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Anomalous bodily experiences and perceived social isolation in schizophrenia: An extension of the Social Deafferentation Hypothesis

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ABSTRACT

Background: Disturbances of the bodily self are fundamental to the phenomenological experience of individuals with schizophrenia, a population at risk for social isolation. Both proprioception and exteroception contribute to a sense of consistent body boundary that contains the self across time and space, and this process is influenced by self-other (social) interactions. However, the relationship between social isolation, exteroception, and in-the-moment changes in body representation has not been elucidated. We investigated susceptibility to anomalous bodily experiences with a phantom nose induction procedure that elicits a sensation that one's nose is changing (Pinocchio Illusion: PI) in relation to exteroceptive awareness and social isolation.

Methods: 25 individuals with schizophrenia (SZ) and 15 matched controls (CO) participated in a PI induction procedure to quantify susceptibility to bodily aberrations and a tactile discrimination task to assess exteroception. Clinical symptoms in SZ and schizotypy in CO were assessed, in addition to a self-report measure of perceived social isolation.

Results: Compared to CO, SZ showed increased PI and impaired tactile discriminability. SZ reported greater loneliness than CO. PI scores were correlated with increased loneliness and decreased tactile discriminability.

Conclusions: Greater susceptibility to anomalous bodily experiences, together with reduced exteroceptive awareness and increased loneliness, is compatible with the framework of Hoffman's Social Deafferentation Hypothesis, which posits that a functional "amputation" from one's social environment could lead to a reorganization of the social brain network, resulting in hallucinations and delusions. These findings underscore the importance of the relationship between social isolation and self-disturbances in schizophrenia.

1. Introduction

A tacit understanding of one's body as a continuously unified entity with fixed boundaries allows one to distinguish self from other, and this experienced unity of self and body is necessary for adaptive social functioning (Petkova et al., 2011; Postmes et al., 2014; Park and Nasrallah, 2014). Self-disturbances and anomalous beliefs concerning one's own body were important to Bleuler's (1911) conceptualization of schizophrenia. Clinical descriptions of schizophrenia are replete with sudden alterations in size and shape of the body, abnormal body ownership, anomalous agency, and even out-of-body experiences (e.g., Chapman et al., 1978; Priebe and Röhricht, 2001; Saks, 2008; Kean, 2011). These self-disturbances are present during the prodromal stage and remain salient throughout the course of the illness (Sass and Parnas, 2003; Lysaker and Lysaker, 2010; Nelson et al., 2012; Nasrallah, 2012; Koren et al., 2013; Brent et al., 2014). These phenomenological accounts of self-disturbances in schizophrenia are supported by empirical studies of two aspects of self-disturbances: anomalous agency (Frith et al., 2000; Fourneret et al., 2002; Graham et al., 2015; Garbarini et al., 2016; Hur et al., 2014) and abnormal body ownership (Peled et al., 2000; Peled et al., 2003; Thakkar et al., 2011; Ferri et al., 2014; Gallese and Ferri, 2014). However, more elusive yet crucial experiences of temporary changes in the shape, size, or location of one's own body parts (see Chapman et al., 1978) have not been extensively investigated in the laboratory.

Since bodily aberrations tend to occur spontaneously, they are difficult to objectively measure, and interview-based assessments may not be optimal for quantifying subtle anomalies in real time. However, susceptibility to bodily self-aberration can be reliably demonstrated via a family of proprioceptive paradigms, such as the Rubber Hand Illusion (e.g., Botvinick and Cohen, 1998; Albrecht et al., 2011; Thakkar et al., 2011), the Full Body Illusion (Ehrsson, 2007; Blanke and Metzinger, 2009; Mizumoto and Ishikawa, 2005), and the Pinocchio Illusion (PI: Lackner, 1988; Burrack and Brugger, 2005).

The PI is a proprioceptive illusion that engenders the feeling that one's nose is growing. To induce it, a vibrator is applied to the biceps brachii of the participant while she touches her nose with the index finger of the stimulated arm (Fig. 1). The vibrator stimulates muscle

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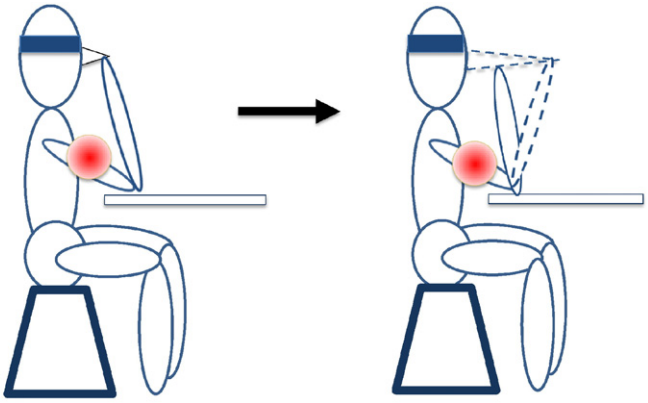

1A. Test Configuration: Blindfolded participant sits, touching her nose. The area of stimulation (biceps brachii) is marked in pink.

1B. Illusion Outcome: Hypothesized effect of stimulation on participant's perceived arm and nose locations (bodily boundary) is in dicated by dotted lines.

Fig. 1. Pinocchio Illusion induction.

spindles in the biceps that would normally be activated by the stretching muscle, but since the arm position is fixed by requiring the subject to touch her nose, this procedure creates a kinesthetic illusion that the arm is moving away from the face. Because the finger touching the nose is still giving tactile information of being in contact with the nose, while the arm is perceived to be moving forward, the participant feels that the nose is also moving away from the face, as the brain works to reconcile conflicting proprioceptive and tactile sensations. Thus, the perceived shape, size, and orientation of one's own body parts can be manipulated to generate false information about limb position. In contrast to the RHI, the PI does not include an "other" component, and, therefore, is more suitable for investigating representation of bodily boundaries without influences of altered agency or body ownership.

Proprioception links one's bodily movement with the body's location, contributing to the spatial and peri-personal sense of self. Tactile perception (i.e., exteroception) contributes to one's sense of body boundary (i.e., self versus non-self) through interpretation of sensory stimuli on the skin. Reduced exteroceptive awareness or misinterpreted tactile perception exacerbates self-disturbances and psychosis risk (Nelson et al., 2008; Postmes et al., 2014). Indeed, tactile sensitivity is reduced in the schizophrenia-spectrum (Chang and Lenzenweger, 2001, 2005).

The bodily self does not exist in a vacuum. Infants' sense of the body schema and bodily self develop via dynamic multisensory (especially proprioceptive and tactile) interactions with the environment (Piaget and Inhelder, 1967; Morgan and Rochat, 1997). Thus, our sense of the bodily self and awareness of embodied psychological self are significantly shaped by our interactions with the world. Specifically, social interactions provide us with a framework to interpret and disambiguate somatic signals (Cioffi, 1991; Russell, 2003). When these constant interactions with the world are removed, ensuing social isolation and loneliness lead to adverse consequences (Cacioppo and Hawkley, 2009). Specifically, social isolation and withdrawal are thought to trigger or exacerbate delusions and hallucinations in vulnerable individuals across diagnostic categories (Brugger et al., 1999; Hoffman, 2007; Jiang et al., 2013; Selten et al., 2013; El Haj et al., 2016) and worsen positive symptoms (Grassian, 1983; Siegel, 1984; Hoffman, 2007; De Sousa et al., 2015). Hoffman's (2007) Social Deafferentation Hypothesis posits that a loss of social connectedness leads to a tendency to create human-like agents (i.e. hallucination) and increased belief in the supernatural (i.e. delusion) through neural re-organization. These tendencies may be magnified by the unmet need for social support and connectedness (Epley et al., 2008) and impaired self-perception (Bastian & Haslam, 2010). Moreover, there are neuroanatomical consequences of social isolation. Loneliness exerts a detrimental impact on the left posterior superior temporal sulcus (pSTS) that normally supports social cognition (Kanai et al., 2012). Abnormal function and reduced volume of the pSTS are associated with hallucinations, delusions, and thought disorder in schizophrenia (Shenton et al., 1992; Kim et al., 2011). Furthermore, the areas that contribute to the social brain network (e.g., temporo-parietal junction (TPJ) and the inferior temporal region) and the areas implicated in bodily processing overlap (Blanke et al., 2005; Wible, 2012). Taken together, these findings suggest an important role of impoverished social interactions in clinical symptoms and the sense of bodily self, including both proprioceptive and exteroceptive abnormalities.

In the present study, we aimed to fill in important gaps in the literature by quantifying subjective bodily experiences (i.e. aberrant proprioception and exteroception) and identifying potential underlying mechanisms (i.e. social isolation). We hypothesized increased susceptibility to anomalous bodily experiences and impaired exteroceptive awareness would be associated with the severity of clinical symptoms in schizophrenia. Furthermore, we hypothesized that social isolation and reduced exteroceptive awareness would be associated with increased susceptibility to the PI.

2. Methods

2.1. Participants

Twenty-five outpatients who met the DSM-IV criteria for schizophrenia (SZ) were recruited from outpatient facilities in Nashville. All, except for one, were medicated. Symptoms were assessed with the Brief Psychiatric Rating Scale (BPRS; Overall and Gorham, 1962), the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1984), and the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1983). Fifteen healthy controls (CO) without history of DSM-IV Axis I disorder in themselves or in their families were recruited from Nashville by advertisement. Schizotypy in CO was assessed with the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991).

All participants were screened for substance use within the past 6 months, neurological disorders, and past head injuries. Participants were not taking any pain medication. The two groups were matched in age, handedness, and gender but not on IQ or education. However, the mean IQ and education level of SZ were well within the normal range. All participants gave written informed consent and were paid.