mimicry is associated with emotion recognition ability, as has been previously argued (Neal & Chartrand, 2011; Ponari, Conson, D'Amico, Grossi, & Trojano, 2012; Weyers et al., 2006), then investigation into the integrity of this relationship is warranted in individuals with schizophrenia. Underlying this relationship is the idea that we understand others through shared representation of their emotional states and that this shared representation recruits associated features of said individuals emotional experience (Singer & Lamm, 2009). If sharing in the emotional experience of others is aberrant in individuals with schizophrenia they they would need to engage other, potentially more error-prone, means of coming to an understanding of how others feel. Through investigating the association between spontaneous facial mimicry and emotion recognition performance, the following study provides an important step forward in growing our understanding of this complex process.

Methods

Twelve outpatients with schizophrenia were recruited from private care facilities in Nashville, TN. Diagnoses were confirmed with the structured clinical interviews (SCID; First et al, 2002) according to the Diagnostic and Statistical Manual 4th Edition-Text Revised (DSM-IV TR). All 12 outpatients were taking an atypical antipsychotic**.** Mean chlorpromazine (CPZ) equivalent dose was 359.63 mg/kg/day (s.d.=247.61). Clinical symptoms were assessed using the Brief Psychiatric Rating Scale (BPRS; Overall & Gorham, 1962), the Scale for the Assessment Positive Symptoms (SAPS; Andreasen, 1984), and the Scale for the Assessment Negative Symptoms (SANS; Andreasen, 1984).

Twelve healthy controls were recruited from the same community via advertisements. They were screened for current and prior history of Axis I disorders using the SCID (First et al, 2002) and a history of psychosis in their first-degree relatives.

Exclusion criteria for both groups were as follows: IQ score lower than 85, a prior history of head injury or neurological disorder or history of drug use in the year prior to the study.

Intelligence (IQ) was estimated using the North American Adult Reading Test (NAART; Uttl, 2002), an assessment tool measuring premorbid IQ. All subjects were assessed to be of at least average intelligence and had achieved at least a high school education (See Table 3). All participants had normal or corrected to normal vision. Participants gave written informed consent as approved by the Vanderbilt Institutional Review Board. The two groups were matched on age, gender, estimated IQ, but not years of education. See Table 3 in CHAPTER V for demographic and clinical information.

Materials and Procedure

The two emotional avatar tasks were presented on a 24” flat LCD panel monitor (resolution 1980 x 1080). The task was delivered via Unity3D game engine. The avatars were originally designed for a study investing emotion recognition in individuals with autism spectrum disorders (Bekele et al., 2013). Briefly, seven emotional expressions were selected based on Ekman’s proposal of universally recognition emotional expressions: enjoyment, surprise, contempt, sadness, fear, disgust and anger. Four levels of intensity for each emotional expression were created (low, medium, high, and extreme) for a total of four levels of emotional expression per emotion; see Figure 15 for an example of the avatar. In addition to the emotional expressions, lip-synced avatars were also developed in order to deliver the social vignettes prior to the emotional expression in the social vignette task. During presentation of the social vignette, the voice spoke in a neutral tone and the avatar did not express any emotion until the vignette was finished.

Prior to the start of this study, a pilot study was completed, using college-age students, in order to assess whether all the emotional expressions developed were of sufficient quality to be included in the study. The results of this pilot study indicated that most confused contempt with disgust and fear with anger. Therefore, in the current study, contempt and fear were excluded from the task and only the five remaining emotions were presented.

Figure 15. Example of the virtual reality avatars that were used to express the emotions selected for the study.

Across both the social vignette and emotional expression task, participants were presented with 20 trails (five emotions x four intensity levels) in randomized order. The emotional expression was presented for five seconds. In the social vignette task, the vignette was presented without prosody in the voice so as to control for confounding factors in the emotional expression judgment that the participant was required to make. After the emotional expression was presented, participants selected which emotion they believed was expressed by the avatar and then indicated how confident they were in their decision, using a five point Likert scale (0%, 25%, 50%, 75%, 100%).

As occurred in CHAPTER V, participants had the physiological sensors placed on their person prior to the start of the study and then they were asked to sit quietly for three minutes so that baseline recordings from the physiological sensors could be gathered. Two electromyographic sensors were placed on the participants' faces; on the corrugator supercilli and zygomaticus in order to index participant facial expression activity during the task. Description of specific placement, data recording, and data processing are described in CHAPTER V.

Data Analysis

Behavioral performance was calculated for the number of trials participants answered correctly out of the total number of trials administered. Group differences were compared through a repeated measures ANOVA where group (SZ or CO) was the between group factor and task type (Social Vignette and Emotion Expression) were the within group factors. Within each task, performance was compared by emotion between the two groups in order to assess and emotion specific effects. Confidence ratings were also submitted to a repeated measures ANOVA in order to determine whether there were differences between the groups with regard to their confidence in recognizing the emotions expressed.

Electromyographic activity during the emotion expression portion of the two tasks was calculated by entering, separately, the mean activity of the corrugator sensor and zygomatic sensor into a repeated measures ANOVA where, again, group (SZ and CO) was the between group factor and dynamic emotional expression viewed (Joy, Anger, Sadness, Surprise, Disgust, Baseline) was the within group factor. Due to technical error during the Social Vignette task, one participant from each group did not provide full data for either EMG recording and therefore were removed from group analyses for that for the EMG analyses.

Finally, Pearson's correlations were conducted to investigate the relationship between facial expression activity, behavioral performance, current symptomatology, and questionnaire responses.

Results

Behavioral Performance

See Figure 16 for the results. Overall, there were no group differences in performance across both tasks, ($F(1,22) = 0.81$; $p = 0.38$). Although, across both groups, performance was significantly better for the Emotion Expression task versus the Social Vignette task ($F(1,22) = 19.66$; $p = 0.002$). Given the lack of overall group differences in performance on the two tasks, there was no group by task interaction ($F(1,22) = 0.07$; $p = 0.80$).

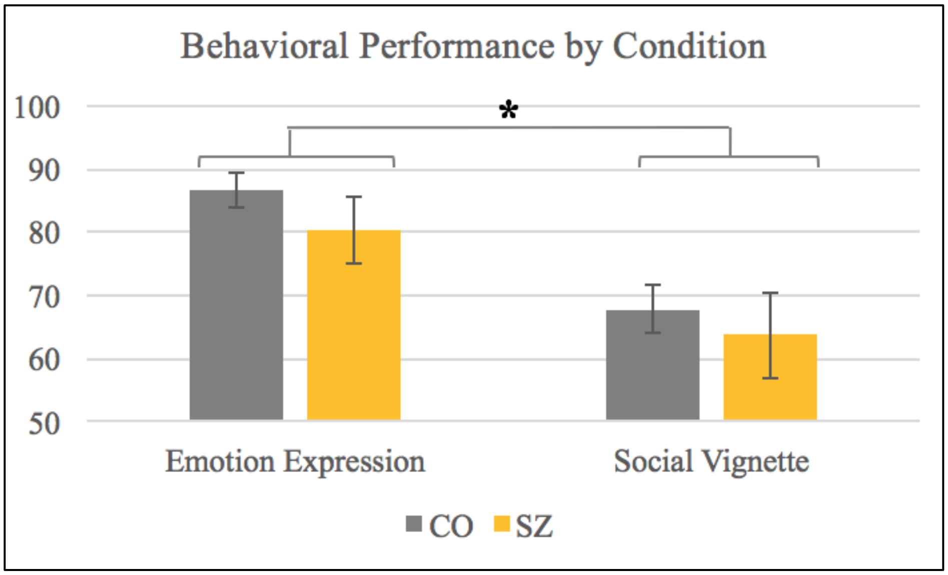

Figure 16. Overall, the two groups did not differ in their performance on either task. Performance, in general, was better when participants were solely presented with the VR emotional expression than when the expression was accompanied by a short auditory vignette.

Given that previous research has shown that individuals with schizophrenia display emotion-specific deficits on recognition tasks, we conducted follow-up analyses within each task to determine whether performance was affected by the emotion displayed. On the Emotion Expression task, there was no main effect of group ($F(1,22) = 1.11$; $p = 0.30$). There was a main effect of emotion ($F(4,88) = 3.57$; $p = 0.009$). Follow-up analyses indicated that across both groups, recognition of surprise was significantly better than recognition of joy ($p = 0.02$). There was a trend for there to be a group by emotion interaction ($F(4,88) = 2.30$; $p = 0.07$). Follow-up analyses did not reveal any significant emotion-specific deficits in the outpatient group versus the control group.

On the Social Vignette task, there was no main effect of group ($F(1,22) = 0.82$; $p = 0.38$). Again, there was a main effect of emotion ($F(4,88) = 7.01$; $p < 0.001$). Follow-up analyses indicated that the recognition of sadness was significantly better than the recognition of surprise and joy ($p < 0.05$). There was no group by emotion interaction ($F(4,88) = 0.34$; $p = 0.85$).

Across both tasks, both groups reported similar degrees of confidence in their responses ($F(1,22) = 0.005$; $p = 0.94$). There were no significant differences in participants' confidence ratings for the two tasks ($F(1,22) = 0.01$; $p = 0.91$). Finally, there was no group by task interaction ($F(1,22) = 1.29$; $p = 0.27$).

Electromyographic Activity

Corrugator Supercilli

See Figure 16 for the results of corrugator activity on both tasks. On the Emotion Expression task, activity of the corrugator muscle during viewing of dynamic emotional expressions, across different emotional expressions, did not differ between the two groups ($F(1,5) = 1.32$; $p = 0.26$). There was a significant effect of emotional expression on the activity of the corrugator muscle, across both groups ($F(5,110) = 61.64$; $p <0.001$). Follow-up analyses indicate that this significant main effect was driven primarily by the significant differences in corrugator activity during the viewing of emotional expressions compared to baseline activity; all emotional expressions viewed elicited greater corrugator activity than what was recorded at baseline. The two groups did not significantly differ in the degree to which they activated the corrugator muscle during viewing of the dynamic emotional expressions ($F(5,110) = 0.84$; $p = 0.52$).

On the Social Vignettes task, similar patterns were seen with regard to nonsignificant group differences in overall corrugator activity ($F(1,20) = 2.35$; $p = 0.14$) but significant differences in corrugator activity when viewing the dynamic emotional expressions compared to baseline activity (F(5,100) = 22.33; p <0.0001). Again, follow-up analyses indicated that the significant main effect of emotional expression was driven by the elicited activity while viewing the dynamic emotional expressions when compared to baseline. As was the case in the Emotion Expression task, the two groups did not significantly differ in the degree to which the dynamic emotional expressions elicited corrugator activity (F(5,100) = 1.53; p = 0.19).

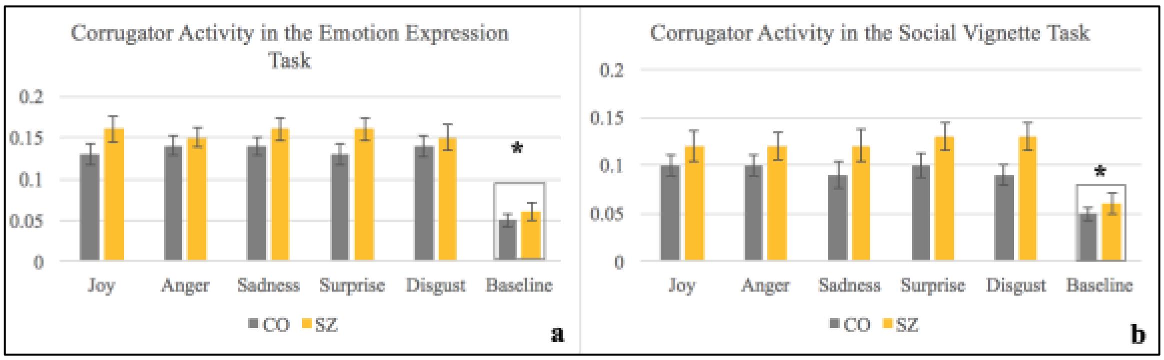

Figure 17. a,b) Corrugator activity was significantly greater while viewing dynamic emotional expressions than during baseline.

Zygomaticus Major

See Figure 17 for the results of zygomaticus activity during the two tasks. With regard to zygomatic activity during the Emotion Expression task, the two groups did not significantly differ in their mean zygomatic response (F(1,22) = 2.64, p = 0.12). Following the pattern of the corrugator activity, there was a main effect of emotion with regard to zygomatic muscle activity (F(5,110) = 89.18; p < 0.0001). As before, this was driven by the significant difference between baseline activity and activity elicited during viewing the dynamic emotional expressions. Additionally, there was no group by emotion interaction (F(5,110) = 1.24; p = 0.29).

Mean activity of the zygomatic muscle during the Social Vignette task significantly differed between the two groups, with the outpatient group showing, on average, greater activity of the zygomatic muscle ($F(1,20) = 11.80$; $p = 0.003$; $d = 1.5$). As with the other tasks, there was a main effect of Emotion with regard to zygomatic activation ($F(5,100) = 30.83$; $p < 0.0001$). Activation of the zygomatic muscle was significantly greater during viewing of dynamic emotional expressions than during baseline recording for all emotions presented. Finally, there was a significant group by emotion interaction ($F(5,110) = 2.97$; $p = 0.02$); zygomatic activity was greater in the outpatient group than the control group for all of the dynamic emotional expressions viewed.

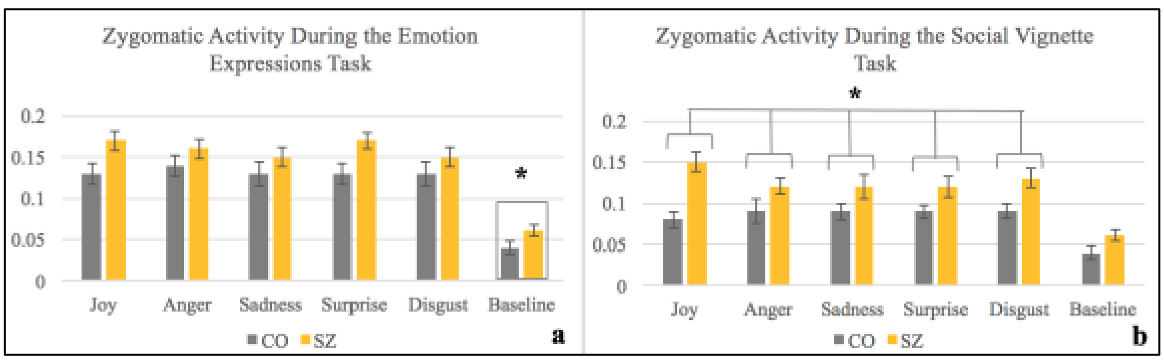

Figure 18. a) Zygomatic activity was significantly greater while viewing dynamic emotional expressions during the Emotion Expressions Task. b) In outpatients, zygomatic activity was significantly greater than controls during the dynamic emotional expression in the Social Vignettes task.

Correlations

Across both of the groups, performance on the Emotion Expressions task was positively associated with participants' self-report of confidence in their answers ($\rho = 0.68$; $p = 0.0003$). Additionally, confidence ratings on both of the tasks were positively associated with one another ($\rho = 0.75$; $p < 0.0001$). Generally, EMG activity was not associated with performance on either task.

Within the healthy control group, the degree of endorsement of items on the Interpersonal subscale of the SPQ was negatively associated with zygomatic activity, in the Emotion Expressions task, during Joy trials ($\rho = -0.66$; $p = 0.02$), Sadness trials ($\rho = -0.60$; $p = 0.04$), and Surprise trials ($\rho = -0.75$; $p < 0.005$). Suggesting that greater endorsement of interpersonal difficulties is associated with less recruitment of facial musculature when viewing emotional expressions.

Discussion

In the assessment of spontaneous facial mimicry during emotion recognition tasks, a number of findings ran counter to expectations given previous findings in the literature. First and foremost, counter to most investigations of emotion recognition in schizophrenia (see Kohler et al, 2010 for review), in the present study, outpatients and healthy controls did not differ in their performance accuracy on either the Emotion Expression or Social Vignette tasks. Previous studies utilizing dynamic stimuli in the presentation of emotional facial expressions found individuals with schizophrenia displayed worse recognition performance than controls (Archer et al., 1994; Johnston et al., 2010). While the current findings conflict with this previous investigation, there are a number of methodological differences that may partially explain the lack of effect in the current study. Johnston and colleagues (2010) used only two emotions (fear and surprise) in their assessment of emotion recognition ability. Additionally, their stimuli were created by phasing images taken from the NimStim stimulus set (Tottenham et al., 2009), which while dynamic in presentation, does not fully capture the dynamic nature of an emotional expression. In the current study, virtual reality avatars were used and their development for each of the emotional expressions was accomplished through the adjustment of the parts of the avatar's face that would be involved in the instantiation of that emotional reaction. Such differences in the presentation of emotional expressions may have given rise to the conflicting findings.

Another unexpected finding was that performance on the Social Vignette task, which provided both an emotional scenario auditorally and a congruent emotional expression, was worse than performance on the Emotion Expression task. Lee and colleagues (2012) found that, when provided situational context for a particular emotional expression, individuals with schizophrenia provided similar ratings of emotional intensity that was congruent with the situation, when compared to controls. Therefore, one might expect the outpatient group in the current study to also benefit from the situational context of the vignettes presented prior to the emotional expression to facilitate identification. One possible cause of lowered performance, across both groups, was that the social vignettes were presented in a monotone voice that did not provide prosodic cues to the emotional valence of the situation. Such an artificial presentation, which was initially selected so that the role of dynamic emotional expression on emotion recognition ability could be isolated, could have negatively affected participants' "reading" of the situation. Therefore, rather than facilitating performance in the two groups by providing a situational context, participants may have been thrown by the lack of prosodic congruence to what was being said.

Interestingly, when both tasks were analyzed separately, participants displayed variable performance in the recognition of the specific emotions. No discernable pattern was able to be identified with regard to rates of recognition for the different emotions presented. Future research is needed to investigate whether dynamic expressions show consistent differences in the rates of accurate identification of the target emotion.

Of particular importance for this study was the role of spontaneous mimicry of emotional expressions, as assessed through fEMG. Counter to expectations, outpatients with schizophrenia generally showed similar recruitment of the corrugator muscle during viewing of dynamic negative emotional expressions, when compared to healthy controls. While both groups did show more activation of the corrugator muscle during viewing of emotional expressions, when compared to baseline, this activation was indiscriminate to the emotion viewed. These findings are counter to both findings in healthy individuals (Dimberg, Thunberg, & Elmehed, 2000), and in individuals with schizophrenia (Kring et al., 1999; Sestito et al., 2013; Varcin et al., 2010). While some previous studies in individuals with schizophrenia show similar activation of the corrugator muscle in outpatients and healthy controls (Kring et al., 1999; Sestito et al., 2013), such activation was only seen when participants were viewing negative stimuli. As noted previously, individuals with schizophrenia experience can experience an affective ambivalence whereby positively-valenced stimuli, for example, can co-activate both hedonic and aversive responses (Cohen & Minor, 2010).

With regard to zygomaticus activity, participants showed the same general pattern of activation on the Emotion Expression task as was seen with the corrugator activity, but outpatients show significantly greater activation on the Social Vignette task and this greater activation was specific to when participants were viewing emotional expressions. Counter to the present findings, Kring and colleagues (1999), found that while individuals with schizophrenia showed greater corrugator activity to congruent negative facial expressions, compared to healthy controls, their zygomaticus activity was similar. Again, while activation of the zygomaticus muscle was greater, both groups displayed indiscriminate responses to the various emotional expressions. Further research is needed to determine whether such indiscriminate responses can be replicated or if this result is anomalous.

It is possible that the current findings could be in part due to the type of stimuli used. The intent of the current study was to use more ecologically valid stimuli than static images of facial expressions that have been used previously. More and more frequently, virtual reality is being used in both research and in the general public as a means of interacting with humans in a controlled manner. A number of studies have shown that healthy individuals show differential facial musculature activation to virtual reality avatars expressing various emotions (Mojzisch et al., 2006; Weyers et al., 2006). Given that virtual reality has been shown to engage spontaneous mimicry to a similar degree seen with static images of human faces, the argument that the current study's incongruent findings being the result of the use of virtual reality stimuli is without much merit.

Insofar as the degree of spontaneous facial mimicry has been found to be associated with emotion recognition capacity (Oberman, Winkielman, & Ramachandran, 2007) and greater empathy (Dimberg & Andréasson, 2011), one might expect that the degree of fEMG activity to be associated with emotion recognition performance in the currenty study. Counter to this, there were no significant correlations between fEMG activity and performance on either task for either group. That both groups displayed indiscriminate fEMG activity on both of the tasks likely precluded any possible association from being identified.

This study is not without limitations. A small sample size could be masking effects that could be seen if there were a greater number of participants. Furthermore, the relatively small number of trials per emotion presented may have led performance in the two groups to be more unstable and with a larger number of trials, unintended error in any one trial could be reduced. Finally, the stimuli of this study were developed for a previous investigation into the emotion recognition performance in adolescents with autism spectrum disorders (Bekele et al., 2013). It is possible that the stimuli used, which looked to be adolescents themselves, may have reduced the generalizability of emotional experience to the current sample whose mean age is in the forties. Some research indicates that age-group affects influence the facial mimicry of individuals when viewing individuals of another group (Ardizzi et al., 2014). Adolescents displayed reduced corrugator activity when viewing older adult faces expressing negative emotions than when images of same-age peers were presented, suggesting that age can influence our spontaneous assessment of another’s emotional state.

That the current study does not provide furthering evidence of the role of spontaneous facial mimicry, as a proxy for the role of shared representations, in the act of recognizing emotions in others, does not necessarily negate this theory as a possible mechanism for social cognitive deficits in schizophrenia. Further research into the nature of spontaneous facial mimicry in individuals with schizophrenia is warranted, especially with the use stimuli that are more veridical to everyday emotional expressions. In CHAPTER VII, the findings from the current study and those previously presented will be discussed in relation to one another and where research into social cognitive deficits in schizophrenia should go from this point will be considered.

CHAPTER VII

CONCLUSION

As a social species, we have developed a repertoire of abilities in order to navigate social interactions in service of our needs. Under typical circumstances we readily appreciate those around us with regard to their emotional states and relevant social cues. Within only a few seconds, we are able to garner a wealth of social information that we can use to guide our actions in dealing with others (Ambady & Rosenthal, 1993; Thoresen et al., 2012) and through this, develop meaningful and sustaining relationships. The converse of this, social isolation (Seeman, 1996) and loneliness (Heinrich & Gullone, 2006) have been shown to be exceedingly toxic for humans. Both social isolation and loneliness are reported by individuals with schizophrenia at a higher rate than the general population. Therefore, it is incumbent that we work to better understand the underlying processes, and how they give rise to the debilitating social impairment present in this group of individuals.

The purpose of this dissertation was three-fold. First, a focus on exploring social cognitive deficits, specifically socio-emotional recognition deficits in individuals with schizophrenia, through ecologically valid stimuli. Second, probe the generalizability of inattention to salient features involved in the recognition of emotion (Loughland, Williams, & Gordon, 2002a; Marsh & Williams, 2006). Third, explore these deficits in the context of embodied emotion and investigate whether the emotion recognition deficits result from a breakdown in the shared representation of other's emotional states. CHAPTERS III, IV, and VI, incorporated stimuli that were dynamic in their expression of various emotional states and presented those states via the body and the face. Movement is known to engage visual attention systems (Abrams & Christ, 2003), and the motion associated with facial movements involved in emotional expressions, appears to aid in the detection of emotional expressions (Kaufman & Johnston, 2014). Thus movement is likely an intrinsic component of the emotion recognition process. Insofar as this is the case, exploration into the integrity of emotion recognition deficits in schizophrenia in this dissertation revealed both consistencies with the previous literature and some deviations from past findings. Both inpatients with schizophrenia spectrum disorders and outpatients with chronic, stable schizophrenia displayed emotion recognition deficits when viewing emotional gaits in the present studies and aligns with the few previous investigations using dynamic gait (Couture et al., 2009; Henry et al., 2010; Peterman et al., 2014). That individuals with schizophrenia display these deficits across the disease course, both in an acute psychotic phase and during a more stable phase, is consistent with previous findings (Kohler et al., 2010), but an interesting wrinkle in this was that the inpatient group did not benefit from an increase in the intensity of the emotional cues to the same degree seen in previous investigations in chronic patients (Peterman et al., 2014). While both studies were cross-sectional in nature and the previous study used only two emotions (angry and happy), it is possible that in a more acute phase, individuals with schizophrenia have less resources to allocate to using more overt emotional displays to aid in their recognition of emotional states. Finally, these individuals displayed a greater rate of misperception of the neutral stimulus, in that they perceived emotional cues when none were present. By "reading into the movements of others" however innocuous, could lead to the deployment of discordant behaviors to the social situation.

In line with the misperception of emotional states, investigation into how inpatients with schizophrenia spectrum disorders view others along social trait dimensions showed that these individuals do not use the emotional state inherent in the movement when making judgments. In fact, their judgments appear to go in the opposite direction of how healthy individuals judge the emotional movement. In healthy populations, the emotion inherent in the movement has been shown to drive the social trait judgments that we make (Thoresen et al., 2012) therefore individuals with schizophrenia may be using other cues in the gait or perhaps misrecognizing how the individual is moving and making decisions based off this incorrect inferral. Indeed, this latter conclusion may be driving the discordant ratings seen in this population given their emotion recognition deficits (Henry et al., 2010).

As to how these errors in the recognition of emotional states occurs, CHAPTER IV directly probed this question by investigating whether it was due to this population not attending to the aspects of the body that convey our emotional states. Counter to what one would expect given previously consistent findings of inattention to the salient features of the face (Loughland, 2004; Marsh & Williams, 2006), individuals with schizophrenia displayed remarkably similar allocation of attention to the parts of the body involved in the expression of emotion. Furthermore, proportion of fixations and amount of time spent fixating on the salient areas of the body was associated with accuracy in identifying emotions expressed. And yet, the individuals with schizophrenia were unable to recognize the emotions displayed to the same degree as the healthy individuals. While not significantly different, the individuals with schizophrenia appeared to be spending more time looking at the salient area. Why might this be the case? Why is it that “looking” does not necessarily translate to “seeing”? It is this question that led to the third purpose of the dissertation, which is to consider these deficits in a different light. Perhaps when provided an experience that is closer to real life, seeing the expression of emotion as it is intended, through movement, individuals with schizophrenia do look where healthy individuals look. This does not appear to be sufficient for the understanding of other’s emotions. As was detailed in CHAPTER II, the breakdown in understanding others may come from within; the ability to “share” in the emotional experience of others through the simulation. Individuals with schizophrenia do not respond the same way, on a neural level (Mehta, Basavaraju, Thirthalli, & Gangadhar, 2012; Mehta, Thirthalli, Basavaraju, Gangadhar, & Pascual-Leone, 2014; Thakkar et al., 2014), to the overt expressions of others and this lack of resonance with other’s actions could impair their ability to accurately infer how others are feeling.

This breakdown in the understanding of others does not appear to extend to the understanding of one’s self. When comparing across studies, individuals with schizophrenia generally do not differ in their evaluation of emotionally evocative stimuli (Cohen & Minor, 2010; Doop & Park, 2006; Herbener et al., 2008) but that when they need to make a decision in response to how others are presenting themselves, they are prone to error. Reflecting upon one’s own emotional responses and experiences is intact, as seen in CHAPTER V, but when asked to extrapolate on other individuals’ emotional responses, as indexed by identifying the emotions, they misrecognize and over-perceive emotional states when they are not present. This impairment is present not only when attempting to recognize the facial expressions of others, but also in the emotional states conveyed in one's body movement. If the understanding of other's emotional states is due, in part, through the manifestation of the congruent emotion in oneself, as others have theorized (Carr et al., 2003; Decety & Chaminade, 2003; Niedenthal, 2007; Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009), then the underlying cause for the deficits seen in the studies presented herein, must be due to a breakdown in shared representations.

As for where this breakdown occurs, we can turn to CHAPTERS V and VI for possible insight. When presented with emotionally evocative stimuli, individuals with schizophrenia report the magnitude of valence and arousal for these images to a similar degree that healthy individuals report. Additionally, they do not differ with regard to the emotion experienced when viewing various emotional images. Thus, from a subjective level, individuals with schizophrenia report experiencing the emotions that other experience in response to the same evocators. Thus it is not the case that elicitors of particular emotions differ across these two groups. The question though of what is being physiologically experienced that gives rise to this subjective sense does appear to differ. In CHAPTER V, outpatients with schizophrenia displayed increased tonic GSR, regardless of the valence or sociality of the images presented and suggests that individuals with schizophrenia are at a higher level of arousal (Levenson, 1992). Such undifferentiated arousal may then lead to less of a reliance on this internal cue as an indicator of emotional state. There is some preliminary evidence that the degree to which we experience emotions in an embodied manner, as in experiencing our emotions through our bodily sensations, is associated with our ability to identify emotional states from others' body movements (Blain, Snodgrass, Peterman, Nummenmaa, Glerean, & Park, In Preparation). Whether such a process is disrupted in individuals with schizophrenia, if they do not "experience" their emotional states in the context of their bodily sensations, then this could have implications for their ability to identify others' emotional states.

Finally, the outpatients displayed incongruent activity of the corrugator during viewing of positive images. Considered holistically, the convergence of these different streams of emotional experience appear to be discordant from what is typically seen in the healthy individuals (Britton, Taylor, Berridge, Mikels, & Liberzon, 2006b). In particular, the undifferentiated activity of the corrugator muscle in the outpatients suggest a disconnect between the self-reported experienced emotion and the engagement of concordant facial musculature.

In line with this, CHAPTER VI revealed that individuals with schizophrenia displayed undifferentiated fEMG activity to different dynamic emotional expressions. Counter to what one would expect given previous findings of concordant recruitment of facial musculature involved in the presented emotional expression (Likowski et al., 2012; Neal & Chartrand, 2011), individuals with schizophrenia activated both the zygomatic and corrugator muscles, compared to baseline, irrespective of the perceived emotion. Additionally, in the instance of greater recruitment of the zygomatic muscle compared to controls, this was directly opposite to the findings of Kring and colleagues (1999). Given the caveats presented in the CHAPTER VI discussion, such as the stimuli used as well as the task design employed, interpretation of the results of CHAPTER VI must be considered with caution. What could potentially be at play though, in CHAPTERS V and VI, is that in the process of perceiving another individual's emotion expression, what is being perceived is not being effectively translated and mapped onto the congruent emotional experience in the perceiver. Insofar as the said perceivable expression does not activate a discernable emotional experience inside the perceiver, then inferences based of this shared representation would be muddled. Indeed, Likowski and colleauges (2012) found simultaneous recruitment of congruent facial musculature during viewing of emotional expressions and associated mirror neuron activity in healthy individuals.

In both CHAPTERS V and VI, individuals with schizophrenia displayed undifferentiated facial musculature responses to emotional elicitors (e.g. evocative images and dynamic facial expressions). If the motoric manifestation of an emotional state is decoupled in individuals with schizophrenia, then such a cue provided by a potential social partner would not be of benefit to developing an understanding of that social partner's emotional state. Previous research has pointed to this decoupling of motoric expressions of emotional experiences in that individuals with schizophrenia display greater difficulty in miming emotional expressions when cued (Park et al., 2008), less motoric resonance when interacting with others (Kupper et al., 2010), and, when producing emotional expressions, are less recognized, than expressions produced by healthy individuals, by independent viewers (Healey, Pinkham, Richard, & Kohler, 2010). Together, these studies point towards the conclusion that regardless of the subjective emotional state that individuals with schizophrenia report, they do not engage all aspects of an emotional response in an emotional experience. While other studies using fEMG have found intact recruitment of facial musculature during emotional experiences (Kring & Moran, 2008; Kring & Neale, 1996), it is unclear from those studies, how this might interact with the understanding of other's emotional states. Given that investigations in healthy individuals has suggested a link between emotional expressivity and emotion recognition (Künecke et al., 2014; Neal & Chartrand, 2011; Oberman et al., 2007), individuals with schizophrenia may be deprived of this facilitation of understanding through shared representation.

When considered in the context of research indicating that individuals with schizophrenia exhibit aberrant activation of the mirror neuron network, which has been implicated in the context of emotion recognition in healthy individuals (Carr et al., 2003; Likowski et al., 2012; Wicker et al., 2003), visual input of the emotional expression of another may not be sufficient to engage the associated emotional processes that would give rise to a shared representation in the individual with schizophrenia. Therefore, the individual with schizophrenia may not be able to pick up on the fact that the individual is experiencing an emotional state. Conversely, given the undifferentiated activation produced in facial musculature seen in CHAPTERS V and VI, the associated emotional processes engaged may be incorrect. Indeed, from a recognition perspective, the inpatients in CHAPTER III misrecognized the lack of emotion (Neutral avatar) at a higher rate than the healthy controls did. “Seeing” emotional cues when they are not present could be consequent to a blurring of distinct emotional sequelae and lead to misunderstanding of others.

This may also have consequences in the physiological aspects of emotional experience as well. As was seen in CHAPTER V, individuals with schizophrenia displayed greater tonic physiological arousal throughout all conditions. Furthermore, they displayed greater phasic arousal during a neutral image condition, which, in typical individuals would not produce such a response (Lang, Greenwald, Bradley, & Hamm, 1993). This increased arousal was not associated with increased arousal ratings by the outpatients suggesting that subjective ratings were not influenced by physiological arousal. In such instances, individuals with schizophrenia would not be able to infer the emotional context from the visceral sensations they are experiencing. Indeed, insular functioning, known to be associated with interoceptive experiences when experiencing emotion (Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004), is repeatedly found to be aberrant in individuals with schizophrenia (Wylie & Tregellas, 2010). If individuals with schizophrenia are not interpreting their subjective emotional experience through the physiological sensations they are experiencing, then what information are they drawing from? First the question of what individuals with schizophrenia experience interoceptively has not been investigated in a systematic manner, therefore this question is one of great significance.

It is important to note the possible role of neuroleptics in affecting physiological arousal in CHAPTER V. Given that all participants were medicated at the time of testing, the results seen could be due, in part, to pharmacological effects. This does not seem to be the case given that second generation antipsychotics, which all of the participants were taking, appear to have less of an effect on physiological arousal compared to first generation anti-psychotics (Fakra et al, 2008). Furthermore, if other studies do find a relationship between neuroleptic use and physiological arousal, as indexed by galvanic skin activity, most find a reduction in activity rather than a heightening which was seen in CHAPTER V (Schnur, 1989). Thus it does not appear that the greater physiological arousal seen when individuals with schizophrenia are viewing emotionally salient stimuli is due to medication effects.

To summarize, based on the studies presented in this dissertation, as well as findings from other investigations into the complex question of why individuals with schizophrenia have such difficulty understanding others' emotional experiences, evidence points to the possibility that the difficulty lies in the inefficiency of producing congruent shared representations of others' emotional states. This difficulty may be the result of a decoupling of sub-processes that typically co-occur when one experiences an emotion (subjective experience, physiological activity, outward expressivity) leading to these associated sub-processes not being recruited or activated. Or if they are activated the information extracted from the social partner's expressions is done within a less sensitive or 'noisy' system. Given these difficulties, individuals with schizophrenia may be required to engage more effortful, top-down strategies to understand those people with whom they interact. Application of excessive top-down strategies when they are not necessary may lead to false attribution errors.

This interpretation of the collected studies provides opportunities for new forms of intervention with this population. If individuals with schizophrenia are less attune to their own physiological sensations and how these sensations relate to their emotional states, then mindfulness practices, which have been shown to increase interoceptive awareness (Khalsa et al., 2008), could offer an opportunity to help individuals with schizophrenia be more aware of their own emotional experiences. This increased awareness may then translate to an increased understanding of others. Other interventions, such as virtual reality programs designed to help individuals with schizophrenia simulate social interactions would provide an opportunity for this population to engage "socially" with avatars whose emotional expressions and actions could be controlled to maximize learning of socio-emotional cues. For example, by providing overt, or exaggerated expressions to first engage the individual with schizophrenia which has been shown to improve performance (Peterman et al., 2014). Then by reducing the intensity of expression as performance improves, these individuals may be able to effectively recognize subtler expressions which are more common in social interactions. These interventions may then be able to join together again what appear to be disparate processes of emotional experience in individuals with schizophrenia.

Future investigations should explore the interoceptive experience of individuals with schizophrenia and whether awareness of their own physiological experiences of emotional states associates with identifying the emotional states of others. Additionally, future studies should recruit greater numbers of individuals, which is a valid limitation of CHAPTERS V and VI of this dissertation, in order to provide enough power to detect what is likely a subtle process. Regarding the physiological arousal differences in CHAPTER V, calculation of the sample sizes needed in order to find that effect are 32 participants per group. This effect size was used due to it being the smallest effect size from that study. Based on the strong effect size of the differences in zygomatic recruitment during the social vignette task in CHAPTER VI, both sample sizes of about 18 per group is required. Other limitations, referenced previously, are the use of stimuli in CHAPTER VI that were designed for a younger population and may have resulted in weaker engagement of participants' shared representation of emotional expression (Ardizzi et al., 2014).

In conclusion, this dissertation provides new insight into the complex experience of socio-emotional functioning in individuals with schizophrenia. By exploring these abilities through the use of more ecologically valid tools, new avenues for inquiry opened up with regard to how and why individuals with schizophrenia experience difficulty in understanding those with which they interact. These new avenues will lead to the development and use of new interventions that could provide improvement in this significantly debilitating aspect of these individuals lives.

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