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Disturbances of spontaneous empathic processing relate with the severity of the negative symptoms in patients with schizophrenia: A behavioural pilot-study using virtual reality technology

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ABSTRACT

Behavioural and neuroimaging data have recently pointed out that empathy (feeling *into* someone else) is associated with mental imagery and transformation related to one's and other's visuo-spatial perspectives. Impairments of both empathic and visuo-spatial abilities have been observed in patients with schizophrenia. Especially, it has been suggested that schizophrenics are altered in *spontaneously* simulating another individual's first-person experience. However, there is so far only little evidence regarding the relationship between deficits in empathy and disturbances in spontaneous heterocentered coding in schizophrenia. In the present pilot-study, we tested with schizophrenic patients our behavioural paradigm that enables to measure from the bodily postures and movements whether individuals in ecologically more valid conditions are interacting with another individual by using egocentered – as in sympathy (feeling *with* someone else) – or heterocentered – as in empathy – visuo-spatial mechanisms. For that, ten patients and ten controls, standing and moving, interacted with a virtual tightrope walker, displayed life-sized, standing and moving as well. We show that patients with higher negative symptoms had, in most cases, deficits in spontaneously using heterocentered visuo-spatial mechanisms and employed preferentially an egocentered referencing to interact with the avatar. In contrast, preserved spontaneous heterocentered visuo-spatial strategies were not linked to a prevailing negative or positive symptomatology. Our data suggest that the severity of the negative symptoms in schizophrenia relates with disturbances of spontaneous ("online") empathic processing in association with lower scoring self-reported trait cognitive empathy.

1. Introduction

Clinical data from behavioural and neuroimaging studies with psychiatric populations have provided increasing support that schizophrenia is associated with deviant social functioning (Brüne, 2005a; Corrigan & Nelson, 1998; Frith, 2004; Shamay-Tsoory, Shur, Harari, & Levkovitz, 2007; Sperber & Wilson, 2002). Understanding the structure of these social behavioural impairments is of critical importance for establishing predictive markers of the illness as social abnormalities have been often observed to precede the psychosis outcome (Brüne, 2005b; Schenkel, Spaulding, & Silverstein, 2005). Notably, schizophrenic patients and people with high schizophrenia-like traits have been suggested to suffer respectively from altered and reduced empathic abilities (Decety & Moriguchi, 2007; Dinn, Harris, Aycicegi, Greene, & Andover, 2002; Henry, Bailey, & Rendell, 2008; Lee, Farrow, Spence, & Woodruff, 2004; Milgram, 1960; Montag, Heinz, Kunz, & Gallinat, 2007; Shamay-Tsoory et al., 2007; Thakkar & Park, 2010). However, there is only limited evidence regarding the relation between empathy deficits and schizophrenia (Bora, Gökçen, & Veznedaroglu, 2008).

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1.1. The multidimensional approach of empathy

Empathy is the capacity to share, react to and understand the lived experience and associated mental state of others (Davis, 1980, 1994). As a complex and multifaceted socio-cognitive construct (Berthoz, 2004; Preston, 2007; Preston & de Waal, 2002; Thakkar, Brugger, & Park, 2009), empathy incorporates automatic, emotional, cognitive and regulatory processes and combines cooperating and/or competing activations (Berthoz, 2004) in topographically distributed and functionally distinct brain networks (Decety, 2007; Decety & Jackson, 2004). The automatic and emotional components of empathy – similar to the first-person like processes involved in simulation (Goldman, 2006) – enable to internally reproduce another person's subjective experience, as if individuals were experiencing this given mental state themselves. The cognitive and regulatory components refer to a controlled process whereby people understand the mental state of others while adopting their psychological viewpoint based upon perspective-taking and self-other distinction. These are strongly akin to the processes involved in Theory of Mind (ToM) (Premack & Woodruff, 1978) or mentalizing (Frith & Frith, 2003) which is the ability to represent and attribute mental state to others. Self-regulation mechanisms further contribute to decoupling computational mechanisms between first- and second-person information and tap into executive functions (Decety & Jackson, 2004; Decety & Michalska, 2009; Frith & Frith, 2003; Ochsner & Gross, 2005; Van der Meer, Groenewold, Nolen, Pijnenborg, & Aleman, 2011).

1.2. The visuo-spatial and body-related mechanisms in empathy

Although empathy – i.e., "putting oneself in the other's shoes" – is generally admitted to require both self-other distinction and psychological perspective-taking, little experimental work has focused on self-regulation and more basic visuo-spatial mechanisms (Thakkar & Park, 2010). However, recent studies have shown that empathy entails mental imagery and transformations related to one's and others' visuo-spatial perspective (Mohr, Rowe, & Blanke, 2010; Thakkar et al., 2009; Thirioux, Jorland, Bret, Tramus, & Berthoz, 2009; Thirioux, Mercier, Blanke, & Berthoz, 2014; Thirioux, Mercier, Jorland, Berthoz, & Blanke, 2010). The prerequisite for empathy – or "feeling into" (from the Germane "ein [into] – fühlen [to feel]"; Jorland & Thirioux, 2008) – is a sort of awareness of being outside the other person and having "to reach [her/him]" (Gelhaus, 2011). It enables to understand the other's current experience as the experience of someone else while distinguishing oneself from the other (Decety, 2007; Decety & Jackson, 2004; Hein & Singer, 2008; Singer et al., 2004). Therefore, empathy requires perspective-change and is based upon a mental transformation of one's own-body in space in which individuals are mapping their body into the other's body in a rotation-like manner [Self → Other] (Thirioux et al., 2009, 2010). Accordingly, empathy specifically modulates self-location (the experience of where I am in space; Blanke, 2012) and the egocentered (centered on one's own-body) visuo-spatial perspective (the experience from which I perceive the world; Blanke, 2012), two key phenomenological aspects of the bodily self which are substantial for self-other interaction. Empathy is, thus, associated with disembodied self-location (in which the imagined self-location does not match the position of one's physical body in space; Blanke et al., 2005) and heterocentered (centered on another individual's body; Cleret de Langavant et al., 2011; Degos, Bachoud-Lévi, Ergis, Petrissans, & Cesaro, 1997) visuo-spatial perspective (Fig. 1A).

We have newly assumed that empathy relies upon continual and bi-directional perspective-change processes, i.e., dynamic shifts between the egocentered and heterocentered visuo-spatial frameworks, enabling on-line comparisons between first- and second-person signals, moment-to-moment adaptation to changes in the others' behaviours, and maintaining self-other distinction (Berthoz, 2004; Berthoz & Thirioux, 2010; Thirioux & Berthoz, 2011; Thirioux, 2011).

Using electrical neuroimaging (EEG)-based measurements with non-clinical populations, we reported that heterocentered coding in empathy is sustained by activations in the left temporo-parietal junction (TPJ) at ~520–630 ms post-stimulus onset (PSO) (Thirioux et al., 2010) and preceded by sequential activations in the mirror neuron system (MNS) from the left insula to the right inferior frontal gyrus (IFG) via the inferior parietal lobule (IPL) at ~65–425 ms and co-activations in the right dorsolateral prefrontal cortex (dlPFC) at ~330–425 ms (Thirioux et al., 2014). This activation of the TPJ – a key-region of the heteromodal cortex and vestibular system integrating body-related and self-location information (Blanke, Landis, Spinelli, & Seeck, 2004; Blanke, Ortigue, Landis, & Seeck, 2002; Kahane, Hoffmann, Minotti, & Berthoz, 2003; Lobel, Kleine, Bihan, Leroy-Willig, & Berthoz, 1998) and sustaining perspective-taking in ToM (Decety & Lamm, 2007; Schnell, Bluschke, Konradt, & Walter, 2011) – strengthens the hypothesis that empathy is associated with visuo-spatial transformations. Moreover, this earlier recruitment of the executive functions in our data echoed inhibitory processes and shifts from egocentered strategies in the MNS to heterocentered strategies in given nodes of the mentalizing network (TPJ) (Frith & Frith, 2006) (Thirioux et al., 2014). It corroborates the view that non-egocentered simulation requires inhibiting one's egocentered perspective (Nardini, Burgess, Breckenridge, & Atkinson, 2006) and is dlPFC-dependent (Van der Meer et al., 2011; Vogeley et al., 2001). In the same vein, a correlation has been found between rightward biases in spatial attention and scores to affective empathy in self-rating questionnaires (Thakkar et al., 2009). And, Mohr et al. (2010) reported that faster reaction times (RTs) in egocentered transformation tasks positively correlate with high scoring self-reported trait empathy.

1.3. Heterocentered vs. egocentered referencing dissociate empathy from sympathy

Disentangling the involvement of egocentered vs. heterocentered visuo-spatial mechanisms in empathy is essential as it further enables to dissociate empathy from sympathy – or "feeling with" ("mit [with] – fühlen"; Jorland & Thirioux, 2008; Hojat et al., 2011; Hojat, Spandorfer, Louis, & Gonnella, 2011). These intersubjective phenomena are most often conflated in experimental studies with non-clinical, neurological and psychiatric populations.

This is doubtless due to that empathy and sympathy are closely related and in part converge. The "feeling", common to both phenomena, corresponds to the mental experience of one's physiological and bodily states and changes (Damasio & Carvalho, 2013) that are generated by the perception of the others' current experience and enables to access the embodied mind of others, i.e., "in their bodily and behavioural expressions" (Zahavi, 2008). However, when sympathizing (feeling with), individuals are feeling the same thing as others are feeling (the same kind of inner state; Gelhaus, 2011) and at the same time (Olinick, 1987), tending to merge identities (Wilmer, 1968). It leads to attributing the other's experience to oneself as if individuals were the other person (Gelhaus, 2011). This self-attribution is based upon a body-related mental imagery and spatial transformation process in which individuals are mapping the others' body into their own-body in a mirror-like linear manner [Other → Self] (Thirioux et al., 2009, 2010). Accordingly, sympathy is associated with embodied self-location (the normal experience that the self is located within one's bodily borders at a specific position in space; Arzy, Thut, Mohr, Michel, & Blanke, 2006) and egocentered visuo-spatial perspective (Fig. 1A), i.e., without perspective-change, contrary to empathy (Berthoz &