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Review

Schizophrenia as a self-disorder due to perceptual incoherence ☆

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ABSTRACT

The aim of this review is to describe the potential relationship between multisensory disintegration and self-disorders in schizophrenia spectrum disorders. Sensory processing impairments affecting multisensory integration have been demonstrated in schizophrenia. From a developmental perspective multisensory integration is considered to be crucial for normal self-experience. An impairment of multisensory integration is called 'perceptual incoherence'. We theorize that perceptual incoherence may evoke incoherent self-experiences including depersonalization, ambivalence, diminished sense of agency, and 'loosening of associations' between thoughts, feelings and actions that lie within the framework of 'self-disorders' as described by Sass and Parnas (2003). We postulate that subconscious attempts to restore perceptual coherence may induce hallucinations and delusions. Increased insight into mechanisms underlying 'self-disorders' may enhance our understanding of schizophrenia, improve recognition of early psychosis, and extend the range of therapeutic possibilities.

1. Introduction

We perceive our environment and ourselves by all our sensory systems (Critchley et al., 2004; Gallagher, 2005; Angelaki and Cullen, 2008; Craig, 2008; Bermúdez, 2011; Gallese, and Sinigaglia, 2011; Bremner et al., 2012; Damasio, 2012). The neurobiological process of organizing and processing sensory information for effective interaction within the environment is called 'multisensory integration', and evolves during maturation (Rochat and Striano, 2002; Lewis and Ramsay, 2004; Ayres et al., 2005; Bremner, et al., 2012; Ghazanfar, 2012). It is regarded as crucial for various aspects of normal self-experience: recognition of own body, actions, imagination, memory, and (emotional) awareness (Gallagher, 2000; Damasio, 2001; Jeannerod, 2003; Rainville et al., 2006; Tsakiris et al., 2007; Craig, 2008; Vianna et al., 2009; Bermúdez, 2011; Damasio, 2012; Prebble et al., 2012).

Many impairments affecting multisensory integration have been demonstrated in schizophrenia (Table 1). We hypothesized that these sensory deficiencies and abnormal self-experiences in schizophrenia might be connected. The aim of this review is to explore research on self and self-disorders in schizophrenia from the perspective of multisensory integration, in a developmental context. All sensory modalities, including 'interoception' and vestibular sense, are our study objects.

First we will outline the historical context. After specifying the concept of self we will provide a description of self-experience in healthy individuals from a developmental and multisensory perspective. Subsequently, we describe the relationship between self-disorders and perceptual incoherence and schizophrenia spectrum disorders. Finally, we propose a sensory model as to self-disorders that may lead to psychotic symptoms, and postulate that subconscious attempts to restore perceptual coherence may induce hallucinations and delusions.

2. Method

A PubMed literature search was performed to address two questions: *Are perceptual incoherence and self-disorders related in schizophrenia spectrum disorders? If so, how can we characterize the relationship between perceptual incoherence, self-disorders and psychotic symptoms?*

Our search used the following keywords: schizophrenia, self-disorders, body image, body awareness, self-awareness, self-other organization, imagination, olfactory sense, proprioception, vestibular sense, interoception, haptic sense, sensory integration, sensory processing, crossmodal, and development. Additional literature was retrieved via references. There were no limitations regarding year of publication, languages were limited to English, French, German and Dutch.

3. Historical context

Many prominent psychiatrists have shared the concept that schizophrenia is associated with disintegration of self. In Bleuler's terminology

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Table 1
An outline of sensory dysfunctions affecting multisensory integration in schizophrenia spectrum disorders. Sensory dysfunctions regarding almost all senses are associated with increased risk for schizophrenia. Sensory deficits have been demonstrated in schizophrenia (Sz), Capgras syndrome (Cpg) and Delusions of Control (DoC), in relatives of schizophrenic patients (Rel), schizotypic personality (StP), depersonalization disorder (DPD) and self-delusions caused by brain lesions (BL). The only sensory deficit that is *protective* for schizophrenia is congenital blindness, which is associated with compensatory *strengthening* of somatosensory processing.

Senses	Sensory deficit	Investigated subjects	Literature
Olfactory sense	Deviant olfactory experiences	Predictive: Sz, ps	Cascella et al. (2007), Kwapil et al. (1996)
	Olfactory functions, meta-analysis	Sz, StP	Moberg et al. (in press), Cohen et al. (2012)
	Structural impairments olfactory system	Sz	Turetsky et al (2009), Moberg et al. (in press), Cascella et al. (2007)
Haptic sense	Sensitivity and processing	Sz, StP, Rel	Lenzenweger (2000) Chang and Lenzenweger (2004) Chang and Lenzenweger (2005)
	Altered self/other discrimination	Sz	Blakemore et al. (2000), Silverstein et al. (2012)
	Higher susceptibility for Rubber Hand Illusion	Sz	Thakkar et al. (2011), Peled et al. (2000)
Propriocepsis	Impaired sensory processing all cerebral levels	BL	Feinberg (2009)
	Lower processing speed/attenuated beta and gamma oscillations-proprioceptive info	Sz, StP	Arnfred et al. (2006), Arnfred et al. (2010)
	Recognition and prediction motor actions	Ps, Sz, DoC	Ferri et al. (2012), Franck et al. (2001) Frith et al. (2000), Frit (2005), Fourneret et al. (2002), Jeannerod (2003), Shergill et al. (2005), Silverstein et al. (2012), Synofzik et al. (2010)
Vestibular sense	Eye tracking abnormalities	Sz	Jones and Pivik (1985), Levy et al. (2010), Pawlak-Osińska et al. (2000)
	Hypo-reactivity and dysfunction	Sz, HR-Sz	Colbert et al. (1959), Fish and Dixon (1978) Gordon (1979), Levy et al. (1983)
	Altered vestibular responses and synchrony	Sz, DPD	Haghgooie et al. (2009), Ornitz (1970), Sang et al. (2006)
	Visuo-vestibular disintegration	Sz, Szt	Schilder (1933), Pawlak-Osińska et al. (2000)
	Caloric vestibular nerve stimulation is beneficial	Sz, BL	Levine et al. (2011), Lopez et al. (2012), Rubens (1985)
Interoception	Autonomic abn. & disconnection response	DPD, Sz, Cpg	Dawson et al., (2010), Lewis et al. (2001), Ellis and Lewis (2001), Roux et al. (2010), Williams et al. (2007)
	Simult. co-activation two evaluative systems	Sz	Trémeau et al. (2009)
	Interoception related to emotion processing	Sz, DPD	Seth et al. (2011), Wylie (2010)
	Pain processing and monitoring	Sz Rel	Josephus Jitta (2012), Kring and Neale (1996), Potvin and Marchand (2008), Shintani (2010), Singh et al. (2006)
Audio–visual	Hearing or visual dysfunction	Higher risk: Sz	Butler and Javitt (2005), Butler et al. (2009), Chen et al. (2003), Chen (2011), Coleman et al. (2009), Javitt (2009), de Jong et al. (2009), de Gelder et al. (2005)
	Congenital blindness is protective for Sz	Sz	Silverstein et al. (2006), Silverstein et al. (2012)
	Visual processing	Sz	Butler and Javitt (2005)
	Auditory processing	Sz	Micoulaud-Franchi et al. (2012, 2011), Leitman et al. (2008)
	Audio–visual processing	Sz	de Jong et al. (2009), Ross et al. (2007)

'splitting of the psyche' or 'loosening of associations' is manifested in, ambivalence, inappropriate or flattened affectivity and autism (Bleuler, 1911; Moskowitz and Heim, 2011). Some psychiatrists linked sensory dysfunction with disturbance of self in schizophrenia (Pick, 1904; Schilder, 1933; Blankenburg, 1971; Mahler and McDevitt, 1982). Schilder (1933) related sensory disintegration to disintegration of the ego directly, and assigned a special role for the vestibular apparatus.

Various investigators observed disturbance of sensory integration and vestibular pathology in childhood and adult schizophrenia (Colbert et al., 1959; Ornitz, 1970; Ayres, 1972; Jorstad et al., 1977; Fish and Dixon, 1978; Gordon, 1979; Blakeney et al., 1983; Levy et al., 1983; Jones and Pivik, 1985; Fish and Kendler, 2005). Blankenburg's investigations led to what he regarded as the core phenomenon of schizophrenia: "der Verlust der natürliche Selbstverständlichkeit", literally translated 'the loss of natural self-evidence', in English literature often referred to as 'a loss of common sense' (Blankenburg, 1971; Uhlhaas and Mishara, 2007).

After the rise of the Diagnostic and Statistical Manual of Mental Disorders (DSM), the influence of the abstract concept of self and the concept of sensory integration both declined. DSM fulfilled a need for objectivity and scientific verification. Against the grain, phenomenological studies continued in Europe (Huber, 1995; Klosterkötter et al., 1997; Parnas, 1999). Sass and Parnas (2001, 2003) introduced a phenomenological model, which relates self-disorders to positive and negative symptoms and disorganisation.

Damasio (2001) offered another perspective: patterns of sensory information, especially 'interoception' (i.e. the sensing of the organism's interior) lead to awareness of emotions.

By now, phenomenological ideas are welcomed again as a valuable approach in the area of early detection and prevention of psychosis (Nelson et al., 2012) and the subject of sensory integration in schizophrenia gains in interest rapidly (Javitt, 2009).

4. Development of self

For pragmatic reasons we describe normal sense of self as a feeling of unitary entity, the "I", that owns and authors its thoughts, emotions, body and actions. The development of a sense of self is intertwined with the developmental abilities to integrate sensory input (Rochat and Striano, 2002; Lewis and Ramsay, 2004; Rochat, 2011b; Bremner et al., 2012). Though the environment continuously influences us, we are demarcated from it (Kuiper, 1986; Gallagher, 2000; Kircher and David, 2003). Multisensory input continuously informs us, which is essential for normal self-experience (Gallagher, 2005; Zahavi, 2005; Craig, 2010; Gallese and Sinigaglia, 2011; Blanke, 2012; Damasio, 2012). Like our nose is always present in the centre of our visual field, a 'background composition of multisensory input', responsible for an abstract awareness of ourselves, is present in every experience we have (Table 2). This 'sensory self' is analogous to phenomenological concepts as 'presence', 'core self', 'minimal self' or 'ipseity' (Sass and Parnas, 2003; Stanghellini, 2004; Gallagher, 2005; Cermolacce et al., 2007; Bermúdez, 2011; Damasio, 2012).

Normal development of self requires increasing skills to reach agreement between different perspectives of self, in different situations, without a gross distortion of reality. Neurological and phenomenological self-development is intertwined, has analogous hierarchical composition, and is consistent with developmental milestones.

In the first months after birth, information from the inner body and physical boundaries is dominant (Rochat, 2001; Rochat and Striano, 2002; Feinberg, 2009; Rochat, 2011a,b; Bremner et al., 2012). Newborns appear to have a sense of being embodied in an environment in which they have agency (Rochat, 2011a). This minimal self-awareness is infused with meaning arising from interaction with others (Mahler and McDevitt, 1982; Aitken and Trevarthen, 1997; Rochat, 2001; Rochat and Striano, 2002; Rochat, 2011a). In infancy (0–12 months),