

Sensory thresholds and the sense of bodily identity in schizophrenia

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Abstract

Aim of the study: The aim of the study was to investigate: 1) whether schizophrenia is associated with disturbances in bodily identity (BI) and in sensation thresholds (STs) assessed by a questionnaire and experimental methods (pain and proprioception thresholds); 2) whether disturbances in STs are related to BI in the schizophrenia group.

Materials and methods: Fifty-four outpatients with schizophrenia in remission and 54 controls completed: Bodily Identity Scale, Heightened Thresholds Scale, and Lowered Thresholds Scale. Their pain and proprioception thresholds were estimated using the TempTest Apparatus and the Discrimination Weights Test, respectively.

Results: Compared to the control group, patients with schizophrenia: reported more disturbances in BI and in the STs examined by questionnaire, displayed increased proprioception, but a lower pain threshold. In the schizophrenia group disturbances in BI were only associated with distortions in STs examined by questionnaires.

Discussion: Disturbances in stimulus processing in the experimental setting did not explain disruptions in BI in schizophrenia, which may be due to the study's methodology and the weak (pain threshold) or moderate (proprioception threshold) manifestation of STs disturbances in the experimental setting in the clinical group.

Conclusions: In schizophrenia remission no coherent pattern of sensitivity to experimental stimuli is observed. The increased sensitivity to experimental pain in patients in remission is consistent with the results of previous studies, and undermines the popular thesis of pain indifference in schizophrenia. Patients with schizophrenia struggle throughout their lives with disturbances of bodily identity and states of both over – and under-sensitivity to environmental stimuli.

schizophrenia; sense of self; sense of bodily identity; pain; proprioception

INTRODUCTION

Schizophrenia is associated with severe disruptions in the sense of self and abnormalities in sensory processing across all modalities, including olfactory, visual, auditory, pain, tactile

and proprioceptive stimuli [1]. Psychological evidence suggests that the perception of stimuli from within the body is a key component of internal states, such as bodily needs or emotions, and the integration of sensations from interoceptors and exteroceptors forms the basis of body representations, such as body schema, body image or body boundary [1-4]. Both the perception of stimuli and their integration into representations are prerequisites for the formation of a core

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sense of self [1-6]. Therefore, it has been hypothesised that disturbances in the sense of self in schizophrenia result from impaired sensory processing, leading to distortions in body representations [1-3,4,6].

In this paper the sense of bodily identity (BI), a concept introduced by Sakson-Obada and colleagues [3], is understood as the aspect of the sense of self that refers to the way in which an individual experiences his or her own body. The sense of BI includes the following components: (a) a sense of being alive; (b) a sense of physical boundaries; (c) a sense of coherence with the body; (d) a sense of continuity of the

body in time (e) and in space [3]. Normally, the sense of BI is preconscious and makes the individual feel at home in their own body. Qualitative research, based on phenomenological interviews [7], and quantitative questionnaires [3,8,9] have shown that disturbances in BI are characteristic of schizophrenia and are observed in the prodrome of the illness [7], even if researchers have used different terminology to define them (see Table 1). Considering the assumption about the significance of disturbed stimulus processing for BI, the present study will present data regarding disturbances in pain and proprioception thresholds in schizophrenia.

Table 1 A disturbed sense of BI in schizophrenia in the context of sensory disturbances and disturbances in representation of the body.

Aspect of bodily identity	Terms used by other authors	Examples of disturbances	Sensory disturbances/disturbances in representation of the body
A sense of being alive	Devitalisation [5]	A sense of emptiness, psychological death ("I feel dead inside", "I seem to feel pain, but it has no meaning")	Elevated sensory thresholds. Representations of body are either absent or lack personal involvement.
A sense of boundaries	Sense of boundaries [6,7]; demarcation [5]	Difficulty in distinguishing where the subject ends and the environment begins ("when someone touches me, it is as if they were attacking me"; "other people's sweat particles penetrate me").	Disturbance of sensitivity to touch and pain. A poorly distinguished representation of the body surface, which results in experiencing the body as vulnerable to invasion.
A sense of coherence • with the visual image of the body • with movement	Dysmorphic experiences [5]; depersonalisation [7]; a feeling of alienation towards one's appearance [6] Morbid objectification [5]	Feeling alien to body image („when I look in the mirror, I don't recognise myself there") Inability to control one's bodily movements, accompanied by a sense of alienation ("sometimes I can't make a move, I'm blocked").	Disintegration of body image. Body image is inconsistent with other representations of self. Disruption of the perception and integration of sensations from proprioceptors, the sense of balance, touch (body schema).
A sense of continuity of body in time	Changes in body image [6]; dysmorphic experience [5]	A sense of interruption in bodily continuity in time ("the I of yesterday and the I of today are different", "I was possessed, I felt things that are alien to me")	A radical disruption of sensation and integration representations of bodily states. Body image is unstable, with little separation, content contamination (between representations).

Aspect of bodily identity	Terms used by other authors	Examples of disturbances	Sensory disturbances/disturbances in representation of the body
A sense of continuity in space	Dynamisation of the body structure [5]; changed body size [6]	A sense of alienation of parts of the body in relation to the rest of the body ("I have a feeling that my body is not whole", "sometimes one part of my body becomes unnaturally long")	Disturbed perception and integration of proprioception and the sense of balance (body schema), and visual stimuli.

Pain provides important information about the state of one's body, and its nature, localisation and duration allow interpreting nociceptive sensations in terms of illness, fatigue or prolonged emotional tension. Clinical observations [10] showing that schizophrenia is associated with reduced or absent pain response during painful medical procedures, illnesses, and self-harm were the starting point for the hypothesis of elevated pain threshold in schizophrenia [11]. Experimental assessment of pain perception (i.e., experimental pain) in schizophrenia has relied on various types of stimulation, such as thermal or electrical stimulation, and mechanical pressure (for a review see [12–15]). The vast majority of studies, confirmed by the results of meta-analyses [12,14], found that patients with schizophrenia had a higher experimental pain threshold and higher pain tolerance than controls. Although these results supported Dworkin's thesis of psychotic analgesia [11], a few studies showed either no differences in experimental pain thresholds [16] or increased sensitivity to nociceptive stimuli in individuals with schizophrenia compared to controls [17–19]. These contradictory results may be explained by the type of stimulation. According to Carrasco-Picazo et al.'s meta-analysis [14], the lowered pain threshold in schizophrenia mainly applies to mechanical stimulation that requires a long application time, introducing an additional stress factor that affects the results obtained. In an attempt to explain the elevated pain threshold in schizophrenia, both the effect of antipsychotic treatment and abnormalities in receptor function or nerve conduction were excluded [13]. It was proposed that affective or cognitive disturbances were behind the delayed signaling of experimental pain. The hypothesis emphasising the involvement of affective processes concerned the disconnection of the affective component of pain (i.e., suffer-

ing) from the sensory perception. Cognitive explanations, on the other hand, pointed to difficulties in focusing attention or in evaluating a stimulus due to an imposed criterion [11].

Proprioception involves perceiving sensations like limb position, joint and muscle force, tension, and balance. It forms the body schema, which controls movement and provides a sense of unity with one's own body (a sense of agency [2, 6]). Proprioception, along with other somatic sensations, creates a sense of being alive, which is based on a stream of sensations that remain in the background of our consciousness [20]. Beginning with observations on various so-called soft neurological symptoms (e.g. motor slowing, involuntary movements) observed in people prone to developing schizophrenia, Rhado [21] and Meehl [22] formulated a hypothesis on the key role of proprioceptive deficit in the etiopathogenesis of sense of self disorder and loss of reality testing in schizophrenia. Studies evaluating weights confirmed the presence of proprioceptive deficits, mainly in patients with chronic schizophrenia [23].

The link between disturbances in BI and sensory processing abnormalities in schizophrenia can be explained from two perspectives. The first suggests that delayed processing of stimuli results from chronic neurological deficits, which by dint of accumulation lead to disturbances in the sense of self [21]. The second explanation highlights the primary involvement of a psychological factor: the disturbance of the basic embodied self, leading to confusion in the experience of one's own body, both in terms of sense of self and sensations [20,24]. In previous study [3], was found that schizophrenia is linked to disturbances in BI and both heightened and diminished sensitivity to stimuli. This suggests that schizophrenia does not imply permanent insensitivity to sensation, as experimental results

might indicate. The heightened sensation thresholds observed in experimental settings could be due to an indifferent attitude secondary to difficulty in processing sensations or difficulty in assessing incoming stimulation, resulting in delayed reaction time.

To date, only Arnfred et al.'s study [25] demonstrated a link between weak processing of experimentally induced proprioceptive stimulation in schizophrenia and self-disorders, including those related to the body. Additionally, there have been no studies examining modality-differentiated thresholds of sensation and their connections with disturbances in BI.

Current study

The main goal of this study is to investigate whether sensory disturbances are related to disturbances in BI in schizophrenia. In relation to this question, the following hypotheses were formulated: (a) individuals with schizophrenia will display heightened sensory thresholds in experimental settings (pain and proprioception thresholds); (b) will have a greater number of disturbances in the sensory thresholds examined via questionnaire (both increased and decreased thresholds of sensations) and in BI than controls; (c) disturbances in the sensory thresholds examined via questionnaire and in experimental setting will be related to disturbed BI in individuals with schizophrenia. The study also tested whether clinical characteristics of the disease are related to sensory thresholds and BI. Since the analyses relating to the last question posed were not central to the hypotheses tested, only statistically significant results ($p < .05$) are included in their presentation.

METHOD

Study design and participants

108 people participated in the study (conducted from 2018 to 2020), including 54 schizophrenia outpatients in a stable psychiatric state (in partial or full remission) with a diagnosis of schizophrenia according to the ICD 10 criteria. The clinical group was recruited from psychiatric day care units, and mental health outpatient's clinics (Provincial Psychiatric Treatment Centre in Olsztyn, Psychiatric Treatment Cen-

tre in Poznań). The control group ($n = 54$) was matched the clinical group in terms of gender, age and years of education. The following exclusion criteria were used: chronic somatic illness or physical disability and alcohol or psychoactive substance dependence for both groups; difficulty in making contact for the clinical group; a history of psychiatric hospitalisation, current psychological or psychiatric treatment for control group. The participants completed questionnaires first, followed by the measurement of their proprioception, and pain thresholds. The clinical and control groups were examined by the psychologist, who was the project leader. Three trained final year psychology students were employed as paid staff to examine 40 individuals from the control group. Clinical assessments in schizophrenia group were conducted by the attending psychiatrists.

Measures

The Bodily Identity Scale (22 items, [20]) was used to assess disturbances in BI, relating to the boundaries of the body, a sense of life, continuity of the body in time or space, and coherence with body movement and with body image (e.g. The boundaries of my body are sometimes so unclear that I don't know where I end and where I begin; Sometimes I feel dead inside; Sometimes, when looking at photos from the past, I have doubts whether it's really me). Each item is scored on a five-point scale from 5 (I strongly agree) to 1 (I strongly disagree).

The Sensory Thresholds Scales [20] measure disturbances in the perception of stimuli from the environment. The Heightened Thresholds Scale consists of eight items and measures decreased sensitivity to stimuli (e.g. Sometimes I don't feel pain when I hurt myself). The Lowered Thresholds Scale consists of 7 items and measures increased sensitivity to stimuli (e.g. Sometimes even a gentle touch is painful). Each item is scored on a five-point scale from 5 (I strongly agree) to 1 (I strongly disagree).

The Discrimination Weights Test was applied using the forced-choice comparison method in order to measure the proprioceptive sensitivity [23]. The study used a set of six identical oval containers, differentiated by weight (between

95g and 75g). Each trial involved sequentially lifting two weights, one at a time, and indicating which was heavier. In each trial the standard container weighing 75g was compared to a test weight (between 95g and 77,5g). The task was progressively more difficult as the weight differences between the standard and test weights decreased. Each weighed pair was tested 8 times and the proprioceptive threshold was determined for the lightest weight that the subject could accurately identify in 75% of trials (6 correct responses).

The TempTest Apparatus was used to measure heat-induced pain thresholds. The apparatus consisted of a heating element (a metal plate), a control unit and a manipulator, the subject uses to signal the onset of pain. Subjects placed the underside of their wrists against the heating element with an initial temperature of 30 degrees Celsius. Their task was to signal the moment the increasing temperature caused a painful sensation. The pain threshold indicator was expressed in degrees Celsius.

The Positive and Negative Syndrom Scale, developed by Kay et al. [26], was used to assess the positive, negative symptoms of schizophrenia, and general psychopathology.

Statistical Analysis

As the variables had no normal distribution, the one-sided bootstrapped Yeun's t-test was used to examine intergroup differences in dependent variables and the corrected Cohens d was calculated

to assess the effect size. The differences between the clinical and control groups in terms of demographic variables were analysed using the Mann-Whitney U test, Student's t test and the chi-square test of independence. The Mann-Whitney U test and Spearman's rho correlation coefficient were used to analyse the associations between the dependent variables and demographic or clinical characteristics. The SPSS (ver. 28.0.1) was used for the analyses; the effect size was calculated by the Jamovi software (ver. 2.4.0).

A design with a sample size of paired 54 subjects in each group will reliably (with probability greater than 0.8) detect effect sizes of $\delta \geq 0.343$, assuming a one-sided criterion for detection that allows for a maximum Type I error rate of $\alpha = 0.05$.

RESULTS

Table 2 presents the demographic and clinical characteristics of the study groups. The study groups did not differ in terms of age or years of education. However, those with a diagnosis of schizophrenia were more often single than the control group. The dominant diagnosis in the clinical group was that of multiple episodes with partial remission (59%), with the onset occurring in early adulthood. All participants in the clinical group were taking antipsychotic medication (85.2% second-generation drugs; 12.9% combination of first – and second-generation antipsychotics; 1 person a first-generation drug).

Table 2 Demographic and clinical characteristics of the study groups.

	Schizophrenia (n = 54)	Controls (n = 54)	Test ($\chi^2 / z; p$)
Gender (n, %)			
Women	27 (50%)	27 (50%)	ns.
Man	27 (50%)	27 (50%)	
Relationship status (n, %)			
Single	44 (81.5%)	15 (27.8%)	31.42 ₍₁₎ < 0.001
in a relationship	10 (18.5%)	39 (72.2%)	
Age (SD)	37.94 (9.51)	38.54 (10.01)	ns. ^a
Years of education (SD)	13.35 (2.74)	13.46 (2.74)	ns.
Clinical characteristics	Mean; (SD)		
Illness onset time (years)	24.94; (8.26)		

Number of hospitalisations (within the last three years)	1.31; (1.79)		
PANSS			
positive symptoms	11.98; (5.09)		
negative symptoms	16.44; (7.27)		
general psychopathology	32.67; (10.97)		
Schizophrenia type (n, %)			
first episode, full remission	8 (7.4%)		
first episode, partial remission	5 (4.6%)		
multiple episodes, full remission	9 (8.3%)		
multiple episodes, partial remission	32 (59.3%)		
Note. ns = not significant; ^a = Student's test			

Table 3 shows the results of intergroup differences in sensory thresholds and BI using the one-sided bootstrapped Yuen's t-test. Individuals with a schizophrenia diagnosis are characterized by a higher proprioception thresholds and a lower pain threshold than the control group, when experimentally measured. The clinical group

also had a higher number of disturbances in both heightened and lowered sensation thresholds and in BI when measured by questionnaire. A medium effect was discovered in terms of BI and proprioception threshold, while heightened and lowered thresholds in questionnaire, and pain thresholds in experimental setting had a small effect.

Table 3 Means, standard deviations and medians of sensory thresholds and bodily identity in groups with results of comparison test.

Sensory threshold	Schizophrenia (M±SD; Md)	Controls (M±SD; Md)	Yuen's bootstrap t(df)	p-value	Cohens d*
Proprioception threshold	84.44±5.04; 85	80.83±3.43; 80	3.19 (62.9)	0.004	0.51
Pain threshold	42.49±3.98; 43.6	44.06±4.26; 45.6	-2.34 (65.8)	0.023	0.32
Heightened thresholds	1.90±0.71; 1.2	1.56±0.57; 1.4	2.62 (62.8)	0.004	0.35
Lowered thresholds	1.93±0.73; 1.9	1.66±0.61; 1.4	1.92 (61.8)	0.050	0.29
Bodily identity	2.13±0.67; 2.0	1.45±0.48; 1.3	6.03 (61.9)	<.001	0.72
Note. Bootstrapped t-test based on 2000 samples.					

The statistical analyses revealed that none of the experimentally measured sensory thresholds was associated with disturbances in BI ($r_{prop} = .20, p = .15; r_{pain} = .03, p = .841$), whereas both heightened and lowered sensations thresholds measured via questionnaire were related to BI disturbances ($r_{lowT} = .69, p < .001; r_{highT} = .59, p < .001$).

In the analysis of associations between sensory thresholds and BI disturbance, on the one hand, and clinical variables, on the other, scores on the PANSS scales, number of psychiatric hospitalisations within the last three years, and time of onset were included. The number of hospitalisations correlated positively with an increased threshold for pain, and BI disturbances (r_{pain}

$= .33, p = .016; r_{identity} = .29; p = .035$). There were no correlations between the remaining clinical variables (onset time and PANSS) and sensory thresholds (investigated via questionnaire and in an experimental setting). Bodily identity disturbances correlated positively with positive symptoms of schizophrenia ($r = .27; p = .045$).

DISCUSSION

Sensory processing disturbances in schizophrenia have been widely studied, but not all modalities have received equal attention. Previous research focused on only one type of stimulation, primarily exploring disruptions in olfactory and

pain processing, while proprioceptive processing abnormalities received less attention [1]. Our study is the first to consider both experimentally studied perception of two types of stimuli (pain and weight) and sensory thresholds assessed via a questionnaire. Previous postulations about a link between disturbed sensory processing and self-disorder in schizophrenia have not been empirically verified, except for Arnfred et al.'s study [25]. Our study aimed to verify two main hypotheses: first, disturbances in stimulus perception were more frequent in the schizophrenia group, and second, these abnormalities were associated with sense of self-disorder operationalized as disturbed sense of BI.

In line with expectations and the results of a previous study of patients hospitalised for schizophrenia [3], it was shown that individuals in remission struggle with alternating states of both excessive and reduced sensitivity to stimuli, examined using two independent scales in the questionnaire (correlation between the scales: $r = .62$; $p < .001$). Stimulus hypersensitivity in schizophrenia is linked to sensory gating deficits and leads to a breakdown in the perceptual field and sensory overload [27] which is phenomenologically characterised as "feeling attacked by sensations". In turn, an elevated sensation threshold may be a defence against an intolerable onslaught of stimuli.

The hypothesis regarding differences in experimentally measured sensory thresholds between the clinical and control groups was partially confirmed. Individuals diagnosed with schizophrenia showed higher thresholds for proprioception as expected, but they were more sensitive to pain than the control group. Moreover, the present study found that the proprioceptive deficit in schizophrenia is present even in those in remission, contrary to previous observations mainly in severe cases [23]. The results also undermine the popular thesis of pain indifference in schizophrenia. Our study is not the first to show increased sensitivity to pain in schizophrenia [17-19]. The key factor appears to be the specificity of the clinical group, as all these studies were conducted on outpatients (likely to be in the remission). In contrast, studies demonstrating an elevated pain threshold in schizophrenia were conducted on hospitalized patients during the chronic or acute phases of the illness [13]. There-

fore, reduced sensitivity to nociceptive stimuli seems to depend more on the phase and course of the illness rather than the schizophrenia diagnosis itself [28]. Our study showed a relationship between the number of psychiatric hospitalizations and lower sensitivity to pain, supporting the idea that reduced sensitivity to this stimuli is related to the severe course of schizophrenia.

Increased sensitivity to pain with simultaneous decreased sensitivity to proprioceptive stimuli in people with a diagnosis of schizophrenia suggests the involvement of different psychological factors in the evaluation of these two types of stimuli. While pain perception includes an affective component, estimating proprioceptive thresholds involved working memory, as it required memorization of the standard weight, which was then compared to the test weight. The obtained results therefore suggest that faster pain signalling in people in schizophrenia remission may be due to hypervigilance to aversive stimuli and heightened levels of anxiety [17] compared to the control group. In contrast, the proprioceptive threshold test method does not solely examine sensitivity to proprioceptive sensations, as it involves additional cognitive processes. Working memory deficits possibly made testing proprioception thresholds a more challenging task for the clinical group as evidenced by the finding that intergroup differences were more strongly expressed when proprioception thresholds were tested than when pain thresholds were examined.

Another hypothesis concerned the greater number of disturbances in BI in schizophrenia. It was confirmed, based on a questionnaire, that individuals diagnosed with schizophrenia struggle with a number of disruptions in BI, including such experiences as uncertainty about body boundaries, loss of sense of being alive and unity with their own body, and discontinuity of the body in time and space. Co-occurrence of disturbances in BI with florid symptoms of psychosis and the number of psychiatric hospitalisations is consistent with the results of other studies [6] and suggests that severe disturbances in the sense of BI may be an early marker of proneness to schizophrenia and may develop into full-blown psychosis [4,7].

We hypothesised that accumulated disturbances in sensory perception investigated by the

questionnaire should be associated with a disturbed sense of BI. Our study confirmed this hypothesis, as both excessive and reduced sensitivity to the stimuli examined via questionnaire were associated with disturbances in BI.

The results of presented study have revealed no significant correlation between experimentally tested sensation thresholds and BI. Previous data on the co-occurrence of disrupted sensory processing and the fragmentation of identity was based on testimonies of individuals with schizophrenia [29]. The co-occurrence of these experiences was observed during transient states of disorientation, where individual felt lost in their own experiences and the world. However, the participants of presented study were well-functioning individuals in remission who, while responding affirmatively to the questions in the questionnaire regarding disturbances in BI and sensory perception, did not necessarily display these disturbances during the study. This might explain the discrepancies in the results of presented research and those obtained by Arnfred et al. [25], who demonstrated the coexistence of proprioceptive deficit in experimental setting with self-disorder in schizophrenia. Arnfred et al.'s study involved hospitalised patients during their first episode of psychosis, who also displayed disruptions in somatosensory processing in response to rapid changes in the weight held in the hand. This means that the differences in the results obtained may be due to the specificity of the group studied (remission vs active psychosis) and the method of measuring the disruptions in perception in experimental setting (patient's subjective assessment vs. assessment of brain bio-electrical activity by evoked potentials). Additionally, the lack of correlations between BI and experimentally tested sensation thresholds, with simultaneous correlations between BI and questionnaire-tested sensory disturbances, may also be due to the greater contribution of a situational factor (e.g. the patient's condition) when a single stimulus-response is measured. This means that associations based on questionnaires are easier to establish than those based on a single reaction, especially when its strength is only weakly (pain thresholds) or moderate (proprioception threshold) expressed.

CONCLUSIONS

The current study leads to several interesting conclusions. In remission from schizophrenia we observe no coherent pattern of disturbances in experimentally measured sensory thresholds: although thresholds for proprioception are elevated, the pain threshold is lowered. The results obtained undermine the common assertion of indifference to pain in schizophrenia. Based on previous research, it might be assumed that indifference to pain is present only in severe forms of the illness, while in remission from schizophrenia an increased sensitivity to pain is observed. Schizophrenia is associated with numerous disturbances in BI, including a sense of internal death, body boundary dissolution, a lack of coherence in movement and in body image, and a loss of continuity of the body in time and space. The lack of assumed association between disruption in the processing of stimuli in experimental settings and the BI stems from the study methodology and the specific characteristics of the experimental group. The co-occurrence of severe disruptions in the processing of stimuli and disturbed BI occurs in transient states of the fragmentation of identity, as borne out by the testimonies of individuals with schizophrenia [29], and was confirmed by the results of this study based on declarative methods.

LIMITATIONS

The study has certain limitations. Firstly, the clinical group was specific: although the duration of remission was not examined, the patients were stable and in good rapport. Presumably, chronic schizophrenia or its acute phase would have been associated with different outcomes. More precisely, disorientation or emotional withdrawal would be associated with significantly higher sensory thresholds measured in experimental settings than those observed in presented study. Secondly, the questionnaire-based study of BI concerned the presence of states experienced at different moments in life, which does not imply their presence during the study. A link between BI and disturbed sensation processing in experimental setting could therefore be observed in active psychosis or in

the situation of provoking disturbances in sensorium, which is, however, ethically controversial.

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