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Upcoming tactile events and body ownership in schizophrenia

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ABSTRACT

Schizophrenic patients may report unusual perception of their own body. Studies using the rubber hand illusion (RHI) proposed that they exhibit a distorted sense of body ownership. However, since the RHI is mostly achieved with the contribution of visuo-tactile integration, the stronger RHI observed in schizophrenic patients could reflect either a general increase of the response to multisensory stimuli or a larger influence of visual cues on the tactile sensory experience. The purpose of the present study is to investigate patients' perception of their own body by means of a behavioral paradigm that measures their proneness to the RHI without relying on multisensory integration occurring during actual experience of touch. In a previous study we demonstrated in healthy participants that expectation of touch experience arising at the sight of a human hand approaching a rubber hand is enough to induce a sense of ownership over the same hand. Here we take advantage of the same paradigm to investigate body ownership in schizophrenia. Patients observed the experimenter's hand while approaching – without touching – either a rubber hand or a piece of wood placed in front of them. The seen object could be either aligned to participant's hand or rotated by 180°. Phenomenology of the illusion revealed that schizophrenic patients exhibited sense of ownership over the rubber hand, but more weakly than healthy controls. The present study sheds new light on the experience of body ownership in schizophrenic patients, corroborating the notion that alterations of bodily self-awareness play an important role in schizophrenia.

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1. Introduction

Schizophrenia-spectrum disorders have been described as psychiatric conditions critically associated with anomalies of self-experiences. Schizophrenic patients can suffer from deficits in self-recognition and self-attribution of thoughts and actions (Schneider, 1950). Unrevealing the processes that underlie these symptoms might shed some light on the human ability to make a distinction between self and non-self and on the origin of its disruption in schizophrenia. Accordingly, from the phenomenological perspective, recent investigations suggest that disturbances of basic self-experience are predictive of psychosis onset in

the ultra high risk for psychosis prodromal population (Nelson et al., 2012).

Empirical research on self-recognition processes in schizophrenia mainly refer to a disruption of the sense of ownership, defined as the feeling that something is part of one's own body, and agency of action, defined as the subjective awareness that one is controlling one's own volitional actions in the world (for reviews see, for example, Cermolacce et al., 2007; Jeannerod, 2009; Moore and Fletcher, 2012). As highlighted by Waters and Badcock (2010), in general, studies on sense of body ownership and sense of agency examine specific cues contributing in their own unique way to the sense of self-recognition, such as sensory integration and body schema (body ownership processes), efferent motor signal processing and psychological binding experiences (action representation processes). In particular, previous studies investigating body ownership in schizophrenic patients used the rubber hand illusion (RHI, Botvinick and Cohen, 1998). To elicit this illusion, the participant's real hand is hidden from view while a rubber hand is placed in front of her. The experimenter generally uses two paintbrushes to stroke synchronously the rubber hand and the participant's hidden hand. After a short period (about 30 s), people have the

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experience that the rubber hand is their own hand and that it is the rubber hand that senses the touch of the paintbrush. The experience of the illusion can be quantified by means of the proprioceptive drift. In this test participants verbally report, before and after the synchronous visuo-tactile stimulation, the perceived location of their hand (Tsakiris and Haggard, 2005). After synchronous visuo-tactile stimulation, people consider their hand to be closer to the rubber hand than it really was.

According to limited current knowledge, schizophrenia patients show higher sensitivity to the illusion as compared to healthy controls (Peled et al., 2000; Peled et al., 2003; Thakkar et al., 2011). Moreover, in patients, vividness of the illusion seems to be associated with elevated positive symptoms (Peled et al., 2000, 2003; Thakkar et al., 2011). However, sense of body ownership and its experimental proxy, that is the RHI, rely on the integration of sensory signals from different modalities (Botvinick and Cohen, 1998; Botvinick, 2004; Tsakiris and Haggard, 2005; Tsakiris, 2010; Ehrsson, 2012). Thus, when the visual and spatio-temporal signals received from a limb all match, a feeling of ownership then arises for that limb (Ehrsson, 2012).

Such constitutive role of the integration of actual multisensory signals in the RHI makes its use problematic to investigate sense of body ownership in schizophrenic patients. There is, indeed, enough evidence suggesting that multisensory integration is altered in schizophrenia (Foucher et al., 2007; de Jong et al., 2009; Seubert et al., 2010; Ebisch et al., 2013). For example, it has been demonstrated that schizophrenia patients show reduced McGurk effects (Pearl et al., 2009). The McGurk effect is a phenomenon where an auditory syllable is presented simultaneously with a silent video showing a model articulating an incongruent syllable which results in fused or combined syllable perception (McGurk and MacDonald, 1976). Schizophrenia patients also show reduced interference effects when detecting the emotional content of voices paired with facial expressions of a different emotion (de Jong et al., 2009), and patients benefit less from seeing the visual articulation of words when combined with noisy vocal presentations of the same words (Ross et al., 2007). It was suggested that these deficits result from impairments in higher-order speech processing and biological motion perception networks (Ross et al., 2007; Szyck et al., 2009); however, a more general disturbance of multisensory integration may also contribute to the phenomena. Accordingly, Williams, Light, Braff, and Ramachandran (Williams et al., 2010) recently revealed that schizophrenia patients show impairments in basic audio-visual integration. This observation was made by using a simple target detection task without a speech component.

We think that multisensory integration deficits should be carefully considered before reaching the conclusion that schizophrenic patients “might have a weaker or more flexible internal model of their body, making them more susceptible to the illusion” (Thakkar et al., 2011). Indeed, the stronger RHI observed in these patients (Peled et al., 2000; Peled et al., 2003; Thakkar et al., 2011) could reflect either a general increase of the response to multisensory stimuli (e.g., Stone et al., 2011), or a larger influence of visual cues on tactile sensory experience, compared to healthy participants. This would be also consistent with possible alterations of proprioception and somatosensory processing (Chang and Lenzenweger, 2005).

In the present study we explore the extent to which visuo-tactile integration contributes to susceptibility to the RHI in schizophrenia, by using a procedure in which no tactile stimulation is applied and multisensory integration is elicited only by anticipation of touch experience. Indeed, we want to rule out the possibility that the stronger RHI observed in schizophrenic patients, compared to controls, is due to an imbalanced contribution of vision and experience of touch. To this aim we take advantage of a new induction procedure of the RHI (Ferri et al., in 2013), that is, without delivering synchronized visuo-tactile stimuli. In this new induction procedure, participants observe a rubber hand being approached but not touched, while their own hand is out of sight. Obtaining the same results as with

the classic RHI induction procedure would mean that higher susceptibility to “classic” RHI in patients does not rely either on actual stimulation nor on the overweighting of visual over tactile information, but it likely reflects a more flexible internal model (Thakkar et al., 2011). However, one could also hypothesize different scenarios. 1) Patients might experience RHI as much as control participants, which would indicate that higher susceptibility to “classic” RHI in patients does rely on actual stimulation and overweighting visual information so that when actual stimulation is absent, visuo-tactile integration seems generally unimpaired. 2) Patients might experience RHI less than control participants, which would indicate that higher susceptibility to “classic” RHI in patients does rely on actual stimulation and that anticipation, rather than actual experience of touch, is not sufficient to create ownership over the rubber hand in schizophrenic patients. In this case, it would be also possible that altered self experiences, that is, disturbed body ownership manifesting itself as lower susceptibility to RHI, could be differently related to symptomatology. In particular, it could be associated with negative symptoms, whereas higher susceptibility to RHI could be associated with positive symptoms.

2. Methods

2.1. Participants

21 schizophrenic patients (SCZ; 11 inpatients, 10 outpatients) and 17 control participants (HC) were included in the present study (Table 1). Patients were diagnosed according to the structured clinical interview for DSM-IV. Exclusion criteria for all participants comprised significant medical or neurological illness, substance abuse or dependence in the previous six months, IQ < 85, and, for the HC group, a personal history of Axis I/II disorders or a history of psychosis in first-degree relatives. SCZ and HC groups were matched for age, gender and education. SCZ patients were recruited from outpatient services at Chieti mental health department and from inpatients at the psychiatric clinic “Villa Jolanda”. The mean illness duration was $12,16 \pm 9,33$ years. The SCZ group had intellectual capacities in the range of the average healthy population (IQ mean scores = $104,7 \pm 6,5$). Chlorpromazine equivalents were calculated (Woods, 2003) for antipsychotics (Table 1). The study was approved by the Ethics Committee of Chieti University. Written informed consent was obtained from all participants after full explanation of the procedure of the study, in line with the Declaration of Helsinki.

2.2. Evaluation scales

SCZ patients were evaluated by the structured clinical interview for DSM-IV Axis I disorders (SCID-I) (First et al., 1996b) to establish axis I diagnoses. They were rated for symptom severity using the brief psychiatric rating scale (BPRS; Overall and Gorham, 1962), the scale for assessment of positive symptom (SAPS) and the scale for assessment of negative symptom (SANS; Andreasen, 1984a, b) (Table 1). Patients' intelligence quotient (IQ) was evaluated by means of the Raven standard progressive matrices (SPM).

HC participants were evaluated by means of the structured clinical interview for DSM-IV for Axis II personality disorders (SCID-II) (First et al., 1996a). All the evaluation scales were administered by trained psychiatrists.

2.3. Procedure

Participants sat in front of a table. The right arm was placed on the table in a relaxed position at a fixed point inside a frame. A smaller table, measuring 80 by 30 cm and 20 cm in height, was positioned over the table where the real hand was placed (see Fig. 1). This table was used to both hide participants' hand and to support the object

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