Schizophrenia Research xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Schizophrenia Research

journal homepage: www.elsevier.com/locate/schres

Delusions of control in schizophrenia: Resistant to the mind's best trick?

Martin Riemer

German Center for Neurodegenerative Diseases (DZNE), Aging & Cognition Research Group, 39120 Magdeburg, Germany
Center for Behavioral Brain Sciences (CBBS), 39106 Magdeburg, Germany

ARTICLE INFO

Article history:
Received 15 December 2016
Received in revised form 5 November 2017
Accepted 24 November 2017
Available online xxxx

Keywords:
Delusion of control
Passivity delusion
Agency
Schizophrenia
Volition
Temporal recalibration

ABSTRACT

The existence of a free will is fiercely debated in neuroscience and philosophy. The debate has great impact on society and our self-understanding as human beings. Behavioral and electrophysiological data have challenged the intuitive assumption that human behavior is the result of conscious intentions. This notion has important implications for delusions of control in schizophrenia, where patients experience bodily movements as not being controlled by themselves. Current theories explain control delusions as a deficit to perceive certain aspects of motor control, but many findings are inconsistent with this idea. Here, an alternative view is proposed: Control delusions might be triggered by an even more veridical perception of the temporal order of intentions and actions. This hypothesis is supported by evidence that (a) conscious intentions in healthy subjects are often based on retrospective inferences, (b) temporal recalibrations of conscious percepts occur in healthy subjects and are disturbed in schizophrenia and (c) basic perceptual functions of schizophrenic patients are less influenced by expectations and therefore they can sometimes be closer to physical reality than those of healthy subjects.

1. The temporal order of intention and action

When we observe someone reaching out for a pencil, we assume that he must have wanted it. When we see someone crying, we infer that she must be sad. When someone helps us without expecting a reward, we are likely to conclude that this person is inherently helpful. For all the actions and behaviors we observe in other people, we infer the existence of corresponding intentions or emotional states which have caused these actions. Influential theories like the self-perception theory (Bem, 1972) and the James-Lange theory of emotions (James, 1884; Lange, 1887) suggest that we may use the same cognitive strategies to infer our own intentions and emotional states.

Although it might seem counterintuitive that we should not know our own intentions and emotions until we have observed our behavior, many classical experiments support this assumption (Bem, 1972; Schachter and Singer, 1962). The common ground for these claims is a reversal of the apparent temporal order of what is perceived as cause and effect. First we act in a specific manner and *afterwards* we infer that we possess an attitude for such a behavior (Bem, 1972). First we perceive physiological arousal and *then* we feel anger (Schachter and Singer, 1962). Given that a specific attitude can last over a long period of time, it is hard to decide whether it has appeared before or after a specific behavior. The same is true (although to a lesser degree) for emotional states. Assuming the same reversal of cause and effect is more difficult when applied to the domain of spontaneous bodily movements. Here, the intention[1] for a spontaneous movement is assumed to appear within a very narrow temporal window before the performance of the corresponding movement. Accordingly, experimental studies investigating the temporal order of motor intentions and movements are hard to implement, and therefore scarce.

In their seminal experiments on the relative timing of conscious intentions, Libet et al. (1983) found that the readiness potential, an EEG component preceding spontaneous movements, also precedes the time point at which the intention for the movement is perceived. This finding was replicated using single cell recordings (Fried et al., 2011) and suggests that spontaneous movements are already initiated when we become aware of the intention to move. Although methodological concerns regarding the ability to report the time of a motor intention have been raised (Miller et al., 2010) and the interpretation of the readiness potential as reflecting a preparatory process is questionable (Schmidt et al., 2016; Schurger et al., 2016), the basic idea of actions being initiated unconsciously is strengthened by other experiments, in which it was found that the experience of an intention often depends on post-hoc inferences (Banks and Isham, 2009; Kühn and Brass, 2009; Lau et al., 2007; Wegner, 2002, 2003; Wegner et al., 2003; Yoshie and Haggard, 2013). For example, Banks and Isham (2009) asked their participants to report the time of motor intentions for self-

[1] In this paper, an intention is defined as a conscious thought about a specific movement, which (a) is perceived as having occurred previous to the movement's execution and (b) is interpreted as its immediate cause.

E-mail address: martin.riemer@dzne.de.

https://doi.org/10.1016/j.schres.2017.11.032
0920-9964/

paced finger movements. By introducing systematically delayed feedback regarding these movements, the authors were able to manipulate the perceived onset of motor intentions, leading them to conclude that conscious intentions are inferred on basis of the movements' effects rather than directly perceived during its execution.

Under certain conditions, healthy individuals deny being the initiator of self-caused actions (Sarrazin et al., 2008; Wegner, 2002; Yoshie and Haggard, 2013), or conversely experience an intentional state for actions that were in fact controlled by others (Lynn et al., 2010; Wegner, 2002). Together, these findings suggest that intentions do not arise prior to the corresponding actions, but rather at the same time or even after the action has taken place.

2. Delusions of control in schizophrenia

The notion that actions might not be preceded by corresponding intentions bears a striking resemblance to delusions of control, which are frequently reported by patients suffering from schizophrenia (Frith, 2005; Graham et al., 2014). These symptoms, also known as passivity delusions, denote the feeling that one's actions or thoughts are controlled by external forces. In contrast to other symptoms of impaired motor control, such as the alien hand sign, the experience of control delusions does not prevent the actions from being perceived as intentional and goal-directed (Frith et al., 2000). Patients do not try to stop or correct their actions while still claiming that they are used 'like a ventriloquist' (sic) (Frith et al., 2000; Spence et al., 1997). A patient described in Mellor (1970) reported:

> When I reach my hand for the comb it is my hand and arm which move, and my fingers pick up the pen, but I don't control them… I sit here watching them move, and they are quite independent, what they do is nothing to do with me… I am just a puppet who is manipulated by cosmic strings. When the strings are pulled my body moves and I cannot prevent it.

Delusions of control are often described in terms of a disrupted sense of agency (Graham et al., 2014; Robinson et al., 2016), defined as the sense of being the initiator of a movement, action, or thought (Gallagher, 2004). It is necessary here to distinguish between two subtypes of agency, depending on whether agency relates to external events or to movements of the own body. The feeling of being controlled by external forces refers only to the voluntary control of the own body, whereas the sense of agency for external events deals with the causal relation between bodily movements and effects in the external world. It denotes the experience of having caused these events, and an increase of this sense of agency has often been reported in schizophrenic patients (Graham et al., 2014; Hauser et al., 2011; Robinson et al., 2016). For example, in a study by Hauser et al. (2011), patients were more likely to believe that they caused a series of drum tones than healthy controls, even when the rhythm deviated from their own drumming movements. This and other observations of increased self-attribution in schizophrenia seem to contrast with the experience of control delusions, in which the self-attribution of movements is reduced. However, the sense of agency for external events and delusions of control are related to different aspects of intentional motor behavior.

An increased sense of agency in schizophrenia (as investigated in Hauser et al., 2011), refers to the relationship between actions and their external effects (blue and red boxes in Fig. 1), while delusions of control refer to the relationship between intentions and actions (green and blue boxes). In healthy participants, the perceived times of actions and effects are shifted towards each other, i.e., actions and effects are perceived as being temporally closer to each other than they actually are (Haggard et al., 2002; Voss et al., 2010). A reciprocal attraction between what is perceived as cause and consequence might result in the action being attracted in two opposite directions: forward in time to the external effect, for which it is the cause, and backward in time to the perceived intention, of which it is the putative consequence (Fig. 1a). Thus, the backward attraction partly compensates for the forward attraction. Therefore, the absence of a retrospective inference of an intention, which is then back-dated to precede the action, would enhance the temporal binding between action and effect (Fig. 1b). This model can explain the coexistence of two apparently contradictive phenomena: A reduced experience of intentional control over bodily movements (delusions of control) and an increased feeling that these movements have caused external effects (increased sense of agency).

Although extensive research has been conducted in order to discover the neurological basis for control delusions, as well as to identify factors determining them, there is as yet little concensus in the literature (Frith, 2005; Robinson et al., 2016; Spence et al., 1997). According to the central monitoring hypothesis, control delusions are the consequence of a defective monitor system for internally-generated motor processes (Frith, 1992). When an action is executed in the absence of self-monitoring, it is not recognized as self-generated and might therefore be attributed to external forces. This assumption is reinforced by some findings that patients with control delusions are less aware of their movements than patients without this specific symptom (Farrer and Franck, 2007; Knoblich et al., 2004). Using a similar logic, it has been suggested that control delusions are explained by an impaired prediction of the sensorimotor consequences of intended motor commands (Frith et al., 2000; Synofzik et al., 2010). Specifically, self-generated movements are misattributed to external agents, because the sensory feedback associated with them deviates from the predictions based on efference copies (Frith, 1992). However, these theories are not without their critics (Fourneret et al., 2001; Gallagher, 2004; Giersch et al., 2016; Graham et al., 2014). Giersch et al. (2016) recently suggested an alternative view, according to which delusions of control are based on a deficit in sequencing single subcomponents of an action (due to a delayed sensory feedback).

A common basis of current theories is that delusions of control are invariantly regarded as false beliefs, as an erroneous perception of what is actually happening. However, the considerations on the freedom of will outlined in Section 1 and the accumulating evidence against a causal link between intentions and actions raise another intriguing possibility: Delusions of control might be understood as a more realistic, rather than a distorted, perception of the world. Rather than being caused by a reduced awareness of certain aspects of motor control, they might be triggered by the unusual experience of the veridical temporal order of a movement and the consciously perceived intention for this movement.

Despite the experimental evidence that conscious motor intentions arise only after the corresponding movements are already initiated and that intentions are inferred retrospectively (see Section 1), this hypothesis stands in stark contrast to our phenomenal experience, which clearly assures us: First we have an intention, then we act accordingly. Therefore, it is essential to ask if there is any reason to assume that the perceived time of an intention can differ from its actual time of occurrence. If conscious intentions emerge only after the corresponding movements, how (and why!) can we perceive them in a reversed order?

3. Temporal back-referral of conscious percepts

In recent years, a great deal of evidence confirmed that the perceived time of sensory events can deviate from their actual occurrence (Bechlivanidis and Lagnado, 2016; Fujisaki et al., 2004; Rohde and Ernst, 2016; Stetson et al., 2006). These perceptual shifts in time highly depend on prior expectations of sensory events and retrospective inferences regarding their causes (Dennett and Kinsbourne, 1992; Moore and Haggard, 2008; Voss et al., 2010). Stetson et al. (2006) presented brief light flashes at a fixed delay after their participants pressed a key and asked them for temporal order judgments regarding their actions and the visual effects. After the participants had adapted to the fixed

Please cite this article as: Riemer, M., Delusions of control in schizophrenia: Resistant to the mind's best trick?, Schizophr. Res. (2017), https://doi.org/10.1016/j.schres.2017.11.032