ARTICLE IN PRESS

Consciousness and Cognition xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

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

Bodily self and schizophrenia: The loss of implicit self-body knowledge

Francesca Ferri [a,*], Francesca Frassinetti [b,c], Francesca Mastrangelo [d], Anatolia Salone [d,e], Filippo Maria Ferro [d], Vittorio Gallese [a,f,*]

[a] Department of Neuroscience, University of Parma, Parma, Italy
[b] Department of Psychology, University of Bologna, Bologna, Italy
[c] Fondazione Salvatore Maugeri, Clinica del Lavoro e della Riabilitazione, IRCCS – Istituto Scientifico di Castel Goffredo, 46042 Mantova, Italy
[d] Institute of Psychiatry, G. d'Annunzio University Chieti-Pescara, Chieti, Italy
[e] Department of Neuroscience and Imaging, G. d'Annunzio University Chieti-Pescara, Chieti, Italy
[f] Brain Center for Social and Motor Cognition, Italian Institute of Technology, Parma, Italy

A R T I C L E I N F O

Article history:
Received 3 February 2012
Available online xxxx

Keywords:
Self
Body
Schizophrenia
Implicit awareness
Explicit knowledge

A B S T R A C T

Schizophrenia spectrum has been associated with a disruption of the basic sense of self, which pertains, among others, the representation of one's own body. We investigated the impact of either implicit or explicit access to the representation of one's own body-effectors on bodily self-awareness, in first-episode schizophrenia (FES) patients and healthy controls (HCs). We contrasted their performance in an implicit self-recognition task (visual matching) and in an explicit self/other discrimination task. Both tasks employed participant's own and others' body-effectors. Concerning the implicit task, HCs were more accurate with their own than with others' body-effectors, whereas patients did not show such self-advantage. Regarding the explicit task, both groups did not exhibit a self-advantage, and patients showed a higher percentage of self-misattribution errors. Neither self/other nor implicit/explicit effects were found in both groups when processing inanimate-objects. We propose that FES patients suffer of a disturbed implicit sense of bodily self.

1. Introduction

Schizophrenia spectrum has been described as a psychiatric condition associated with the loss of a coherent sense of self. In schizophrenia also the distinction between self and other may blur (Sass & Parnas, 2003). Accordingly, it has been argued that even the poor social functioning (i.e., compromised social relationships and social behaviours) observed in psychotic disorders may be thought of as a secondary marker of the more basic disturbance of the sense of self (Nelson, Sass, et al., 2009).

From a phenomenological perspective (Parnas, 2000; Parnas & Handest, 2003) three levels of selfhood have been identified. First, there is the implicit awareness that this is 'my' experience. Such pre-reflective level of selfhood is sometimes referred to as the 'basic' or 'minimal' self or as 'ipseity'. Second, there is the more explicit awareness of self as an invariant subject of experience and action. Such reflective level of self-awareness presupposes the minimal self. Finally, there is the social or narrative self, which refers to personality, habits, style and other characteristics of an individual. According to this phenomenological perspective, the main self–disturbance in patients with schizophrenia spectrum disorders occurs at the most basic level, that pertaining to ipseity (Sass & Parnas, 2003). It has been argued that ipseity disturbance may account

* Corresponding authors. Address: Department of Neuroscience, Section of Physiology, University of Parma, Via Volturno 39, I-43100 Parma, Italy. Fax: +39 0521 903900.

E-mail addresses: francesca.ferri@nemo.unipr.it (F. Ferri), vittorio.gallese@unipr.it (V. Gallese).

1053-8100/$ - see front matter © 2012 Published by Elsevier Inc.
http://dx.doi.org/10.1016/j.concog.2012.05.001

for many of the key phenomenological changes that occur during the prodrome (Nelson, Sass, et al., 2009; Parnas, 2005; Parnas, Jansson, & Sass, 1998). Disturbance of mineness of experience, or sense of presence, appears to be one of the most critical features affecting ipseity, but not the only one. Other anomalous experiences of ipseity include (Parnas & Handest, 2003; Parnas & Sass, 2001) disturbed corporeality (anomalous bodily experiences, such as perceived morphological change or motor disturbances), stream of consciousness (e.g., thought interference, thought pressure, or thought block), self-demarcation (e.g., confusion between oneself and other people), and existential reorientation (e.g., self-reference or solipsistic phenomena). All these anomalies of basic self-experience are intimately interrelated (Nelson, Fornito, et al., 2009; Nelson, Yung, Bechdolf, & McGorry, 2008; Parnas & Sass, 2001). Such complexity of the notion of self-disturbance in schizophrenia, however, somehow reflects the multileveled and multifaceted concept of self experience. The implicit self-recognition task employed in the present study may well tap in particular onto the corporeality feature of ipseity, rather than being directly related to the feature of mineness (the sense that this is my experience).

Fuchs and Schlimme (2009) proposed that in schizophrenia the weakening of the basic sense of self, the disruption of implicit bodily functioning and the disconnection from intercorporeality with others are manifestations of a fundamental disturbance of the bodily self, or a disembodiment. How such loss of the implicit structure of the body can lead to compromised social perception and behavior can be exemplified by the following case of a 28-year-old female patient: "For some time I had a feeling as if my clothes did not seem appropriate any more. My gait had changed, I walked stiffly and did not know how to hold my hands. Then I often looked into the mirror and found that my facial expression had changed, and I began to think that I might be regarded as a prostitute. Men looked so strange at me ... I took passport pictures of myself in order to examine whether I only imagined that. Then I began to feel a kind of charging or tension in my body when others came near to me, as if it were passing over from them. Finally I thought I should be made a prostitute by brain manipulation ..." (Fuchs, 2005). In the case reported by Fuchs the patient clearly experiences a progressive alienation from her bodily feelings, a sense of increasing difficulty in recognizing the way she moves or behaves. Such sense of disembodiment leads her to rationalize this state by relying on a delusional explanation (others manipulated her brain). It is clear from this example that one of the first signs of schizophrenia consists in disturbances of the bodily self.

In a previous work from our group, we proposed that the experience we implicitly make of ourselves as bodily selves can be dissociated from the explicit recognition of a body as our own body (Ferri, Frassinetti, Costantini, & Gallese, 2011). In that study, we showed that healthy right-handers submitted to a hand laterality judgment task were faster when judging one's right hand compared to all the other hand stimuli (their own left hand and others' right and left hands). In other words, participants showed the so-called self-advantage effect (Frassinetti, Maini, Romualdi, Galante, & Avanzi, 2008; Frassinetti et al., 2009, 2010). Such effect did not emerge in a second experiment when the same participants were asked to explicitly recognize the owner of the observed hands, which were the same as those they had been presented with in the laterality judgment task. Based on these empirical data, we argued that implicit and explicit recognition of the bodily self can dissociate and only an implicit recognition of the bodily self allows the self-advantage effect to emerge. Such dissociation is in agreement with the developmental transition from the implicit to the explicit self-body processing reported in infants. For example, neonates can discriminate between their own cries and those of other neonates (Dondi, Simion, & Caltran, 1999) and 4 months-old infants show signs of distinguishing between self and others (Rochat & Striano, 2002). However, the ability to recognize oneself in front of a mirror emerges around 2 years of age (Amsterdam, 1972). Thus, during development an implicit sense of self and the ability to implicitly discriminate self from others appears to emerge earlier than the ability to explicitly self-recognize (Rochat, 2003, 2010).

The different contribution to our sense of self, as bodily self, provided by the representation of our body-effectors, when implicitly or explicitly accessed, was shown for the first time in a study in which we contrasted a visual matching task, as the implicit self-recognition task, with an explicit self/other discrimination task (Frassinetti, Ferri, Maini, Benassi, & Gallese, 2011). Both tasks consisted of two distinct blocks, employing, as stimuli, either participant's own and other people's body-effectors (hands and feet) or participant's own and other people's inanimate objects (shoes and mobile phones). The results showed that participants were more accurate in the implicit task with their own rather than with others' body-effectors. In contrast, such self-advantage effect, revealed by the analysis on accuracy, was not found when an explicit recognition of one's own body-effectors was required. Moreover, when processing inanimate-objects both self/other and implicit/explicit effects were absent.

In the present study we use the same tasks of Frassinetti and others (2011) with first-episode schizophrenia (FES) patients, in order to test whether a specific bodily self-advantage effect is either preserved or lost in these patients. We targeted FES patients for two main reasons. The first is that investigating the early manifestation of disorder allows a clearer view of the etiological and pathogenic processes at play. Indeed, secondary illness adversities (e.g., isolation, stigma, unemployment and demoralization, treatment effects, and the patient's attempts to cope and adapt) may cloud the clinical picture in advanced illness stages. The second reason is that the concept of self-disturbance as a phenotypic marker (Nelson et al., 2008) or a core feature (Parnas, 2000; Parnas & Sass, 2001) of schizophrenia is still poorly investigated in FES patients from the empirical perspective. As far as we are aware, there are even fewer empirical studies specifically investigating bodily self-disturbances in FES patients. For example, behavioural research have recently provided evidence for an anomalous sense of agency in these patients (Wilquin & Delevoye-Turrell, 2012). Furthermore, more general abnormalities of bodily experiences have been revealed in early schizophrenia by using a phenomenologically-based qualitative method of inquiry (Stanghellini, Ballerini, Fusar Poli, & Cutting, 2012). According to this evidence and to the phenomenological perspective conceiving of

Please cite this article in press as: Ferri, F., et al. Bodily self and schizophrenia: The loss of implicit self-body knowledge. *Consciousness and Cognition* (2012), http://dx.doi.org/10.1016/j.concog.2012.05.001

schizophrenia as a disturbance of the basic sense of self, mainly consisting of a loss of the "implicit structure of the body" (Fuchs, 2005, p. 95), we expect the bodily self-advantage effect not to be found in FES patients.

2. Methods

2.1. Participants

Twenty-one out-patients with a diagnosis of first-episode schizophrenia (FES) according to DSM-IV criteria and 21 matched healthy control (HC) participants were included in the present study (for demographic variables and participant characteristics, see Table 1). Exclusion criteria for all participants included physical health problems and neurological hard signs, a history of severe head trauma, loss of consciousness, drug abuse, IQ < 85, and, for the HC group, a personal history of Axis I/II Disorders (SCID-I/II) or a history of psychosis in first-degree relatives. FES patients were recruited from regional mental health centres. The mean time from psychotic episode was 6.3 (±4.7) months. All the FES patients were evaluated 6 months after the study and the diagnosis of schizophrenia according to DSM-IV criteria was confirmed. All patients were under medication during the period of the study, and medication was based on a low-medium dose of a single atypical antipsychotic drug (see Table 1). They all responded well to pharmacological therapy, as indicated by relatively compensated positive and negative symptoms and by stabilized global functioning in daily living. The patient group had intellectual capacities (IQ mean scores = 100.0 ± 7.8) in the range of the average healthy population (IQ mean scores = 100.6 ± 8.5). The study was approved by the local Ethics Committee. Written informed consent was obtained from all participants after full explanation of the procedure of the study, in line with the Declaration of Helsinki. The participants were given a recompense for participating in the experiment.

2.2. Evaluation scales

FES patients were evaluated by the Structured Clinical Interview for DSM-IV Axis I Disorders (First, Spitzer, Williams, & Gibbon, 1996), rated for symptom severity with the Positive And Negative Symptom Scale (PANSS; Kay, Fiszbein, & Opler, 1987), and for intelligence quotient (IQ) by means of the Wechsler Adult Intelligence Scale – Revised (WAIS-R; Wechsler, 1997) by trained psychiatrists. HC participants were evaluated by means of the Structured Clinical Interview for DSM-IV for Axis II personality Disorders (First, Gibbon, & Spitzer, 1996).

2.3. Stimuli and procedure

The experimental stimuli consisted of grey-scale pictures of body-effectors (hands and feet) and objects (mobile phones and shoes) (Fig. 1b). Flash photographs were taken with a digital camera perpendicular to body-effectors or objects, which were always photographed in the same position while standing against a uniform white background. Participants' body-effectors and objects were photographed in a session prior to the experiments (1 week before). This session took place in a controlled environment with constant artificial light and a fixed distance between the camera lens and the body-effectors or objects (40 cm). Subsequently, the pictures were modified by Adobe Photoshop software: They were equalized for visual properties, such as brightness and contrast, and digitally edited for extracting the background, isolating the body-effectors or objects and centring them on a uniform white background.

Other people's body-effectors were selected from this database as the best match for size, skin color, age, and gender, in comparison with each participant's hands or feet. The sizes of the hands and feet were compared in the pictures, in order to minimize the differences between matched hands and feet both in length and in width. In addition, the ages of the people whose body-effectors were matched with the participants' body-effectors varied within 0–3 years of the participants' ages. In each experiment stimuli representing body-effectors were counterbalanced for side of the body (left and right).

Table 1
Demographic information about first episode schizophrenia group (FES) and healthy control group (HC).

	FES patients (N = 21)	HC (N = 21)
Age	27.7 (±6.5)	29.2 (±5.9)
Mean time from psychotic episode (months)	6.3 (±4.7)	n.a.
Handedness score	64.8 (±21.2)	66.9 (±14.3)
Male/female	11/10	11/10
Diagnosis	First episode psychosis	n.a.
SCID-II cluster A	n.a.	Negative
SCID-II cluster B	n.a.	Negative
SCID-II cluster C	n.a.	Negative
PANSS negative scale (mean/SD)	22 24 16 12 15 10 9 11 8 11 13 9 11 12 14 9 9 8 12 22 (12.9 ± 4.8)	n.a.
PANSS general psychopathology scale (mean/SD)	25 37 25 22 26 20 20 23 22 23 24 21 25 22 25 19 20 19 22 35 (23.7 ± 4.7)	n.a.
Medication	6 Quetiapine, 7 risperidone, 4 paliperidone, 3 aripiprazole, 1 olanzapine[a]	n.a.

[a] Clorpromazine equivalent mean dose = 484 mg/die SD = 412 (calculated on 17 patients because no equivalents are available for paliperidone).

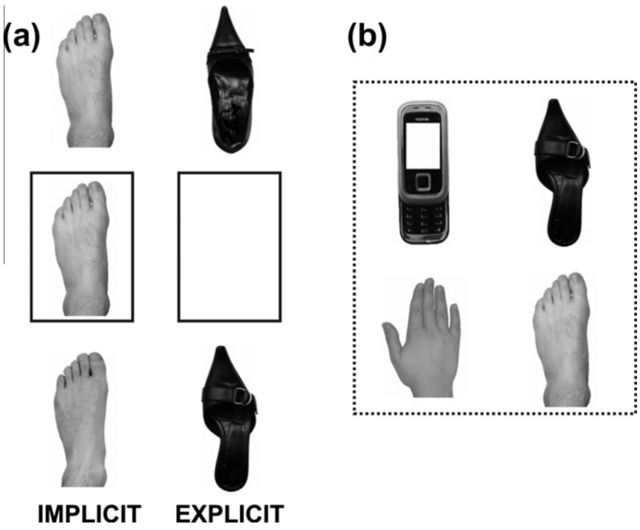

Fig. 1. Tasks and stimuli. (a) An example of a single trial. In Experiment 1 (implicit task) participants were required to decide which of the two images (the upper or the lower one) matched the central stimulus target. In Experiment 2 (explicit task) participants were required to judge whether and which image, between the upper or lower, corresponded to their own body-effectors or objects. (b) Examples of the experimental stimuli. For each category (body-effectors and inanimate-objects), two stimuli (hands or feet and mobile phones or shoes) were presented.

In Experiment 1 three stimuli of the same body-effectors (and of the same gender), or of the same inanimate-objects category, were simultaneously presented in each trial. The stimuli were aligned along the vertical meridian of the computer screen. The central stimulus, which corresponded to the target stimulus, was presented in upright position within a black frame. Stimuli presented in each trial were matched for visual similarity. Participants sat in front of the PC screen, at a distance of about 30 cm. They were required to decide whether the upper or the lower stimulus matched the target stimulus by pressing an upper or a lower (vertically aligned and previously assigned) response key, with their right index finger. Participants were instructed to respond as accurately as possible and within the allowed time interval. The trial was timed-out as soon as participants responded (up to 4000 ms). RTs and response accuracy were recorded (Fig. 1a implicit).

In Experiment 2 two stimuli of the same body-effectors (and of the same gender), or of the same inanimate-objects category, were simultaneously presented in each trial. The stimuli were the same as in Experiment 1, except that there was no target stimulus within the central frame. As in Experiment 1, the stimuli were aligned along the vertical meridian of the computer screen. Participants were required to decide whether the upper or the lower image corresponded to their own body or object by pressing an upper or a lower (vertically aligned and previously assigned) response key, with their right index finger. If none of the stimuli corresponded to their own body-effectors, they had to press a central response key. Participants were instructed to respond as accurately as possible and within the allowed time interval. The trial was timed-out as soon as participants responded (up to 4000 ms). RTs and response accuracy were recorded (Fig. 1a explicit).

For each experiment, at least one stimulus representing the participant's own body-effectors or inanimate-objects was presented in half of the trials (*self* trials), whereas only stimuli representing body-effectors or inanimate-objects of other three people were presented in the other half of the trials (*others'* trials). Stimulus presentation and randomization in a block were controlled using E-prime V1.1 software (Psychology Software Tools, Pittsburgh, PA) running on a PC. Each experiment consisted of 64 trials divided into two blocks, one with body-effectors (32 trials) and one with inanimate-objects (32 trials). Each block was constituted by half *self* trials (each presenting at least one picture of participant's own body-effectors or inanimate-objects, respectively), and half *others'* trials (each presenting only pictures of other people's body-effectors or inanimate-objects, respectively). All participants performed the Experiments in one single session, with 12 practice trials before each block. Since Experiment 1 investigated the implicit and Experiment 2 the explicit self-bodily recognition, Experiment 1 was always conducted before Experiment 2. The order of the blocks in each Experiment was randomized between subjects.

3. Results

Multivariate ANOVAs for repeated measures were separately performed on participants' accuracy (percent of correct response) and reaction times (RTs; see Table 2) for both Experiment 1 and Experiment 2, with Type of stimuli (body-effectors and inanimate-objects) and Owner (self and others'), as within-subjects factors, and Group (HC and FES), as between-subjects factor. Whenever appropriate, post hoc analyses were performed with the Newman–Keuls method.

A further analysis on errors was conducted for Experiment 2. Previous studies on patients with schizophrenia revealed that, when asked to explicitly distinguish one's own from other people's body-effectors, they show a misattribution bias.

Table 2
Accuracy (% correct) and reaction time scores (RTs; ms) in each subject group (HC = healthy control group, and FES = first episode schizophrenia group; BS = body-effectors, self stimuli; BO = body-effectors, others' stimuli; OS = inanimate-objects, self stimuli; OO = inanimate-objects, others' stimuli; SE = standard error).

	Experiment 1				Experiment 2			
	Accuracy		RTs		Accuracy		RTs	
	Mean	SE (±)	Mean	SE (±)	Mean	SE (±)	Mean	SE (±)
HC								
BS	96.7	1.9	1939.4	135.5	64.3	5.4	2799.8	315.9
BO	90.5	2.8	1977.0	194.5	88.7	2.9	2406.2	219.1
OS	97.3	0.9	1263.9	68.5	93.2	2.3	1379.2	79.6
OO	98.5	0.6	1291.7	68.1	90.8	3.5	1511.9	85.5
FES								
BS	83.0	2.9	1696.3	96.8	36.6	6.6	2473.8	365.6
BO	84.5	2.1	1729.2	100.7	64.3	7.3	1864.4	178.9
OS	93.8	1.6	1376.7	84.1	83.9	3.5	1479.2	131.2
OO	93.8	2.1	1364.2	74.1	84.2	5.3	1448.3	84.7

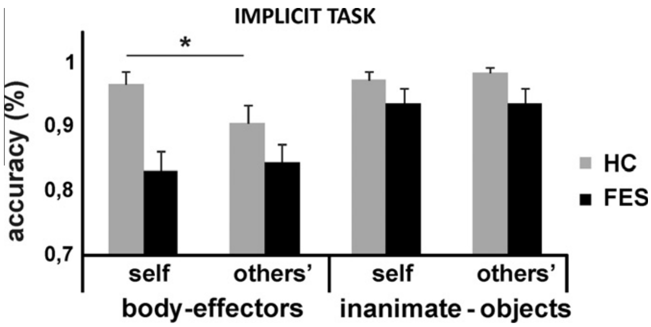

Fig. 2. Experiment 1. Mean percentages of correct responses (accuracy) for one's own (self) and other people's (others') body-effectors and inanimate-objects in the implicit task. Error bars depict the standard error of the mean. *Indicates $p < .05$.

Misattribution errors in schizophrenic patients have been often described as misattributions of agency (i.e., Daprati et al., 1997; Farrer & Franck, 2009, chap. 9; Franck, Georgieff, & Daléry, 2001; Synofzik, Thier, Leube, Schlotterbeck, & Lindner, 2010). Based on this previous knowledge, we performed independent samples *t*-tests to compare the percentage of two types of errors between FES and HC. Errors were classified as *self-misattribution*, when other people's body-effectors were erroneously attributed to oneself, and *self-omissions*, when one's own body-effectors were erroneously recognized as other people's body-effectors. We also performed a signal detection analysis for HC vs. FES, to estimate whether the two groups differed in self-other discrimination taking response bias into account. We used hit rates and false alarm rates to calculate d' prime values for each subject and each group.

3.1. Experiment 1: implicit task

3.1.1. Accuracy

The multivariate analysis of variance revealed that the factor Group was significant [$F_{(1,40)} = 13.3$; $p < .001$, $\eta^2 = .25$], since HC were more accurate than FES (96% vs. 89%). The factor Type of stimulus was significant [$F_{(1,40)} = 20.2$; $p < .001$, $\eta^2 = .34$] as well. This effect was accounted for by higher accuracy with inanimate-objects than with body-effectors (96% vs. 89%). Relevant to the main goal of the study, the three-way interaction Group × Type of stimulus × Owner was also significant [$F_{(1,40)} = 5.5$; $p < .05$, $\eta^2 = .12$]. Post hoc tests revealed that HC were more accurate with their own than with others' body-effectors (97% vs. 90%, $p < .05$), whereas FES were not (83% vs. 85%, $p = .44$). No significant difference was observed between one's own and others' inanimate-objects both in HC (97% vs. 99%, $p = .54$) and in FES (94% vs. 94%, $p = 1.0$) (Fig. 2 and Table 2).

3.1.2. Reaction times

Trials in which participants failed to respond correctly were excluded from the analysis of response times (RTs). The mean RTs were calculated for each condition; responses more than 2 standard deviations from the individual mean were treated as outliers.

The multivariate analysis of variance revealed the significance of the main effect of Type of stimulus [$F_{(1,40)} = 56.6$; $p < .001$, $\eta^2 = .59$], being both groups faster with inanimate-objects than with body-effectors (1324 ms vs. 1836 ms) (Table 2). The other factors and their interactions were not significant.

Please cite this article in press as: Ferri, F., et al. Bodily self and schizophrenia: The loss of implicit self-body knowledge. *Consciousness and Cognition* (2012), http://dx.doi.org/10.1016/j.concog.2012.05.001

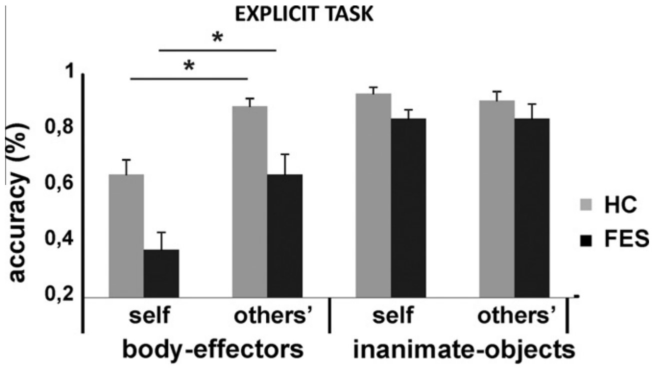

Fig. 3. Experiment 2. Mean percentages of correct responses (accuracy) for one's own (self) and other people's (others') body-effectors and inanimate-objects in the explicit task. Error bars depict the standard error of the mean. *Indicates $p < .05$.

3.2. Experiment 2: explicit task

3.2.1. Accuracy

As patients' accuracy scores were close to 50% (chance level) in some experimental conditions (see Table 2), we firstly assessed whether they performed above chance, or not, in this task. Two-tailed z tests for one proportion showed that FES' performance was significantly different from chance level in all experimental conditions ($z > 3.5$, $p < .001$, all conditions).

The multivariate analysis of variance revealed the significance of all the factors, that is, Group [$F_{(1,40)} = 22.8$; $p < .001$, $\eta^2 = .36$], being HC more accurate than FES (84% vs. 67%); Type of stimulus [$F_{(1,40)} = 64.1$; $p < .001$, $\eta^2 = .62$], because participants were more accurate with inanimate-objects than with body-effectors (88% vs. 63%); Owner [$F_{(1,40)} = 9.8$; $p < .005$, $\eta^2 = .20$], due to participants' higher accuracy for others' than self stimuli (82% vs. 69%). The interaction Group × Type of stimulus was also significant [$F_{(1,40)} = 8.8$; $p = .005$, $\eta^2 = .18$], since HC were more accurate than FES with body-effectors (76% vs. 50%, $p < .001$), but not with inanimate objects (92% vs. 84%, $p = .08$). Finally, the interaction Type of stimulus × Owner was also significant [$F_{(1,40)} = 17.7$; $p < .001$, $\eta^2 = .31$]. This effect was accounted for by participants' lesser accuracy with their own than with others' body-effectors (50% vs. 76%, $p < .001$), whereas they were similarly accurate with their own and others' inanimate-objects (89% vs. 88%, $p = .82$). This was true for both groups, since the three-ways interaction Group × Type of stimulus × Owner was not significant ($p = .98$) (Fig. 3 and Table 2).

3.2.2. Reaction times

Trials in which participants failed to respond correctly were excluded from the analysis of response times (RTs). The mean RTs were calculated for each condition; responses more than 2 standard deviations from the individual mean were treated as outliers.

The factor Type of stimulus [$F_{(1,40)} = 38.1$; $p < .001$, $\eta^2 = .49$] was significant, because both groups were faster with inanimate-objects than with body-effectors (1455 ms vs. 2386 ms). The factor Owner was also significant [$F_{(1,40)} = 4.0$; $p = .05$, $\eta^2 = .09$], being participants faster with others' stimuli than with their own stimuli (1808 ms vs. 2033 ms). Finally, the multivariate analysis of variance revealed the significance of the interaction Type of stimulus × Owner [$F_{(1,40)} = 5.2$; $p < .05$, $\eta^2 = .12$]. This effect was explained by participants' faster responses to others' than to their own body-effectors (2135 ms vs. 2637 ms, $p < .01$), whereas no difference was found between participants' responses to others' and to their own inanimate objects (1480 ms vs. 1429 ms, $p = .77$) (Table 2).

3.2.3. Errors

Independent samples t-test on percentages of self-misattribution errors showed that they were significantly ($t_{40} = -2.96$; $p = .005$) higher in FES (17%) than in HC (6%). Conversely, the same test on percentages of self-omission errors did not reveal any significant between-group difference [$t_{40} = -1.814$; $p = .08$; FES = 24% vs. HC = 16%]. When these data were used to calculate d' measures for self-detection in each group, the mean d' value was 2.37 (±.32) for HC and 0.70 (±.26) for FES. They were submitted to the independent samples t-test. Difference between HC and FES was significant ($t_{40} = 4.0$, $p < .001$), suggesting that HC had access to more discriminative information for self-recognition than FES.

4. Discussion

The main result of the present study is that FES patients, coherently with our working hypothesis, did not show the self-advantage effect in the implicit task (Experiment 1), whereas HC did. Thus, our results firstly show that FES patients suffer of a disturbed implicit sense of their bodily self. Furthermore, when explicitly required to recognize their own body-effectors (Experiment 2), both groups of participants did not show a self-advantage. FES patients, however, performed overall worse

Please cite this article in press as: Ferri, F., et al. Bodily self and schizophrenia: The loss of implicit self-body knowledge. *Consciousness and Cognition* (2012), http://dx.doi.org/10.1016/j.concog.2012.05.001

than HC with body-effectors and, when failing to explicitly recognize own body-effectors, showed also a higher percentage of self-misattribution errors with respect to control participants.

The implicit self-recognition task employed in the present study does not tap onto the concept of mineness of experience directly, rather it mostly pertains to the corporeality feature of ipseity, as explained in Introduction. It follows that our results do not lead to the conclusion that the mineness of experience is lost in FES patients, which would be implausible. Indeed, even in FES patients the mineness of experience is not completely lost (for discussion, see Cermolacce, Naudin, & Parnas, 2007), as patients still experience their delusion and hallucinations as being experienced by them, for example. Rather, as supported by the notion that implicit self-body knowledge and self-advantage are based on self-body experience (Ferri, Frassinetti, Ardizzi, Costantini, & Gallese, 2012; Ferri et al., 2011), our results suggest that FES patients' anomalous experience of their own body may lead to altered bodily-self representation and, as a consequence, to the loss of the implicit self-advantage. But, what is the core experience of ourselves as bodily selves making a coherent self representation possible? And, how the disruption of such bodily self experience may account for disorders of self in schizophrenia?

Philosophers, psychologists, psychopatologists and cognitive neuroscientists have attempted to distinguish among several kinds of self representation and self awareness. A variety of first- and third-person approaches have been used in order to define a core sense of self, by following the intuition that "even if all the unessential features of self are stripped away", "there is a basic, immediate or primitive 'something' that we are willing to call a self" (Gallagher, 2000, p. 15). This minimal sense of self has been referred to as consciousness of oneself as bodily subject of action (Legrand, 2006, 2007), speaking of sense of agency (the sense of being the one who generates an action) and/or sense of ownership (the sense of being the one who undergoes any experience, no matter if internally or externally generated). Furthermore, it has been recently proposed that there is a sense of body that is enactive in nature and that enables to capture the most primitive sense of self as bodily self (Gallese & Sinigaglia, 2010, 2011). According to this perspective, the body is primarily given to us as 'source' or 'power' for action, that is, as the variety of motor potentialities that define the horizon of how we can interact with the world we live in. Such primitive sense of self as bodily self is conceived of as being antecedent the distinction between sense of agency and sense of ownership.

Schizophrenia spectrum has been described as a psychiatric condition associated with disorders that affect the functioning of core self (Zahavi, 2005), also referred to as ipseity (Parnas, 2000; Sass & Parnas, 2003, 2007). The notion of 'self-disorder' in schizophrenia indicates that minimal self is fragile and unstable, being affected in its basic phenomenological aspects: Phenomenality (appearing), first-person perspective and self-presence (Cermolacce et al., 2007). In line with this account, self-disorder in schizophrenia has been elsewhere described as a disembodiment of the self (Fuchs, 2005; Stanghellini, 2009). In other words, "schizophrenic patient does not inhabit her body any more, in the sense of using as taken-for-granted its implicit structure [...] as a medium for relating to the world" (Fuchs, 2005). More generally, the phenomenological approach to schizophrenia proposes the notion of embodiment as central to understand different symptoms, such as loss of self, loss of common sense, and intentionality disorders. According to this approach, the coherence between such heterogeneous symptoms can be caught only if their common bodily roots are deemed (de Haan & Fuchs, 2010). Furthermore, the loss of the implicit functioning of the body in everyday life would lead also to the inability to interrelate with others (Fuchs, 2005; Stanghellini & Ballerini, 2011). In this sense, social dysfunctions in schizophrenic patients would primarily have their roots in disturbances of bodily self-experience (Gallese, 2003; Parnas, Bovet, & Zahavi, 2002; Sass & Parnas, 2003), rather than primarily concerning the intersubjective domain. All these suggestions from the phenomenological account are supported by our results showing that FES patients suffer from a disturbed implicit bodily self-knowledge, as revealed by the absence of the self-advantage effect in the implicit task (Experiment 1). In previous studies we tested the hypothesis that implicit and explicit bodily self knowledge tap into different sources of information (Ferri et al., 2011; Frassinetti et al., 2011). We showed that while the implicit distinction between one's own body parts from other people's body parts takes advantage from the recruitment of sensorimotor information, as confirmed by increased efficiency of the controlateral ventral premotor cortex activation while processing self right hands (Ferri et al., 2012); explicit self-other discrimination of the same body stimuli, on the other hand, likely recruit different cognitive and/or perceptually-based mechanisms (Ferri et al., 2011; Frassinetti et al., 2011). According to this evidence, we concluded that the awareness of oneself, as bodily self, essentially articulates from one's own sensorimotor experience. Such experience provides us with a pre-reflexive and pre-verbal knowledge of our potentialities for action, which would shape the sensorimotor representation of ourselves as bodily selves. Given such sensorimotor self-representation, it is possible that when we look at a picture of a body-effector, the more we implicitly associate it to our motor potentialities, the more we immediately recognize it as ours. This can be hypothesized to happen only for HC participants during Experiment 1 consisting of a visual task, for which we do not actually know the involvement of motor representations. Conversely, the more such pre-reflexive and pre-verbal knowledge is overshadowed by the recruitment of different cognitive and/or perceptually-based abilities required by the task, the less we implicitly associate the picture of the body-effector to our motor potentialities and the self-advantage does not emerge. This can be hypothesized to happen during Experiment 2, that is, even when participant's cognitive resource are required to focus on making a self/other discrimination. The conclusion would be that an implicit bodily self-knowledge, which is fed by sensorimotor activation, facilitates the self-advantage effect in HC, but not in FES patients. Another conclusion would be that the self-advantage effect does not rely on a reflective and explicit bodily self-knowledge, both in HC and in FES patients. However, this is not the whole story. Previous studies, indeed, found a self-advantage effect with explicit tasks in healthy people. These tasks, though, clearly involved a motor representation of the bodily self. For example, Van den Bos and Jeannerod (2002) showed that when participants are required to make a self-other discrimination between two movements simultaneously performed by themselves and by an experimenter, both presented on a monitor, 'bodily cues' are used only when 'action cues' are ambiguous. Moreover, they observed that when relying exclusively on 'action cues', explicit self-recognition is almost perfect. In the same vein, Daprati and colleagues (2007) proposed that, in the absence of morphological cues, kinematic templates largely suffice for explicit self-recognition. Tsakiris and others (2005) further demonstrated that afferent information is not sufficient for self-recognition of a moving hand. Indeed, by comparing passive- and active-movement conditions they observed that accuracy of the judgements is higher when participants make a voluntary action. All in all, empirical evidence (Daprati et al., 2007; Ferri et al., 2011, 2012; Tsakiris et al., 2005; van den Bos & Jeannerod, 2002) seems to suggest that, in healthy participants, referring to the sensorimotor representation of one's body, either implicitly or explicitly, facilitates self-recognition. Conversely, there is evidence supporting that this does not occur in schizophrenia (Daprati et al., 1997; de Vignemont et al., 2006).

Previous studies tested the abilities of schizophrenic patients to attribute an action to its proper agent (Daprati et al., 1997). Healthy participants and schizophrenic patients with and without hallucinations and/or delusional experiences were required to execute simple finger and wrist movements, without direct visual control of their hand. One of three possible images of a hand could be presented to the participant on a TV-screen in real time: their own hand, the experimenter's hand performing the same movement as participant's hand, the experimenter's hand performing a different movement. The task for participants was to explicitly discriminate whether the hand presented on the screen was their own or not. Only when presented with images of the experimenter's hand performing the same movement, hallucinating and deluded schizophrenic patients were more impaired in discriminating their own hand from the alien one than the non-hallucinating ones, and tended to misattribute the alien hand to themselves. Thus, despite the differences between Daprati and colleagues' (1997) and our study, mainly concerning the symptom severity in patients and the object of the required attribution judgment (body parts vs. action), in both cases it is observed that, when required to explicitly discriminate their own body parts from those of another, schizophrenic patients show a clear tendency to misattribute the alien body parts to themselves. This seems to occur regardless of the visual or motor nature of the task.

We add to previous knowledge, firstly, that such misattribution tendency is already present in first episode schizophrenia patients; secondly, that a more basic self-impairment (revealed by the lack of the self-advantage effect) is present also at the implicit level, likely before and below the misattribution tendency at the explicit level. Thus, we do not want to conclude that patients suffer of a disturbed implicit sense of their bodily self while their explicit bodily self knowledge is preserved. Indeed, given that patients performed overall worse in the explicit task than in the implicit task, this conclusion would be clearly wrong. What we are proposing here is that the implicit bodily self-awareness in schizophrenic patients is disturbed and such disturbance may importantly contribute to their previously established alterations of explicit bodily self knowledge. Coming back to the phenomenological perspective and to viewing schizophrenia as a disturbance of ipseity affecting various types of self-experience, this would mean also that disturbed corporeality may be no less important than disturbed sense of presence (or mineness).

Empirical evidence supporting the idea of a weaker or more flexible sense of bodily self in schizophrenia comes also from the literature on the rubber hand illusion (RHI; Peled, Ritsner, Hirschmann, Geva, & Modai, 2000). The Rubber Hand Illusion (RHI, Botvinick & Cohen, 1998) consists in watching a rubber hand being stroked together with one's own unseen hand. If the stroking of the rubber and real hands occurs synchronously, the position sense of the real hand shifts towards the location of the dummy hand. Participants report that they feel the dummy hand to be part of their body. A recent study (Thakkar, Nichols, McIntosh, & Park, 2011) demonstrated that patients with schizophrenia experience stronger RHI than healthy controls, indexed by self-report and mislocalization of their own hand. These data clearly suggest that body ownership is disturbed in schizophrenia. However, it is worth reminding here that, as recently argued (Gallese & Sinigaglia, 2010, 2011), different studies on RHI have shown that the multisensory integration leading to the experience of our body as our own, far from being the outcome of a mere visual–proprioceptive perceptual association is conditioned by the possibility- or not-to perform actions with a given body part (Tsakiris & Haggard, 2005; Tsakiris, Prabhu, & Haggard, 2006; Tsakiris, Schutz-Bosbach, & Gallagher, 2007). Thus, converging evidence suggests that the weaker sense of bodily self in schizophrenia can be related to an impaired possibility to live one's own body in terms of its motor potentialities.

The last point to be addressed is that no difference was found between patients and controls concerning inanimate objects, neither in the implicit nor in the explicit task. A simple explanation could be that in both tasks the object discrimination is easier than the body-effector discrimination, as indicated by analyses of accuracy. However, the fact that schizophrenic patients are more impaired in processing body-effectors than objects is not entirely new. For example, de Vignemont and colleagues (2006) showed that schizophrenic patients performing a laterality judgment task are less accurate than controls when mentally rotating body parts, but are as accurate as controls when mentally rotating inanimate objects, like letters.

Previous work has demonstrated that the rotation of body parts requires participants to simulate a motor rotation of their own body parts (Kosslyn, DiGirolamo, Thompson, & Alpert, 1998; Parsons, 1994; Wraga, Shephard, Church, Inati, & Kosslyn, 2005; Zacks, 2008), whereas the rotation of objects involves the manipulation of an object-relative frame of reference (Kosslyn et al., 1998; Wraga et al., 2005; Zacks, 2008). Thus, mental rotations of body parts emphasize the motor representation of the bodily self to a greater extent than mental rotations of objects. In a recent fMRI study we showed that indeed this is the case since mental rotation of participants' dominant hand correlates with activity in the contralateral ventral premotor cortex (Ferri et al., 2012). The lesser accuracy of schizophrenic patients than controls when judging the laterality of body parts, but not when judging the laterality of objects, may be related to deficits in the motor representation of their bodily self.

Evidence that schizophrenic patients are unable to generate accurate internal images of their own movements and have difficulty with maintaining an internal representation of intentional behavior (e.g., Danckert, Rossetti, d'Amato, Dalery, & Saoud, 2002; Maruff, Wilson, & Currie, 2003) would further support the above mentioned hypothesis of an impaired motor representation of their bodily self. In other words, schizophrenic patients would not experience themselves as a bodily structure that affords a given range of actions. According to this hypothesis, we could speculate that the lack of the self-advantage effect we observed in first episode schizophrenic patients is also due to a disruption of their implicit awareness of the bodily self as potentiality for action.

5. Conclusions

It has been argued that analyzing disorders of self-experience in schizophrenia may disregard the fact that the self is essentially shaped by intersubjectivity, which is antecedent to the self-other distinction (Stanghellini, 2001). While agreeing upon the impossibility of conceiving of a properly developed sense of self outside of the social domain, however, our results suggest that disturbances of the implicit bodily self-awareness leading to self-advantage in healthy people may have a crucial role in schizophrenia, prior than disturbances of the explicit bodily self knowledge. Accordingly, it has been recently demonstrated (Ebisch et al., 2012) that FES patients show reduced activation in ventral premotor cortex for observed bodily tactile stimulations, in addition to anomalous differential activation in posterior insula for first-person tactile experiences and observed affective tactile stimulations. These results show that social perception in FES patients is characterized by disturbances of self-experience at a pre-reflective level. Such disturbances include impaired multisensory representations and self-other distinction.

Acknowledgments

This work was supported by the EU Grant TESIS to VG.
The authors declare no conflicts of interests that could influence the results or their interpretation.

References

Amsterdam, B. (1972). Mirror self-image reactions before age two. *Developmental Psychobiology, 5*(4), 297–305.
Botvinick, M., & Cohen, J. (1998). Rubber hands 'feel' touch that eyes see. *Nature, 391*(6669), 756.
Cermolacce, M., Naudin, J., & Parnas, J. (2007). The "minimal self" in psychopathology: Re-examining the self-disorders in the schizophrenia spectrum. *Consciousness and Cognition, 16*(3), 703–714.
Danckert, J., Rossetti, Y., d'Amato, T., Dalery, J., & Saoud, M. (2002). Exploring imagined movements in patients with schizophrenia. *NeuroReport, 13*(5), 605–609.
Daprati, E., Franck, N., Georgieff, N., Proust, J., Pacherie, E., Dalery, J., et al (1997). Looking for the agent: An investigation into consciousness of action and self-consciousness in schizophrenic patients. *Cognition, 65*(1), 71–86.
Daprati, E., Wriessnegger, S., & Lacquaniti, F. (2007). Knowledge of one's kinematics improves perceptual discrimination. *Consciousness and Cognition, 16*(1), 178–188.
de Haan, S., & Fuchs, T. (2010). The ghost in the machine: Disembodiment in schizophrenia – Two case studies. *Psychopathology, 43*(5), 327–333.
de Vignemont, F., Zalla, T., Posada, A., Louvegnez, A., Koenig, O., Georgieff, N., et al (2006). Mental rotation in schizophrenia. *Consciousness and Cognition, 15*(2), 295–309.
Dondi, M., Simion, F., & Caltran, G. (1999). Can newborns discriminate between their own cry and the cry of another newborn infant? *Developmental Psychology, 35*(2), 418–426.
Ebisch, S. J., Salone, A., Ferri, F., De Berardis, D., Romani, G. L., Ferro, F. M., et al. (2012). Out of touch with reality? Social perception in first-episode schizophrenia. *Social Cognitive and Affective Neuroscienceand Social Neuroscience*.
Farrer, C., & Franck, N. (2009). Sens du corps dans la schizophrénie. *Encéphale, 35*(1), 43–51. English version: Farrer, C., & Franck, N. Sense of body in schizophrenia. In N. Boutros (Ed.), *Yearbook of international psychiatry and behavioral neurosciences*. Nova Publishers.
Ferri, F., Frassinetti, F., Ardizzi, M., Costantini, M., & Gallese, V. (2012). A sensorimotor network for the bodily self. *Journal of Cognitive Neuroscience*, 1–12.
Ferri, F., Frassinetti, F., Costantini, M., & Gallese, V. (2011). Motor simulation and the bodily self. *PLoS ONE, 6*(3), e17927.
First, M. B., Gibbon, M., & Spitzer, R. L. (1996). *Structured clinical interview for DSM-IV axis II personality disorders, (SCID-II, version 2.0)*. New York: Biometric Research Department, New York State Psychiatric Institute.
First, M. B., Spitzer, R. L., Williams, J. B. W., & Gibbon, M. (1996). *Structured clinical interview for DSM-IV axis I disorders-research version, (SCID-I, version 2.0)*. Biometric Research Department, New York State Psychiatric Institute.
Franck, Farrer, Georgieff, Marie-Cardine, & Daléry (2001). Defective recognition of one's own actions in patients with schizophrenia. *American Journal of Psychiatry, 158*, 454–459.
Frassinetti, F., Ferri, F., Maini, M., Benassi, M. G., & Gallese, V. (2011). Bodily self: An implicit knowledge of what is explicitly unknown. *Experimental Brain Research, 212*(1), 153–160.
Frassinetti, F., Maini, M., Benassi, M., Avanzi, S., Cantagallo, A., & Farne, A. (2010). Selective impairment of self body-parts processing in right brain-damaged patients. *Cortex, 46*(3), 322–328.
Frassinetti, F., Maini, M., Romualdi, S., Galante, E., & Avanzi, S. (2008). Is it mine? Hemispheric asymmetries in corporeal self-recognition. *Journal of Cognitive Neuroscience, 20*(8), 1507–1516.
Frassinetti, F., Pavani, F., Zamagni, E., Fusaroli, G., Vescovi, M., Benassi, M., et al (2009). Visual processing of moving and static self body-parts. *Neuropsychologia, 47*(8–9), 1988–1993.
Fuchs, T. (2005). Corporealized and disembodied minds: A phenomenological view of the body in melancholia and schizophrenia. *Philosophy, Psychiatry and Psychology, 12*, 95–107.
Fuchs, T., & Schlimme, J. E. (2009). Embodiment and psychopathology: A phenomenological perspective. *Current Opinion in Psychiatry, 22*(6), 570–575.
Gallagher, I. I. (2000). Philosophical conceptions of the self: Implications for cognitive science. *Trends in Cognitive Sciences, 4*(1), 14–21.
Gallese, V. (2003). The roots of empathy: The shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology, 36*(4), 171–180.
Gallese, V., & Sinigaglia, C. (2010). The bodily self as power for action. *Neuropsychologia, 48*(3), 746–755.
Gallese, V., & Sinigaglia, C. (2011). How the body in action shapes the self. *Journal of Consciousness Studies, 18*(7–8), 117–143.
Kay, S. R., Fiszbein, A., & Opler, L. A. (1987). The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophrenia Bulletin, 13*(2), 261–276.

Kosslyn, S. M., DiGirolamo, G. J., Thompson, W. L., & Alpert, N. M. (1998). Mental rotation of objects versus hands: Neural mechanisms revealed by positron emission tomography. *Psychophysiology, 35*(2), 151–161.

Legrand, D. (2006). The bodily self: The sensori-motor roots of pre-reflective self-consciousness. *Phenomenology and the Cognitive Sciences, 5*, 89–118.

Legrand, D. (2007). Pre-reflective self-as-subject from experiential and empirical perspectives. *Consciousness and Cognition, 16*(3), 583–599.

Maruff, P., Wilson, P., & Currie, J. (2003). Abnormalities of motor imagery associated with somatic passivity phenomena in schizophrenia. *Schizophrenia Research, 60*(2–3), 229–238.

Nelson, B., Fornito, A., Harrison, B. J., Yucel, M., Sass, L. A., Yung, A. R., et al (2009a). A disturbed sense of self in the psychosis prodrome: Linking phenomenology and neurobiology. *Neuroscience and Biobehavioral Reviews, 33*(6), 807–817.

Nelson, B., Sass, L. A., Thompson, A., Yung, A. R., Francey, S. M., Amminger, G. P., et al (2009b). Does disturbance of self underlie social cognition deficits in schizophrenia and other psychotic disorders? *Early Intervention in Psychiatry, 3*(2), 83–93.

Nelson, B., Yung, A. R., Bechdolf, A., & McGorry, P. D. (2008). The phenomenological critique and self-disturbance: Implications for ultra-high risk ("prodrome") research. *Schizophrenia Bulletin, 34*(2), 381–392.

Parnas, J. (2005). Clinical detection of schizophrenia-prone individuals: Critical appraisal. *British Journal of Psychiatry. Supplement, 48*, s111–112.

Parnas, J., Bovet, P., & Zahavi, D. (2002). Schizophrenic autism: Clinical phenomenology and pathogenetic implications. *World Psychiatry, 1*(3), 131–136.

Parnas, J., & Handest, P. (2003). Phenomenology of anomalous self-experience in early schizophrenia. *Comprehensive Psychiatry, 44*(2), 121–134.

Parnas, J., Jansson, L., & Sass, L. (1998). Self-experience in the prodromal phases of schizophrenia. *Neurology Psychiatry and Brain Research, 6*, 97–106.

Parnas, J., & Sass, L. A. (2001). Self, solipsism, and schizophrenic delusions. *Philosophy, Psychiatry, and Psychology, 8*(2–3), 101–120.

Parnas, J. (2000). The self and intentionality in the pre-psychotic stages of schizophrenia: A phenomenological study. In D. Zahavi (Ed.), *Exploring the self: Philosophical and psychopatological perspectives on self-experience* (pp. 115–148). Amsterdam: John Benjamins.

Parsons, L. M. (1994). Temporal and kinematic properties of motor behavior reflected in mentally simulated action. *Journal of Experimental Psychology: Human Perception and Performance, 20*(4), 709–730.

Peled, A., Ritsner, M., Hirschmann, S., Geva, A. B., & Modai, I. (2000). Touch feel illusion in schizophrenic patients. *Biological Psychiatry, 48*(11), 1105–1108.

Rochat, P. (2003). Five levels of self-awareness as they unfold early in life. *Consciousness and Cognition, 12*(4), 717–731.

Rochat, P. (2010). The innate sense of the body develops to become a public affair by 2–3 years. *Neuropsychologia, 48*(3), 738–745.

Rochat, P., & Striano, T. (2002). Who's in the mirror? Self-other discrimination in specular images by four- and nine-month-old infants. *Child Development, 73*(1), 35–46.

Sass, L. A., & Parnas, J. (2003). Schizophrenia, consciousness, and the self. *Schizophrenia Bulletin, 29*(3), 427–444.

Sass, L., & Parnas, J. (2007). Explaining schizophrenia: The relevance of phenomenology. In M. C. Chung, K. W. M. Fulford, & G. Graham (Eds.), *Reconceiving schizophrenia* (pp. 63–95). Oxford, UK: Oxford University Press.

Stanghellini, G. (2001). Psychopathology of common sense. *Philosophy, Psychiatry and Psychology, 8*, 201–218.

Stanghellini, G. (2009). Embodiment and schizophrenia. *World Psychiatry, 8*(1), 56–59.

Stanghellini, G., & Ballerini, M. (2011). What is it like to be a person with schizophrenia in the social world? A first-person perspective study on Schizophrenic dissociality – Part 1: State of the art. *Psychopathology, 44*(3), 172–182.

Stanghellini, G., Ballerini, M., Fusar Poli, P., & Cutting, J. (2012). Abnormal bodily experiences may be a marker of early schizophrenia? *Current Pharmaceutical Design, 18*(4), 392–398.

Synofzik, M., Thier, P., Leube, D. T., Schlotterbeck, P., & Lindner, A. (2010). Misattributions of agency in schizophrenia are based on imprecise predictions about the sensory consequences of one's actions. *Brain, 133*(Pt 1), 262–271.

Thakkar, K. N., Nichols, H. S., McIntosh, L. G., & Park, S. (2011). Disturbances in body ownership in schizophrenia: Evidence from the rubber hand illusion and case study of a spontaneous out-of-body experience. *PLoS ONE, 6*(10), e27089.

Tsakiris, M., & Haggard, P. (2005). Experimenting with the acting self. *Cognitive Neuropsychology, 22*(3), 387–407.

Tsakiris, M., Haggard, P., Franck, N., Mainy, N., & Sirigu, A. (2005). A specific role for efferent information in self-recognition. *Cognition, 96*(3), 215–231.

Tsakiris, M., Prabhu, G., & Haggard, P. (2006). Having a body versus moving your body: How agency structures body-ownership. *Consciousness and Cognition, 15*(2), 423–432.

Tsakiris, M., Schutz-Bosbach, S., & Gallagher, S. (2007). On agency and body-ownership: Phenomenological and neurocognitive reflections. *Consciousness and Cognition, 16*(3), 645–660.

van den Bos, E., & Jeannerod, M. (2002). Sense of body and sense of action both contribute to self-recognition. *Cognition, 85*(2), 177–187.

Wechsler, D. (1997). *WAIS-R. Scala d'intelligenza Wechsler per adulti-riveduta* (O.S., Trans.). Firenze: Organizzazioni speciali.

Wilquin, H., & Delevoye-Turrell, Y. (2012). Motor agency: A new and highly sensitive measure to reveal agency disturbances in early psychosis. *PLoS ONE, 7*(2), e30449.

Wraga, M., Shephard, J. M., Church, J. A., Inati, S., & Kosslyn, S. M. (2005). Imagined rotations of self versus objects: An fMRI study. *Neuropsychologia, 43*(9), 1351–1361.

Zacks, J. M. (2008). Neuroimaging studies of mental rotation: A meta-analysis and review. *Journal of Cognitive Neuroscience, 20*(1), 1–19.

Zahavi, D. (2005). Being someone. *Psyche, 11*(5), 1–20.

Please cite this article in press as: Ferri, F., et al. Bodily self and schizophrenia: The loss of implicit self-body knowledge. *Consciousness and Cognition* (2012), http://dx.doi.org/10.1016/j.concog.2012.05.001