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The sense of body ownership in schizophrenia: research in the rubber hand illusion paradigm

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Summary

Aim. The aim of the research was to explore the susceptibility to disturbances in one's sense of body ownership induced in patients with schizophrenia. The research questions were: 1) Is Rubber Hand Illusion (RHI) significantly more intense in a group of patients with schizophrenia than in a group of patients without a diagnosed mental illness? 2) Is there a correlation between disturbances in the sense of body ownership and the personality organization level, reflected in defense mechanisms? 3) Do the disturbances in the sense of body ownership correlate with the most common defense mechanisms?

Methods. 64 people took part in the study, including 31 patients with diagnosed schizophrenia, according to ICD-10 (93.5% – paranoid type and 6.5% – disorganized type) and 33 people without mental illness diagnosis. The study was conducted in the RHI paradigm. Research tools used: Botvinick and Cohen's RHI Questionnaire and Bond's Defense Style Questionnaire.

Results. There were significant differences between the control group and the schizophrenic group: 1) in the intensity of RHI ($F(1, 62) = 121.86$; $p < 0.001$), as well as 2) on the neurotic ($F(1, 62) = 28.21$; $p < 0.001$) and immature ($F(1, 62) = 36.71$; $p < 0.001$) mechanisms' level. Patients witch schizophrenia activated immature mechanisms most intensively while in the control group the dominant mechanisms were from the mature and neurotic groups.

Conclusions. Patients with schizophrenia experience disruptions in the sense of body ownership much more intensively compared to the control group. The intensity of RHI is related to the personality organization level and to the most common activation of mechanisms from immature group, especially schizoid fantasy and projection.

Key words: schizophrenia, rubber hand illusion, defense mechanisms

The study was not sponsored.

We use part of the mind as a screen (...). One of things the screen hides most effectively is the body, our own body.

Antonio Damasio [1]

Introduction

The intensification of the studies on the sense of body ownership was initiated by a spectacular experiment by Botvinick and Cohen [2], based on which the possibility of inducing an illusion of an external object incorporation – in this case an illusion of having a rubber hand instead of one's own (Rubber Hand Illusion – RHI) – was demonstrated. It was enough to, with the help of a little brush, synchronously stimulate an artificial hand placed in front of the subject and his/her own hand remaining out of sight, for the rubber hand to be perceived as one's own after several minutes. The illusion turned out to be so intense that an attempt to hit the rubber hand with a hammer or to sting it with a needle enhanced a very strong emotional reaction, which was expressed vocally through screaming and in an increased galvanic skin response [3]. The fMRI showed activity in the insula and anterior cingulate cortex areas. Changes were also noted in interoceptive sensations related to fear and danger, which suggests that the rubber hand was included in the body representation not only structurally, but also affectively [4]. Moreover, a disturbance in temperature regulation occurred in one's own, real hand, mentally separated from the body, which may mean a slowdown in speed of processing the somatosensory information in that limb [5].

The results of Botvinick and Cohen's experiment called into question the hitherto prevailing beliefs concerning the sources of body awareness. The domination of proprioception over other sensual experiences, in particular visual, in shaping of the sense of body ownership, ceased to be an obvious fact, especially that the participants of RHI experiment clearly located the feeling of touch in the rubber hand, and not in the biological hand. Moreover, the analysis of neurological and psychiatric disorders (e.g., alien limb syndrome, depersonalisation symptoms in psychotic disorders, anorexia nervosa, or relatively recently identified BIID – Body Integrity Identity Disorder) put into question the simple mechanism of proprioceptive experiencing one's own body as a basis for the sense of body ownership [6, 7].

Two different positions were taken when explaining the phenomenon of artificial disturbances in the sense of arm ownership. The first one, represented by Botvinick and Cohen [2], and later strongly supported by Armel and Ramachandran [8], was characterized by a definite rejection of the unimodal basis of the sense of body ownership. It was assumed that only multisensory integration, i.e. connection of at least three sources of information: visual, tactile and proprioceptive can provide the subject with the capacity to correctly identify one's own body. The mind, on the other hand, creates an illusion through an uncommon usage of accessible visual and tactile information, while the former is perceived as more reliable.

The representatives of the second, opposite approach to the understanding of RHI creation mechanism, among others Tsakiris and Haggard [8], underline the importance of top-down processes, i.e. the significant influence of body-related representations (body image or body scheme) in the appearance of the illusion of rubber hand properties. The scientists conducted a series of experiments, where through manipulating the properties of the artificial limb as well as the time and space conditions, they proved that a simple connection of sensory information is not a sufficient condition for illusion creation. It turned out that 1) replacing the duplicate of a biological limb with a small flat board or a stick, or 2) changing the spatial position of the rubber hand (shifting it by 90 degrees from its natural position), as well as 3) asynchronous tactile stimulation significantly weaken or even completely suppress the illusion of having a rubber hand [8, 9]. The results of the conducted experiments provided strong arguments to support the thesis about the key role of top-down perception processes, in which the structural-spatial body representation has probably key meaning in elaborating multimodal stimuli, rendering the subject resistant to false experience of owning a body.

Disorders in the sense of body ownership are revealed particularly clearly in case of patients with schizophrenia. In this group, the susceptibility to RHI is significantly higher than in the control group, which means that the illusion is created much faster (sometimes even before the beginning of tactile stimulation), and the proprioceptive drift takes a higher value [10, 11]. Taking into account the fact that one of the important symptoms of schizophrenia is disturbed perception of authorship, i.e. placing the source of action beyond oneself, in the external surroundings (delusions of control are its most spectacular representation), as well as the feeling of limited control over one's own body, it can be assumed with a big dose of probability that patients with schizophrenia have a disturbed body representation system [12]. Those disorders concern above all the body scheme, its kinetic dimension (e.g., sense of limited ability to act) and kinesthetic dimension (hallucinations regarding one's body appearance: feeling of change in proportions, size and weight of the body, sense of fragmentation or of losing body boundaries). An unstable and disorganized body scheme in patients with schizophrenia weakens the resistance to a mistake of wrong body identification, contributing to its very peculiar experiencing – fragmented, foreign, sort of lost [13, 14]. Ultimately, the weakened and disturbed sense of body reflects on the weakened sense of bodily self, as well as more broadly, sense of the Self [11, 15].

Due to the complete lack of information in the Polish literature about the research conducted in the paradigm of RHI, the first attempts to fill this blank were undertaken.

Aim

The main purpose of the presented research was to explore the phenomenon of susceptibility to disturbances in one's sense of body ownership (to be exact – the left hand), experimentally induced in patients suffering from schizophrenia. The answer to the following research questions was searched for:

1) Is RHI significantly more intense in a group of patients with schizophrenia than in a group of people without a diagnosed mental illness?

2) Is there an important correlation between the disturbances in the sense of body ownership and the personality organization level, reflected in a scope of most commonly activated defense mechanisms (out of the groups of mature, neurotic or immature mechanisms)?
3) Do the disturbances in the sense of body ownership correlate with the most common activation of specific defense mechanisms from within the group of immature mechanisms, such as somatisation or dissociation?

Material

64 subjects divided in two groups took part in the study. There were 31 patients suffering from schizophrenia in the first group (14 women and 17 men), aged between 19 and 40 (M = 28.42; SD = 5.90), while in the second, control group, there were 33 individuals (23 women and 10 men) without mental illness diagnosis, aged from 19 to 30 (M = 24.67; SD = 2.63). Within the schizophrenic group, 29 patients (93.5%) were diagnosed with paranoid schizophrenia, and the remaining 2 patients (6.5%) with disorganized schizophrenia, according to ICD-10. Around 32.3% of patients fell ill before reaching 18 years of age, as opposed to the remaining 67.7%, who became ill after the age of 18. The average duration of illness was ca. 7.58 years (SD = 5.06) and was not shorter than two years in any of the cases. The number of hospitalization events varied from none to five (M = 1.90; SD = 1.16) – 12 patients experienced a stay on a psychiatric ward once and two patients had never been hospitalized. Nonetheless, all patients suffering from schizophrenia were treated pharmacologically, as well as – except one patient (3.2%) – had undergone or were in the process of undergoing psychotherapy, either individual (29%) or in a group (67.8%).

Both groups were rather homogeneous in respect of such demographic data as place of living. In the control group, only three persons (9.1%), and in the schizophrenia group six persons (19.4%) came from villages, while all the others were from cities. Civil status in both groups was also comparable; most of subjects were single: 90.9% in the control group and 93.5% in the schizophrenia group. The other individuals were married. There were differences in education level. The majority of patients suffering from schizophrenia (74.2%) had reached secondary or vocational education level, while only 8 people (25.8%) had higher education degrees. On the other hand, 20 people (60.6%) from the group without a diagnosed mental illness had a higher education degree, while the remaining 13 (39.4%) reached secondary education level.

All study subjects gave their informed consent for participation in the study.

Method

The following tools were used in the study:

1) Bond's Defense Style Questionnaire (DSQ) (1993). This tool serves to evaluate defensive preferences that reflect in one's system of attitudes and beliefs. By referring to Vaillant's concept, the authors of DSQ adopted an approach that defense mecha-

nisms, employed to reduce danger, vary in terms of maturity level. This maturity is described through the level, in which the image of reality was distorted. They created a three-level defense mechanisms hierarchy – from the least to the most mature [16]. The subjects completed DSQ before participating in RHI procedure.

2) Rubber Hand Illusion procedure and Botvinick and Cohen's RHI Questionnaire (1998). The research was conducted within the rubber hand illusion paradigm. Each subject – both from control and schizophrenic group – underwent an RHI procedure. A subject sat at a table with a rubber hand lying on it, while his/her real left hand was placed behind a screen so that it remained beyond the individual's eyesight. Then, the experimenter began a 10-minute long simultaneous tactile stimulation of both rubber and real left hand with a little brush. The subject's task was to constantly observe the touched rubber hand during the experiment. After the stimulation was terminated, the subject filled in the RHI Questionnaire that was to estimate the strength of illusion the individual underwent during the experiment [2]. The proprioceptive drift's was not examined.

Results

In order to find the answer to the first research question regarding significant differences in RHI intensity between the control group (subjects without a diagnosed mental illness) and the group of patients with schizophrenia, a univariate analysis of variance (ANOVA) was performed. As a result of those analyses, a statistically significant effect of RHI variable was obtained, $F(1, 62) = 121.86$; $p < 0.001$. This means that patients suffering from schizophrenia, compared to subjects from the control group, experienced disturbances in the sense of body ownership in a much more intense manner. A detailed analysis of the results shows that the biggest significant differences between groups concern mainly four experiences: 1) sense of ownership of a rubber hand (Q3); 2) sense of increased number of limbs (Q5); 3) sense of transformation of one's own hand into a rubber one (Q7); and 4) sense of one's own hand becoming similar in appearance to the rubber hand (Q9), (see Table 1).

Table 1. **Mean and standard deviation rating for each item in the self-report RHI Questionnaire for each group: control and schizophrenic**

Self-Report RHI Questionnaire	Control group N = 33		schizophrenic group N = 31		Significance of differences	
	M	SD	M	SD	F(1, 62)	p
Q1. It seemed **as if I were feeling the touch of the paintbrush where I saw the rubber hand.**	6.73	0.45	6.97	0.18	7.63	0.01
Q2. It seemed **as though the touch I felt was caused by the paintbrush touching the rubber hand.**	6.00	0.90	6.45	1.15	3.08	0.08
Q3. I felt **as if the rubber hand was my hand.**	5.48	1.28	6.61	0.56	20.47	0.001

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Q4. I felt **as if my real hand were drifting towards the rubber hand.**	2.85	1.35	3.58	1.96	3.06	0.08
Q5. It seemed **as if I had more than one of the hand that was being brushed.**	1.62	1.01	4.61	1.76	68.68	0.001
Q6. It seemed **as if the touch I was feeling came from somewhere between my own hand and the rubber hand.**	2.79	1.27	3.74	1.63	6.86	0.01
Q7. It felt **as if my real hand was turning "rubbery".**	2.57	1.78	5.48	1.12	59.95	0.001
Q8. It appeared **visually as if the rubber hand was drifting towards my hand.**	2.91	1.33	3.84	1.65	6.16	0.05
Q9. The rubber **hand began to resemble my own hand in terms of shape, skin tone, freckles, or some other visual feature.**	4.51	1.72	6.58	0.76	37.82	0.001

The results of the variance analysis demonstrated in Table 2 show that there are significant differences in the level of neurotic mechanisms ($F(1, 62) = 28.21$; $p < 0.001$) and immature mechanisms ($F(1, 62) = 36.71$; $p < 0.001$) between the two groups. On the other hand, there are no significant differences between groups in the scope of mature mechanisms. In the schizophrenic group the mechanisms from immature group were most intensively activated, especially the following two: schizoid fantasies (M = 15.58; SD=2.99) and projection (M = 15.00; SD = 2.71). In the control group, the main defense mechanisms were the ones from the mature group, above all humor (M = 12.79; SD = 2.81), and from immature group – rationalization (M = 12.06; SD = 2.38). In some other classifications (e.g., Meissner's classification), rationalization mechanism is placed in the neurotic mechanisms group [17].

Table 2. **Comparison of the results from DSQ: differences between the two study groups measured by ANOVA variance analysis**

Defense mechanisms	Control group N = 33		Schizophrenic group N = 31		Significance of differences	
	M	SD	M	SD	F(1; 62)	p
MATURE	40.79	7.20	37.39	11.39	2.06	n.s.
Anticipation	9.54	2.84	11.00	3.66	3.18	n.s.
Humor	12.79	2.81	8.55	3.29	30.75	0.001
Suppression	10.24	4.00	7.97	3.48	5.86	0.05
Sublimation	8.21	3.41	9.87	4.77	2.59	n.s.
NEUROTIC	30.27	7.83	43.81	12.20	28.21	0.001
Pseudo-altruism	8.61	2.68	12.39	4.01	19.86	0.001
Idealization	6.94	2.96	9.42	3.59	9.13	0.01
Reaction formation	8.39	3.22	11.45	4.02	11.33	0.001

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Undoing	6.33	3.07	10.55	4.24	20.94	0.001
IMMATURE	92.64	21.15	122.35	17.83	36.71	0.001
Acting out	10.45	4.20	8.32	5.00	3.43	n.s.
Denial	6.51	3.49	7.39	2.75	1.22	n.s.
Devaluation	7.33	2.86	9.77	2.69	12.33	0.01
Displacement	5.56	3.00	9.22	3.41	20.71	0.001
Dissociation	7.54	3.39	5.00	2.43	11.76	0.001
Schizoid fantasy	7.42	4.05	15.58	2.99	82.87	0.001
Isolation	7.36	4.43	11.68	2.95	20.71	0.001
Passive aggression	7.03	3.15	9.29	3.31	7.84	0.01
Projection	5.03	3.19	15.00	2.71	180.75	0.001
Rationalization	12.06	2.38	9.93	2.77	10.87	0.01
Somatization	8.15	3.82	10.29	4.19	4.56	0.05
Splitting	8.15	3.82	10.87	3.14	9.62	0.01

n.s. – non-significant differences

In order to determine the strength of the relationship between RHI intensity and defense mechanisms, Pearson's correlation coefficient was calculated (see Table 3). The correlations turned out to be moderate or strong between the majority of RHI Questionnaire positions (except Q1, Q2 and Q4) and 9 out of 40 defense mechanisms. Other correlations were very weak; hence, they were omitted in Table 3. A particularly strong, positive correlation exists between RHI Questionnaire results and two immature defense mechanisms: 1) schizoid fantasies ($r = 0.64$; $p < 0.001$); and 2) projection ($r = 0.70$; $p < 0.001$).

Table 3. **Pearson's correlation coefficients for relationships between defense mechanisms variables and RHI variables**

RHI Questionnaire	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Humor	-	-	-	-	-0.42**	-	-0.33**	-	-0.35**	-0.43**
Pseudo-altruism	-	-	-	-	0.36**	0.32**	0.47**	-	0.31*	0.43**
Reaction formation	-	-	-	-	0.35**	-	0.39**	-	-	0.43**
Undoing	-	-	-	-	0.37**	-	0.40**	-	0.33**	0.44**
Displacement	-	-	-	-	-	-	0.37**	-	-	0.34**
Dissociation	-	-	-	-	-0.37**	-0.34**	-	-	-	-0.40**
Schizoid fantasy	-	-	0.31*	-	0.62**	0.35**	0.58**	0.32**	0.31*	0.64**
Isolation	-	-	-	-	0.35**	-	-	-	0.31*	0.40**
Projection	-	-	0.43**	-	0.65**	0.40**	0.59**	0.36**	0.42**	0.70**

*$p < 0.05$; **$p < 0.01$

Analysis of the results

The obtained results of the study conducted in the RHI paradigm show that patients with schizophrenia experience disruptions in the sense of body ownership much more intensively in comparison with the control group ($F(1, 62) = 121.86$; $p < 0.001$). The rubber hand illusion occurred in both groups; however, the experimentally induced disruption in the sense of body ownership was much broader and more intensive in the schizophrenic group. Moreover, it reflected not only in tactile illusion (equally strong in both groups), but above all in a significant change in the manner of experiencing one's own body, among others in the sense of ownership of a rubber hand, sense of increased number of limbs or in the sense of transformation of one's own hand into a rubber one. The obtained results confirmed former studies, also conducted in the RHI paradigm [18–20].

Differences in RHI intensity are in a clear and significant way related to the subjects' level of personality organization expressed in the group of most often activated defense mechanisms. The dominant mechanisms in patients with schizophrenia were the immature ones, while in the control group – mature and neurotic ones. A particularly strong correlation occurs between RHI and two defense mechanisms – schizoid fantasies ($r = 0.64$; $p < 0.001$) and projection ($r = 0.70$; $p < 0.001$). This means that the increase in intensity of those mechanisms is accompanied by an increase of susceptibility to the rubber hand illusion, i.e. increase in disruption in the area of experiencing ownership of one's own body. It is probable that in a situation of endangered coherency of one's own Self, inclusive of the bodily Self, patients with schizophrenia employ schizoid fantasies and projection much more often than other mechanisms. The increase in intensity of those both defense mechanisms from immature group suggests the intensification of desadaptive behaviors that entail distortion of the image of the Self, of the image of one's own body, and of the images of other people, as well as keeping an increasingly large scope of psychological content (in particular the emotional one) beyond one's consciousness (cf. Defense Mechanisms Classification according to DSM-IV) [21]. Employing the mechanism of projection when faced with fear suggests schizophrenic patients' little capacity to differentiate between internal experiences and the ones coming from beyond the Self. On the other hand, employing schizoid fantasies relates to a tendency to withdraw into one's internal world in order to try to defend one's strongly weakened perception of authorship, self-esteem, and above all – sense of the Self. The impossible in real world is "achieved" in the imagined, unreal world. Former studies on the relationship between the bodily self and personality defensive capability in women with bulimia nervosa have shown that along with the increase in disturbances of the bodily self, above all there exists also an intensification of frequency of employing schizoid fantasies defense mechanism [22]. Probably the level of disorders within the field of experiencing one's own body, regardless of the nosological position, is linked to the intense activation of immature defenses, mainly schizoid fantasies and projection.

Conclusions

1) Patients with schizophrenia experience disruptions in the sense of body ownership much more intensively in comparison with people without a diagnosed mental illness.
2) The differences in intensity of RHI are closely related to the personality organization level of the subjects, having its reflection in the group of most commonly employed defense mechanisms. Patients with schizophrenia activate most intensively the mechanisms from immature group, while the dominant defense mechanisms in people without a diagnosed mental illness are the ones from mature and neurotic groups.
3) The intensity of disturbances in one's sense of body ownership (measured with RHI) remains in close relationship with two defense mechanisms from immature group: schizoid fantasies and projection.

References

1. Damasio A. *Tajemnica świadomości*. Poznan: Rebis Publishing House; 2000.
2. Botvinick M, Cohen, J. *Rubber hands "feel" touch that eyes see*. Nature 1998; 391: 756.
3. Braithwaite JJ, Broglia E. *Autonomic emotional responses to the induction of the rubber-hand illusion in those that report anomalous bodily experiences: evidence for specific psychophysiological components associated with illusory body representations.* J. Exp. Psychol. Hum. Percept. Perform. 2014; 40(3): 1131–1145.
4. Ehrsson HH, Wiech K, Weiskopf N, Dolan RJ, Passingham RE. *Threatening a rubber hand that you feel is yours elicits a cortical anxiety response.* Proc. Nat. Acad. Sci. U.S.A. 2007; 104(23): 9828–9833.
5. Moseley GL, Olthof M, Venema A, Don S, Wijers M, Gallace A. et al. *Psychologically induced cooling of specific body part caused by the illusory ownership of an artificial counterpart.* Proc. Nat. Acad. Sci. U.S.A. 2008; 105(35): 13169–13173.
6. Muller S. *Body Integrity Identity Disorder (BIID) – Is the amputation of healthy limbs ethically justified?* Am. J. Bioeth. 2009; 9(1): 36–43.
7. De Vignemont F. *A self for the body.* Metaphilosophy 2011; 42(3): 230–247.
8. Tsakiris M, Haggard P. *The rubber hand illusion revisited: Visuotactile integration and selfattribution.* J. Exp. Psychol. Hum. Percept. Perform. 2005; 31(1): 80–91.
9. Tsakiris M, Carpenter L, James D, Fotopoulou A. *Hands only illusion: Multisensory integration elicits sense of ownership for body parts but not for non-corporeal objects.* Exp. Brain Res. 2010; 204: 343–352.
10. Peled A, Pressman A, Geva AB, Modai I. *Somatosensory evoked potentials during a rubberhand illusion in schizophrenia.* Schizophr. Res. 2003; 64(2–3): 157–163.
11. Thakkar KN, Nichols HS, McIntosh LG, Park S. *Disturbances in body ownership in schizophrenia: Evidence from rubber hand illusion and case study of a spontaneous out-of-body experience.* PLoS One 2011; 6(10): e27089.
12. Mirucka B, Sakson-Obada O. *Ja cielesne – od normy do zaburzeń*. Sopot: Gdansk Psychology Publisher; 2012.
13. Kępiński A. *Schizofrenia*. Krakow: Literary Press; 2009.

14. Laing RD. *Podzielone „Ja". Egzystencjalistyczne studium zdrowia i choroby psychicznej.* Poznan: Rebis Publishing House; 1995.
15. Sass LA, Parnas J. *Schizophrenia, consciousness, and the self.* Schizophr. Bull. 2003; 29(3): 427–444.
16. Andrews G, Singh M, Bond M. *The Defense Style Questionnaire*. J. Nerv. Ment. Dis. 1993; 181: 246–256.
17. Kokoszka A. *Integrujący model stanów psychicznych.* Krakow: Jagiellonian University Medical College; 1997.
18. Peled A, Pitsner M, Hirchmann S, Geva AB, Modai I. *Touch feel illusion in schizophrenia patients.* Biol. Psychiatry 2000; 49(1999): 1105–1108.
19. Peled A, Pressman A, Geva AB, Modai I. *Somatosensory evoked potentials during a rubber-hand illusion in schizophrenia.* Schizophrenia Bulletin 2003; 64(2-3): 157–163.
20. Thakkar KN, Nichols HS, McIntosh LG, Park S. *Disturbances in body ownership in schizophrenia: evidence from the Rubber hand Illusion and case study of a spontaneous out-of-body experience.* PLoS One 2011; 6(10): e27089.
21. *Diagnostic and statistical manual of mental disorders, Fourth edition.* Washington, DC: American Psychiatric Association; 1994.
22. Mirucka B. *Exploring the relationship between the body self and personality defence mechanisms in women with bulimia nervosa.* Pol. Psychol. Bull. 2013; 44(1): 118–126.

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