Face Processing in Schizophrenia:
Deficit in Face Perception or in Recognition of Facial Emotions?

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I hereby certify that all material in this final year project which is not my own work has been identified and that no work is included for which a degree has already been conferred on me.

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Abstract

Schizophrenia is a psychiatric disorder characterized by social dysfunction. People with schizophrenia misinterpret social information and it is suggested that this difficulty may result from visual processing deficits. As faces are one of the most important sources of social information it is hypothesized that people suffering from the disorder have impairments in the visual face processing system. It is unclear which mechanism of the face processing system is impaired but two types of deficits are most often proposed: a deficit in face perception in general (i.e., processing of facial features as such) and a deficit in facial emotion processing (i.e., recognition of emotional facial expressions). Due to the contradictory evidence from behavioural, electrophysiological as well as neuroimaging studies offering support for the involvement of one or the other deficit in schizophrenia it is early to make any conclusive statements as to the nature and level of impairment. Further studies are needed for a better understanding of the key mechanism and abnormalities underlying social dysfunction in schizophrenia.

Keywords: schizophrenia, face processing, face perception, facial emotion processing, social cognition
1. Introduction

Schizophrenia is a serious psychiatric disorder that typically begins in early adulthood with an onset between the ages of 15 and 25. According to the National Board of Health and Welfare (NBHW, 2009) approximately 50,000 people, that is 0.5% of the Swedish population, suffer from schizophrenia. Moreover, according to NBHW (2009) about 30,000 to 40,000 people out of the 50,000 who suffer from the disorder are in need of professional care.

Despite the availability of anti-psychotic medication and psychotherapy for the treatment of symptoms, there is currently no cure for schizophrenia (McKenna, 1997). The earlier the disorder is diagnosed and the symptoms treated the better are the chances for recovery and the lower the likelihood of relapse in the long-run.

People with schizophrenia usually exhibit a combination of various symptoms ranging from positive symptoms and disorganized speech to negative symptoms and grossly disorganized or catatonic behaviour. Positive symptoms refer to the excess or distortion of normal functions including such features as delusions, hallucinations and thought disturbances. Negative symptoms, on the other hand, are those that reflect diminished or loss of normal functions, such as affective flattening. The latter refers to the reduction of emotional expression, where a person for example fails to smile in response to social cues (McKenna, 1997; DSM-IV, 2000).

Schizophrenia is often characterized by social dysfunction, reflected in difficulties of establishing and maintaining interpersonal relationships. The various symptoms of the disorder can all result in social deficits. A delusion of being followed or a hallucination of hearing voices can very well contribute to the fact that a person suddenly quits his or her job or believes that one’s partner is having an affair while he or she has been gone for couple of minutes to do the laundry. Misinterpretation of social cues could also occur due to visual processing deficits, more specifically due to impaired face processing system. Faces are one
of the most important sources of social information used for social communication and
evaluation of social circumstances and therefore a disruption in the processing of facial
information may underlie problems in social cognition and thus lead to social dysfunction in
general. Indeed, several studies have demonstrated deficits in the processing of faces in
people suffering from schizophrenia, but the exact nature and level of these impairments is
poorly understood. Among other things, it is debatable whether the impairment occurs in the
processing of facial emotion, that is, in the inability to recognize emotional facial expressions
and to discriminate different expressions from each other (Kohler et al, 2003; Schneider et al,
2006; Turetsky, Kohler, Indersmitten, Bhati, Charbonnier & Gur, 2007), or whether it is
confined to face perception *per se*, that is, to the processing of facial features (Butler et al,
2008; Chen, Norton, Ongur & Heckers, 2008; Chen, Norton, McBain, Ongur & Heckers,
2009).

The current paper focuses on the latter debate with the aim to describe and
discuss studies and findings that provide evidence for a deficit in face perception mechanism
as such and those suggesting that it is the mechanism dealing with the recognition of facial
emotions that is disrupted in schizophrenia. The critical comparison between those two
approaches can help specify the level of facial processing deficit associated with the disorder.

In the following, first the mechanism of face perception and recognition of facial
emotions in a non-clinical population will be described. Next, an overview of the studies and
findings concerning the impairments in the face processing system in schizophrenia will be
given. Finally, the various results and theories concerning the nature and level of the face
processing deficit in schizophrenia as well as its possible role as a contributory factor to social
cognition deficits in general, will be discussed.
2. Face and Facial Emotion Processing in Non-clinical Population

2.1. Processes of Perception and Recognition

To be able to describe the processing of faces and facial emotions a distinction between the processes of perception and recognition needs to be made. Perception refers to the processes that occur relatively early in time followed by the onset of a stimulus and that achieve processing of the features of the visual image and their configuration (Adolphs, 2002). The most basic aspect of face perception is the detection of a face which includes the ability to extract features that are common to all faces. Face perception also involves face identification which, despite its seeming similarity to face detection, is in fact a distinct concept. While detection refers to the ability to extract features common to all faces, identification means the ability to detect in which way faces differ (Tsao & Livingstone, 2008).

Recognition, on the other hand, requires more than just perceptual information. It requires knowledge about the world and involves processes related to memory (Adolphs, 2002). By holding on to a memory of a given stimulus it is possible to compare and distinguish two stimuli that are presented at separate times. As such, recognition of facial emotions requires more than what can be derived from simple perceptual properties of a face. It requires knowledge about different facial expressions and other stimuli in the world that are in some way associated with a specific expression (Adolphs, 2002). It is necessary to remember the face and where it was seen last to be able to detect what emotion is expressed and to recollect the responses that were given to that face and expression previously. According to Adolphs (2002), recognition of emotions from facial expressions requires that the given perceptual stimulus is associated with knowledge about that specific emotion being expressed, its lexical label as well as with the emotional response triggered in the perceived expression.
2.2. Face Perception

2.2.1 Behavioural findings

Behavioural experiments in non-clinical population have consistently shown that faces are processed differently from other objects. The perception of a face is not possible by simply identifying its different features, such as a mouth, a nose and the eyes. It is generally agreed that face perception is more holistic, that is, faces are processed as a whole (Farah et al., 1998, as cited in Tsao & Livingstone, 2008). Studies in which the holistic processing of faces has been disrupted have shown a deficit in overall face perception (Gazzaniga, 2002). The face-inversion effect, for example, demonstrates that when a face is inverted, that is, turned up-side down, its perception is impaired as compared to non-facial objects (Yin, 1969, as cited in Yovel & Kanwisher, 2006). Furthermore, the feature-configuration or the ‘part-whole effect’ (Tanaka & Farrah, 1993, as cited in Kanwisher & Yovel, 2006) demonstrates that facial features are best recognized when presented in configuration, that is, in the context of the whole face rather than in isolation (e.g., Tanaka & Sengco, 1997). Therefore, it can be said that differently from many other objects faces are processed in a distinct ‘holistic’ manner.

2.2.2. Electrophysiological findings

Studies done with scalp electrodes (electroencephalography, EEG) reveal not only the temporal time-course of face perception but also the face-specific visual components. After face stimulus onset there is a large and consistent negative event-related potential (ERP) component over occipitotemporal sites at approximately 170 msec post-stimulus, labelled as the N170 (Kanwisher & Yovel, 2006). The N170 is increased in amplitude in response to faces than to stimuli from other categories and is known as the ‘N170-effect’ (e.g., Bentin, Allison, Puce, Perez & McCarthy, 1996). The N170 is sensitive to both, the face-inversion and the feature-configuration effect. The component peak has been shown to be delayed and
enhanced by face inversion (e.g., Rossion et al., 2000) as well as by presenting facial features outside the face contour (Zion-Golumbic & Bentin, 2007). Together, these results suggest that N170 is an automatic neural mechanism adjusted to the global detection of a face.

It should be noted, that there are studies demonstrating that rather than being specific to faces, the N170 response is sensitive to expertise at a more general level, such as to cars in car experts (Gautier, Curran, Curby & Collins, 2003) and to birds and dogs in bird and dog experts (Tanaka & Curran, 2001). However, Kanwisher and Yovel (2006) point out that the evidence for this is inconsistent and inconclusive and hence, the N170 (or a corresponding ‘M170’ response as measured by magnetoencephalography, MEG; e.g., Xu, Liu & Kanwisher et al., 2005) can indeed be considered a specific marker of face processing.

2.2.3. Neuroimaging findings

2.2.3.1 Fusiform face area

A brain region known as the fusiform face area, FFA, has been shown to respond more strongly to faces than to scrambled faces, houses or other objects (Kanwisher, McDermott & Chun, 1997). It is located on the ventral surface of the temporal lobe in the fusiform gyrus (see Figure 1). Although faces induce fMRI activation in other cortical areas as well, such as the superior temporal sulcus (fSTS) and the occipital lobe (occipital face area, OFA), it is the FFA that shows the most consistent and robust face selective activation (Kanwisher & Yovel, 2006).
Other evidence supporting the FFA as a global face-selective region include findings demonstrating that (a) the FFA responds to a wide range of face stimuli, such as profile photographs of faces, cat faces and line drawings of faces; (b) the FFA responds strongly to upright Mooney faces (see Figure 2a) as compared to inverted Mooney faces; and (c) when subjects look at bistable stimuli (ambiguous visual images that can be perceived as two mutually exclusive images, such as the illusionary face-vase illusion; see Figure 2b), the FFA responds stronger when subjects perceive a face than when they do not (Kanwisher & Yovel, 2006).
Again, there is some evidence against the face-specificity of the area under question demonstrating the activation of the FFA by non-face objects of expertise. Studies have shown that after extensive training greebles (3D objects resembling faces) can induce FFA activations (Gautier, Tarr, Anderson, Skudlarski, & Gore, 1999), as can cars and birds in car and birds experts, respectively (Gauthier, Skudlarski, Gore & Anderson, 2000) suggesting that it is expertise with faces, rather than the nature of face stimuli per se, that is related to FFA activations. However, Kanwisher and Yovel (2006) refer to a number of problems inherent in the studies mentioned and claim that despite activating the FFA, other objects of expertise do not induce as strong activations as faces and additionally activate other nearby regions as well. As such, there seems to be not enough proof for the expertise hypothesis.

Moreover, evidence from lesion studies further support the face-specificity hypothesis. People who suffer from a condition called prosopagnosia are impaired in face recognition but can easily recognize a person by his or her voice or from other distinct features of that person. Impairment in face recognition could be assumed to follow the impairment in object recognition, however evidence from prosopagnosia shows that few suffer from both deficits. The evidence suggests that there is a double dissociation between face and object recognition (Kanwisher & Yovel, 2006) supporting the assumption that they are neurologically and functionally distinct from each other. Furthermore, brain regions responding preferentially to faces (FFA and OFA) have been shown to be affected in prosopagnosia patients (Drico, Sorgêr, Schiltz, Goebel & Rossion, 2008).

Thus, based on above it can be said there exist distinct cortical areas, especially the fusiform faces area (FFA), that are specialized for face detection and recognition.
2.3. Facial Emotion Processing

2.3.1 Emotion

A facial expression conveys a broad range of social signals, one of the most important of those being the expression of emotions. Emotions can be classified into basic and social emotions. Basic emotions, such as fear and disgust, are immediate physiological responses to situations or stimuli and they are driven by the need for survival. Social emotions, such as shame, embarrassment and guilt are complex emotions that need a more extensive self-representation involving the representation in relation to others as well as the representation of internal mental states of other individuals (Adolphs, 2002).

While it is a major challenge to provide fine-grained categories that reflect both, basic emotions as well as social emotions, there is evidence that at least a subset of emotions, the so-called universal emotions (anger, disgust, fear, happiness, sadness and surprise; see Figure 3) are recognized similarly across different cultures (Ekman, 1994, as cited in Adolphs, 2002). Still, due to social norms and other social aspects different cultures may have different ways for expressing the same emotions as well as different ways of labelling a facial expression. While the similarity of the universal emotions is most apparent at the level of discrimination and perceptual categorization (Russell, Lewicka, & Niit, 1989, as cited in Adolphs, 2002), the differences lie at the level of retrieval of complex and symbolic knowledge (Wierzbicka, 1999, as cited in Adolphs, 2002).

Figure 3. The picture illustrates the 6 universal emotional facial expressions that can be recognized across cultures. From the left: anger, happiness, disgust, surprise, sadness and fear (Adapted from Ekman, 1973, as cited in Gazzaniga et al., 2002).
2.3.2. Behavioural findings

There is consistent evidence that different facial emotions are processed differently in terms of recognition speed and accuracy. Several studies have shown that happiness is recognized faster than sadness (e.g., Hanya, 1992; Crews & Harrison, 1994; all cited in Leppänen & Hietanen, 2004), anger (Hugdahl et al., 1993, as cited in Leppänen & Hietanen, 2004), disgust (Stalans & Wedding, 1985, as cited in Leppänen & Hietanen, 2004), and neutral facial expression (Hugdahl et al., 1993, as cited in Leppänen & Hietanen, 2004). In contrast to the studies named above, other studies have demonstrated that negative emotional expression, such as fear, is processed faster and more accurately than positive or neutrals ones (e.g., Ohman et al., 2001, as cited in Leppänen & Hietanen, 2004). Despite the disagreements as to which emotional expressions are more readily recognized, it can however be stated that faces conveying emotional information are processed differently from non-emotional ones.

2.3.3. Electrophysiological findings

The notion that processing of facial emotions involves distinct mechanisms from those dedicated to face perception in general has been demonstrated by a number of event-related potential (ERP) studies. It has been shown that when subjects are presented a set of faces, some of which are neutral and others conveying various emotional expressions, the face-specific N170 component remains unaffected by emotional expression of the face. That is, a component of a similar amplitude and delay is evoked by both, the non-emotional (i.e., neutral) and emotional faces (e.g. Eimer & Holmes, 2002; Eimer, Holmes & McGlone, 2003).

As to the emotion-specific components of facial processing, it seems to be a fairly complex matter. Until recently, the majority of the ERP studies demonstrated that the emotional components of faces were processed at relatively later stages in the face recognition process, subsequent to the face-specific N170 component (Vuilleumier & Pourtois, 2007). For
example, differences between emotional versus neutral faces have consistently been found to
arise around 250ms after face onset. A negative ERP peaking at approximately 250ms in
fronto-central sites (known as the N250) has been suggested to be sensitive to the emotional
content of a face, discriminating emotional from non-emotional faces (e.g., Streit et al., 1999;
Kromak-Salmon, Fischer, Vighetto & Mauguière, 2001; Sato, Kochiyama, Yoshikawa
Matsumura, 2001). The differences beginning at this latency have been shown to remain
present up to 1s post-stimulus with the later positive components starting from 550ms
suggested to reflect differences between faces conveying different emotional expressions
(Eimer & Holmes, 2002; Vuilleumier & Pourtois, 2007). As such, facial emotion recognition
has long been considered a higher-order process to face perception. Several other recent
studies have reported, however, that emotions can have a much earlier effect on the EEG. It
has been shown that the emotional expression effect can be observed as an enhanced
positivity for emotional compared to neutral faces at about 160ms poststimulus (Eimer et al.,
2003) or even as early as 120ms after face onset (Eimer & Holmes, 2002; Eimer & Holmes,
2007). In particular, this modulation has been shown for fearful expressions (Eimer &
Holmes, 2002) referring to the importance of threat-related signals and their fast analysis.
Although it remains to be clarified whether it is mostly fear-related expressions that are
processed at such an early time-scale and to what extent this applies to other emotional face
expressions, the findings nevertheless seem to suggest that information about the emotional
meaning of facial stimuli can be, at least in some cases, analyzed rapidly, before perceptual
analysis differentiating faces from other objects is fully completed.

Furthermore, the fact that early effects of emotions, arising prior to the N170,
leave the latter component unaffected serves as further evidence for the independence of
facial emotion processing from general face perception processes (Vuilleumier & Pourtois,
2007).
2.3.4. Neuroimaging findings

A large number of different brain structures have been identified to participate in facial emotion recognition, such as the right occipitotemporal cortices (including the FFA), right parietal cortices, and the bilateral amygdala (Adolphs, 2002). Although fMRI studies (e.g., Breiter et al., 1996; Vuilleumier et al., 2001, 2003, as cited in Kanwisher & Yovel, 2006) have demonstrated higher responses to emotional than to neutral faces in the FFA, it has been suggested that rather than being specialized for facial expression processing, the higher activity in this area results from modulation by connections from the amygdala. As such, the higher activity in the FFA in response to emotional faces is proposed to simply reflect general arousal, which emotional faces are thought to generate. Therefore, most of the imaging studies investigating the processing of facial emotion have focused on the amygdala.

2.3.4.1. The role of amygdala in facial emotion processing

The amygdala, a limbic system structure located in the medial temporal lobe, is considered to be primarily involved in emotional learning and memory as well as to play a key role in the indirect expression of fear in situations where emotional learning happens explicitly (Gazzaniga, 2002). Due to wide-range anatomical connections between the amygdala and other visual cortical areas, the former has long been considered important in modulating the emotional content and valance of visual stimuli, such as faces. It is suggested that projections from the amygdala drive the emotional effects on the face fusiform area activity and this is how the amygdala may be related to the processing of facial emotions (Vuilleumier & Pourtois, 2007).

Indeed, a number of studies demonstrate the role of amygdala in facial emotion processing. For example, damage to the structure leads to deficits in emotional processing as verified by both, animal (Hoffman, Gothhard, Schmid & Logothetis, 2007) and human studies (Fitzgerald, Angstadt, Jelsone, Nathan & Phan, 2005; Vuilleumier & Pourtois, 2007). fMRI
studies on patients with amygdala sclerosis, a disorder characterized by the hardening of neural tissues in this structure, have revealed that patients suffering from this condition do not show an enhanced FFA activity to fearful versus to neutral faces, as do patients with intact amygdala (Vuilleumier et al., 2004, as cited in Vuilleumier & Pourtois, 2007). The absence of emotional modulation of faces in patients with amygdala sclerosis strongly refers to the role the amygdala plays in emotional processing of faces, at least of those conveying fearful expressions (see Figure 4).

Even though the amygdala is often associated with the processing of threat-related signals, functional brain imaging studies have provided support to the suggestion that this structure plays a broader and more general purpose role in the processing of facial expressions. In one event-related fMRI study (Winston, O’Doherty & Dolan, 2003), for example, morphed emotional faces (a procedure whereby a neutral face of one gender is continuously changed towards emotionally expressive face of another gender) displaying disgust, fear, happiness or sadness were presented to the subjects. The results demonstrated amygdala activation across all four emotional expressions with no significant differences between the various expressions.

In another study by Fitzgerald and colleagues (Fitzgerald et al., 2005) subjects viewed photographs displaying 6 facial expressions (fearful, disgusted, angry, sad, neutral, happy) while performing a task requiring minimal cognitive performance. Again, the results revealed activation in the left amygdala across all emotions which were not selective for any emotional expression. Therefore, based on the above it can be put forward that rather than being specialized for the processing of negative emotional expressions, the amygdala has a more general-purpose function in the processing of emotional information from faces, independent of the valence.
3. Face and Facial Emotion Processing in Schizophrenic Patients

Interpreting the intentions and emotions of other people by using cues that are at hand is not too difficult of a task as often all it takes it to look at the other’s facial expression. For people suffering from schizophrenia, who are known to have difficulties in interpreting social cues, this is not quite as easy. While the previous chapter dealt with face and facial emotion processing in a non-clinical population, this chapter focuses on the deficits in these processes in schizophrenia so as to shed light upon the potential factors underlying social difficulties seen in the disorder.

3.1. Impairment in Face Perception

3.1.1. Behavioural findings

In order to be able to propose face perception deficits in people with schizophrenia, their impaired performance in face perception tasks need to be demonstrated. Indeed, a number of studies have revealed that schizophrenia patients have great difficulties in detecting and recognizing faces. In a recent study (Zivotofsky, Oron, Hibsher-Jacobson, Wientraub & Strous, 2008), people with schizophrenia were asked to detect human faces and animals...
hidden within eight pictures. The results showed that schizophrenia patients were significantly worse than healthy controls in finding human faces (but not in finding hidden animals) referring to a specific deficit in the face perception system.

Studies conducted by Chen and colleagues (Chen et al., 2008; Chen et al., 2009) offer further support for an impaired face perception mechanism in schizophrenia patients. The authors demonstrated that people suffering from schizophrenia were slower and less accurate in face detection tasks when compared to normal subjects (Chen et al., 2008). In another study (Chen et al., 2009), where subjects were asked to detect a line-drawing of a face that was embedded in a larger line-drawing, the schizophrenia patients’ ability to detect faces was deficient. Moreover, their ability to discriminate a face from the one that was shown recently was impaired suggesting additionally a deficit in the face recognition mechanism.

Furthermore, it has been found (Shin, Na, Ha, Kang, Yoo & Kwon, 2008) that schizophrenia patients are worse than healthy controls in discriminating faces that differ in configural information, compared to faces that differ in featural information. Using sets of pairs of faces, the subjects were asked to decide whether the two presented faces were the same or different relying on either configural or featural information. The faces were either in (a) a configuration set, where the eyes and mouth were moved relative to the original image; or in (b) a featural set, where the eyes in the image were replaced with eyes from three other people of the same gender while still maintaining the same configuration. As mentioned above, patients with schizophrenia performed worse than controls in discriminating configural compared with featural face-sets suggesting that the face processing deficit in schizophrenia may be due to impairment in the configural processing of faces.
3.1.2. Electrophysiological findings

As mentioned previously, the N170 component of the EEG is considered to be a specific marker of face perception as there is an enhanced negativity in response to faces than to other objects (Kanwisher et al., 1997). There is strong evidence that people suffering from schizophrenia show an altered face-specific N170. For example, Herrman and colleagues (Herrman, Ellgring & Fallgratter, 2004) carried out a study in which they measured event-related potentials in subjects while they looked at photographs of buildings and faces. The data revealed that compared to healthy subjects, schizophrenia patients showed a significantly reduced N170 component in response to images of faces, both in the right and left temporo-parietal cortex (see Figure 5).

This finding is corroborated by other similar results (e.g., Onitsuka et al., 2006; Campanella, Montedoro, Strel, Verbanck & Rosier, 2006). Interestingly, Campanella and colleagues (Campanella et al., 2006) also demonstrated that this decrease in N170 amplitude was positively correlated to positive but not to negative symptoms of schizophrenia.

Altogether, ERP studies on face perception in schizophrenia suggest a deficit in the early stages of visual face processing as evidenced by an altered face-specific N170 component.

*Figure 5.* The N170 component in the temporo-parietal cortex is reduced in schizophrenia patients in response to faces, as compared to healthy control subjects (Adapted from Herrman et al., 2004).
3.1.3. Neuroimaging Findings

Evidence from behavioural and event-related potential studies have documented abnormal visual face perception mechanism in schizophrenia patients (Chen et al., 2008; 2009; Herrman et al. 2004). This impairment has been suggested to be related to structural deficits in face-specific cortical areas as indicated by findings showing reduced right fusiform gyrus volume in people with schizophrenia compared with controls (e.g., Lee et al., 2002; Onitsuka et al., 2003). Interestingly however, only two neuroimaging studies to date have focused on the fusiform face area, FFA, and its relation to face perception deficits in schizophrenia.

In the first study conducted by Yoon and colleagues (Yoon, D’Esposito & Carter, 2006), schizophrenia patients and healthy controls were shown series of faces and other objects while completing a one-back memory task. Surprisingly, the authors failed to find any differences in the FFA activation between the two groups (see Figure 6). Moreover, there were also no differences at the behavioural level with the schizophrenia patients performing as good as the controls on the face recognition task. Based on the results, the authors suggested an intact function of the FFA in schizophrenia patients.

![Figure 6. The activations of the FFA in schizophrenia patients were as strong as in the healthy control group. The figure demonstrates slides of the occipital temporal region showing FFA activation in schizophrenia subjects (SZ) and in healthy control subjects (C), (Adapted from Yoon et al., 2006).](image)

Contrary to this, a recent study carried out by Walther and colleagues (Walther et al., 2009) reported differences in the right FFA activation in schizophrenia patients during
visual face processing. This study made use of a more complex experimental design where subjects were asked to first memorize a set of unfamiliar faces (encoding task) and later recognize the faces they had learned previously (recognition task). The results revealed that not only were the schizophrenia patients worse in how fast and accurately they recognized the faces but the differences were also reflected in brain activation patterns with patients showing abnormal FFA activation during the encoding of faces (see Figure 7) as well as decreased activation during face recognition.

Altogether, the studies described above provide evidence for and against the dysfunction of the FFA during early-stage face processing in schizophrenia. The contradictory findings may be explained by differences in the behavioural paradigm (task difficulty) as well as in data analysis methodologies. Hence, future studies are needed to clarify the existence of regions of dysfunction associated with face perception deficits in schizophrenia and the degree of altered activity in these areas.

Figure 7. The figure displays BOLD activation during successful and failed encoding of faces in both right and left fusiform face area, FFA. During the successful encoding of faces schizophrenia patients showed less activation in the right FFA than the healthy control group (Adapted from Walther, Federspiel, Horn et al., 2009).
3.2. Impairment in Facial Emotion Processing

3.2.1. Behavioural findings

A considerable body of behavioural findings suggest specific impairment in facial emotion processing in people with schizophrenia. For example, in a study by Kohler and colleagues (Kohler et al., 2003) subjects were presented a set of photographs displaying emotional (happy, sad, angry, fearful, disgusted) and neutral expressions which they had to discriminate. Results indicated that compared to healthy controls, schizophrenia patients performed worse on recognition of all emotions. It has to be noted, however, that people with schizophrenia also made mistakes in recognizing neutral faces misidentifying those for emotional ones.

Tsoi and colleagues (Tsoi et al., 2008) found that in comparison with healthy controls, schizophrenia patients have difficulties in recognizing happy faces. The authors also found a tendency towards misidentification of any facial emotions as fearful or sad in schizophrenia patients.

In a study carried out by Bediou and colleagues (Bediou et al., 2005) subjects were shown 25 original colour photographs of five men expressing five of the six basic facial emotions: happiness, fear, anger, sadness and disgust. The participants were asked to match the photographs to words that describe these facial emotions. Results showed that schizophrenia patients had difficulties in labelling facial emotions of anger and sadness but not those of fear, disgust and happiness.

A recent meta-analysis (Kohler, Walker, Martin, Healey & Moberg, 2009) covering literature from 1970-2007 and including 86 studies revealed a large deficit in facial emotion perception in patients suffering from schizophrenia relative to healthy controls. The impairment was also found to be moderated by several illness-related (e.g., being hospitalized at the time of testing) and demographic (e.g., age, gender and race) factors.
Altogether, the results suggest that schizophrenia patients have impairment in not only differentiating emotional facial expressions but also in identifying them (by choosing qualitative labels to match various emotional expressions).

3.2.2. Electrophysiological findings

As described previously, ERP studies conducted on healthy subjects suggest the N250 to be sensitive to the emotional content of the face (e.g., Streit et al., 1999; Kromak-Salmon et al., 2001; Sato et al., 2001). Studies on schizophrenia patients have reported alterations in this ERP component. For example, in a study conducted by Wynn and colleagues (Wynn, Lee, Horan & Green, 2008) subjects were asked to identify the gender of a face, the emotion of a face, or if a building had 1 or 2 stories. Results showed that patients and control subjects did not differ in terms of the N170 component, which was largest in response to faces and smallest in response to buildings. As to the N250, it was largest for emotion identification task and smallest for the building identification task for both groups. However, schizophrenia patients exhibited a significantly smaller N250 than controls, which according to the authors seems to suggest that the patients are less efficient at processing facial emotion (see Figure 8).

In sum, the results described above imply that abnormalities in the later stages of face processing can be taken as indication of deficient emotion processing of the facial stimuli in schizophrenia.

Figure 8. As compared to healthy controls, in schizophrenia patients the N250 component was reduced in emotion identification task as well as in gender identification task. Green - facial emotion identification task; blue - gender identification task and red - building identification task (Adapted from Wynn et al., 2008).
3.2.3. Neuroimaging findings

Both, behaviourally and electrophysiological studies have demonstrated abnormalities in facial emotion processing in schizophrenia. Results from neuroimaging studies further corroborate these findings.

In an fMRI study, Schneider and colleagues (Schneider et al., 1998) demonstrated reduced amygdala activity in response to emotional facial expressions in schizophrenic patients. Similar findings were obtained in a PET study (Paradiso et al., 2003) where the participants viewed pleasant and unpleasant pictures and were asked to rate their pleasantness. Compared to normal control subjects, the unmedicated schizophrenia patient group showed decreased cerebral blood flow (CBF) in the left amygdala when they were asked to assess and rate the emotional valence of unpleasant pictures (see Figure 9).

![Figure 9](https://example.com/figure9.png)

*Figure 9. (A) Regions of reduced CBF in unmedicated schizophrenia patients during the rating of pleasant pictures (in yellow or red). (B) Regions of reduced CBF in unmedicated schizophrenia patients during the rating of unpleasant pictures (in blue). (Adapted from Paradiso et al., 2003).*
In a similar vein, Gur and colleagues (Gur et al., 2002) found reduced activation in the left amygdala and bilateral hippocampus. The subjects performed two discrimination tasks: (1) emotional valence task, in which the subjects were asked to determine whether the displayed emotion was positive or negative and (2) age discrimination task, in which subjects were asked to determine whether a face was younger or older than 30. The results revealed minimal left amygdala activation in schizophrenia patients when compared to healthy control group in the emotional valence task.

4. Discussion

Schizophrenia is a severe, disabling psychiatric disorder that is associated with a marked social and occupational dysfunction having a great impact on the lives of people suffering from the condition as well as on people surrounding them. Difficulties in interpreting the emotions and intentions of others lead to impaired interpersonal relationships which can further contribute to the development of the disorder. As social interaction relies heavily on visual information, especially on the information we receive by analyzing the faces of other people, deficits in the visual processing system, specifically in the face processing mechanism, can contribute to the problems in social cognition seen in the disorder.

Indeed, a large number of studies have demonstrated deficits in the processing of faces in people suffering from schizophrenia but the exact nature and level of these impairments is debatable. On the one hand, it is suggested that social dysfunction in schizophrenia patients is a consequence of poor face perception as such. On the other hand, it is hypothesized that rather than a general face perception deficit, the impairment involves poor facial emotion recognition (Tsoi et al., 2008) and discrimination (Bediou et al., 2005).

Evidence supporting the face perception deficit in schizophrenia is provided by a number of behavioural studies demonstrating impairment in face detection (e.g., Chen et al.,
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2009) and recognition (e.g., Chen et al., 2008; 2009) tasks in people suffering from the disorder. As described before, these patients are slower and less accurate in finding faces from among other stimuli and perform worse when having to rely on configural information (Shin et al., 2008). As a face is processed in a holistic manner, meaning that it is processed as a whole rather than by its features (Farah et al., 1998, as cited in Tsao & Livingstone, 2008), it is suggested that the face perception deficit in schizophrenia may be due to impairments in the configural processing of faces.

Evidence from ERP studies offer further support for the face perception deficit hypothesis as it has been shown that schizophrenia patients have a reduced face-specific marker (N170) in response to faces (Herrman et al., 2004).

Despite the strong behavioural and electrophysiological findings supporting the face perception deficit approach, results from neuroimaging studies are not so clear-cut. Due to the FFA being a face-specific region in the cortex, impairment in face perception in schizophrenia patients should be reflected in altered activity in this region (Yovel & Kanwisher, 2004). However, the two studies conducted to date (Yoon et al., 2006) fail to show this conclusively. Whereas Walther and colleagues (Walther et al., 2009) found abnormal activation of the FFA during the encoding of faces in schizophrenia patients, Yoon and colleagues (Yoon et al., 2006) failed to show any differences in the FFA activation between the patients and controls.

Therefore, some studies and findings seem to suggest an early-stage deficit in visual face processing, which could in turn give rise to abnormal facial emotion processing. In contrast, there are a number of behavioural, ERP and neuroimaging results that question the deficit in face perception mechanisms in general and stress the facial emotion processing system as the source of dysfunction. The findings supporting the latter approach indicate deficits in facial emotion recognition independent of the valence of emotion (Kohler et al.,
2003), a lower N250 amplitude (Bediou et al., 2005) as well as reduced CBF in the amygdala of schizophrenia patients in response to emotional faces (Gur et al., 2002; Paradiso et al., 2003; Schneider et al., 1998).

Several limitations need to be addressed and cautions raised when interpreting the studies and findings described above and when trying to make any specific conclusions based on these.

First of all, as mentioned earlier, schizophrenia is assumed to be a complex multifactorial disorder with several different subtypes characterized by a variety of symptoms. As such, it is difficult to create a uniform group of patients making it difficult to compare and as a result, to verify or falsify the various results obtained from the studies. Many researchers, for example Schneider and colleagues (Schneider et al., 2006) have tried to meet this limitation by recruiting patients that have been diagnosed according to DSM-IV criteria and by assessing them with the negative and positive symptom scale. Still, the question remains, whether this kind of classification truly represents a uniform group of subjects.

Another strong limitation affecting the interpretation of studies is related to the medication used for treating subjects taking part in the experiments. Different anti-psychotic medications work in different ways and as such, variability in the medications used can affect the performance of schizophrenia patients. One way to avoid this is, as some researchers have done, would be to select patients who have been treated with the same medication over a period of time.

Possible methodological limitations could have also contributed to the contradicting findings obtained from the studies, such as the choice of stimuli. There has been a great variety in the photographs of faces and facial expressions used in different studies. Some studies have used only black and white pictures while others have employed colour pictures. The same is true for the choice of faces that are presented in the pictures. Using faces
belonging to a different ethnic group, for example, can strongly affect the performance of the subjects. Furthermore, it should also be noted that the facial emotion expressions used in the studies have conveyed emotions at different intensities. All these low-level differences can interfere with perceptual processes and contribute to the ambivalent set of findings.

Last but not least, often it is not clear which processes in the face perception or facial emotion recognition systems are exactly measured. The tasks range from face identity tasks to configural processing of faces when investigating face perception and from facial emotion recognition to the labelling of emotions when studying facial emotion processing. It cannot be ruled out that other processes not targeted \textit{per se}, such as working memory, are not measured instead.

5. Conclusion

This paper has described findings from behavioural, electrophysiological and neuroimaging studies providing evidence that schizophrenia is on the one hand associated with abnormalities in face perception mechanism \textit{per se} and on the other hand with impairments in facial emotion recognition. It still remains difficult to make any specific conclusions as to the nature and scope of the deficit. Further research, taking into account all the possible limitations outlined above, is needed to shed further light on the issue so as to allow a greater understanding of the key mechanisms and abnormalities leading to the dysfunctions accompanying the disorder.
References


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