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Facial decoding in schizophrenia is underpinned by basic visual processing impairments

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A B S T R A C T

Schizophrenia is associated with a strong deficit in the decoding of emotional facial expression (EFE). Nevertheless, it is still unclear whether this deficit is specific for emotions or due to a more general impairment for any type of facial processing. This study was designed to clarify this issue. Thirty patients suffering from schizophrenia and 30 matched healthy controls performed several tasks evaluating the recognition of both changeable (i.e. eyes orientation and emotions) and stable (i.e. gender, age) facial characteristics. Accuracy and reaction times were recorded. Schizophrenic patients presented a performance deficit (accuracy and reaction times) in the perception of both changeable and stable aspects of faces, without any specific deficit for emotional decoding. Our results demonstrate a generalized face recognition deficit in schizophrenic patients, probably caused by a perceptual deficit in basic visual processing. It seems that the deficit in the decoding of emotional facial expression (EFE) is not a specific deficit of emotion processing, but is at least partly related to a generalized perceptual deficit in lower-level perceptual processing, occurring before the stage of emotion processing, and underlying more complex cognitive dysfunctions. These findings should encourage future investigations to explore the neurophysiologic background of these generalized perceptual deficits, and stimulate a clinical approach focusing on more basic visual processing.

1. Introduction

Impaired emotional facial expression (EFE) decoding abilities have been repeatedly documented in schizophrenia and play a role in the more globally altered social cognition (Javitt and Freedman, 2015), interpersonal misunderstandings, and inadequate social behaviours (Pinkham and Penn, 2006) related to this pathology (Couture et al., 2006). However, earlier results suggested that schizophrenic patients (SP) are impaired in the recognition of emotional but also non-emotional facial stimuli (Comparelli et al., 2013; Constant et al., 2011; Kucharska et al., 2005; Sachs et al., 2004), raising the question of whether EFE decoding deficits are confined to emotion identification, reflecting a specific dysfunction in high-level emotion-processing regions such as the amygdala (Javitt and Friedmann, 2015), or are part of a broader impairment in other types of facial processing as well, such as identity, age, or gender (Javitt, 2009b; Sehatpour et al., 2010).

The classical tendency in the schizophrenia literature has been to attribute cognitive dysfunction to deficits in higher-level cognitive processes and to view more low-level forms of cognitive dysfunction as being driven by top-down influences from higher cortical regions. Recent research argues against such hypothesis, by showing deficits within the perceptual systems in schizophrenia that cannot be attributed to top-down dysregulation (Uhlhaas and Mishara, 2007). Furthermore, deficits in lower-level perceptual processing may, by a bottom-up mechanism, undermine the ability to perform more complex cognitive operations (Silverstein and Keane, 2011). Neurobiological findings support these bottom-up hypotheses, notably by documenting specific deficits in the functioning of the magnocellular visual pathway among SP, this pathway affecting early global processing of visual stimuli (Butler et al., 2009, 2001; Javitt, 2009a, 2009b). This magnocellular system's impairments will lead SP to lose this ‘global advantage’ of holistic perceptual organisation, resulting in a fragmented perception of

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reality (Butler, 2013; Hooker and Park, 2002; Sehatpour et al., 2010) but also to higher-order deficits in complex processes (e.g. perceptual closure, object recognition, reading) and even potentially in social cognition (Sergi and Green, 2003).

To our best knowledge the few studies which used psychometrically matched emotional and non-emotional tasks lead to mixed results: early works (Edwards et al., 2002; Kerr and Neale, 1993) concluded that emotion deficits reflect a generalized impairment in face processing rather than a specific emotion-recognition deficit, but more recent ones (Schneider et al., 2006) found stronger impairment in SP for emotion discrimination performance than for the processing of non-emotional features of face, specifically age. Recent reviews on this topic (Bortolon et al., 2015; Darke et al., 2013) have proposed that the deficits observed among SP for face processing tasks are unlikely to be limited to emotion processing, but could rather be associated with a more general deficit in early visual processing which would impact every type of face processing, or even every task involving visual stimuli. However, these reviews concluded that further evidence are necessary, notably based on studies directly comparing different face processing tasks with a control of interfering variables. Indeed, studies investigating non-emotional face processing have used different tasks which did not use comparable stimuli and hampers valid comparison across tasks (Bortolon et al., 2015; Chen and Ekstrom, 2015).

In order to overcome these limitations, we used a controlled design based on Haxby et al. (2000) face perception model, to examine the recognition of both changeable (eyes orientation, emotion) and stable (age, gender) face characteristics in schizophrenia. As our main aim was to offer a direct comparison between emotional and non-emotional facial judgments, our experimental design was based on binary judgments (e.g. male-female for gender, positive-negative for emotion), leading to the fact that we did not evaluate emotional decoding *per se* (i.e. the identification of the emotion presented by the face), on the basis of a wide-range of emotional faciel expressions, but rather emotional valence (i.e. the ability to distinguish positive and negative emotions) using two contrasted emotions (happiness and disgust). A central strength of this procedure is that the sub-task related to the four facial aspects investigated were based on the exact same stimuli, ensuring an ideal control of perceptive aspects across conditions and allowing to clearly determine whether SP confronted with complex facial decoding have a generalized impairment in face processing rather than a specific emotion-recognition deficit.

2. Materials and methods

2.1. Participants

Thirty inpatients[1] (13 women), diagnosed with paranoid schizophrenia according to DSM-IV criteria and based on the clinical diagnosis by trained psychiatrists, were recruited through the Departments of Psychiatry of the Saint Luc University Hospital (Brussels, Belgium), the Beau Vallon Psychiatric Hospital (Namur, Belgium), and the Psychiatric Hospital Sanatia (Brussels, Belgium). All SP had been in a stable phase for at least 6 months, under atypical or mixed (typical and atypical) antipsychotics. Psychopathology was assessed with the Positive and Negative Syndrome Scale PANSS (Kay et al., 1987). SP were individually matched for age, gender and education with 30 control participants (CP, 13 women) who were free of any history of psychiatric disorder or drug/substance abuse. Education level was assessed according to the number of years of education completed since starting primary school. Exclusion criteria for both groups included current or past neurological disease (e.g., epilepsy, dementia, vascular cerebral accident), substance dependence, and age above 60. SP and CP were assessed using several psychological measures, to evaluate the presence of subclinical comorbid psychopathologies and deficits. The following variables were evaluated using validated self-completion questionnaires: State and trait anxiety (State and Trait Anxiety Inventory, form A and B, Spielberger et al., 1983), depression (Beck Depression Inventory, short version, Beck and Steer, 1987), interpersonal problems (Inventory of Interpersonal Problems, Horowitz et al., 1988), and alexithymia (20-item Toronto Alexithymia Scale, Bagby et al., 1994). Twenty-four SP were receiving second generation antipsychotic drugs (M = 246.57 mg; SD = 457.26) and 14 were taking first generation drugs (M = 30.05 mg; SD = 40.58), but no significant Spearman's correlation was found between medication and experimental measures ($p > 0.05$). CP were free of psychotropic medication. Participants were provided with full details regarding the aims of the study and the procedure to be followed, and then gave their informed consent. The study was approved by The Ethical Committee of the Medical Faculty of the Université catholique de Louvain and conducted according to the Declaration of Helsinki.

2.2. Procedure and measures

The experimental task consisted in binary decisions regarding the identification of specific features in human faces. Four experimental tasks were chosen, respectively related to gender, age, eyes orientation and emotion judgments. Each task contained 2 conditions, respectively based on the distinction between male and female (Gender task), child and adult (Age task), left and right (Eyes orientation task), positive and negative (Emotion task). 64 stimuli were selected from the Radboud Face battery (Langner et al., 2010), each being based on a unique combination of the four attributes (e.g. adult female face with negative emotion and left oriented eyes). Positive and negative emotions were respectively depicted by happiness and disgust stimuli. This experimental choice is justified by the fact that, as our experimental design was based on binary decisions, we had to select only one positive and one negative emotions. Happiness is by far the most widely used positive emotion in emotion-recognition studies and its processing has been found to be impaired in SP (e.g. Yang et al., 2015). Disgust processing has been repeatedly shown to be strongly reduced in SP (see Barkl et al., 2014; Comparelli et al., 2013) and its strong interpersonal value (Davey, 2011) is of particular interest when exploring psychopathological states characterized by massive social impairments. These stimuli are illustrated in Fig. 1. All stimuli were then standardized using Photoshop 9.0 (Adobe Systems, Inc., San Jose, CA). They were placed on a black background, resized to a 6.5X5.5 cm format (stimuli subtended a visual angle of 3X4°), and the contrast-luminosity was controlled for. Each task was divided into 3 blocks containing 64 trials. Participants were thus confronted with a total of 12 blocks of 64 stimuli, so that the study consisted in 768 stimuli (96 per condition). Each block contained 32 faces per condition (e.g., 32 child and 32 adult faces for the age task), each face appearing one time by block, and the stimuli were randomly distributed among the block. Each face was thus presented 12 times in the experiment. Importantly, the 64 same stimuli were used in each block to uniformize the perceptive aspects across conditions, but the task to perform varied across blocks. An identical procedure was used in the different experimental tasks: for each face, participants had to perform a binary task as quickly as possible, i.e. judging whether, according to the condition, the face was male-female (gender task), adult-child (age task), left-right (orientation task), or positive-negative (emotion task) by pressing the corresponding button with their right forefinger. Response laterality (e.g., left for adult and right for child) was counterbalanced, and the order of the blocks and

[1] The initial sample was constituted of 32 schizophrenic patients. However, in order to remove participants performing at chance level in the experimental tasks, the binomial cumulative distribution was used to derive chance level threshold (Combrisson and Jerbi, 2015). With a p-value of 0.01, two classes of answers and a sample size of 64 participants, the performance threshold was set at 64.6%. Two schizophrenic participants (respectively presenting a mean accuracy of 56.75% and 53.25%) were thus removed from the analyses, all participants included in the final sample presenting a global mean performance higher than 70%, ensuring that they performed above chance level.