Space and Objects: On the Phenomenology and Cognitive Neuroscience of Anomalous Perception in Schizophrenia (Ancillary Article to EAWE Domain 1)

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nothing is known. Moreover, a fundamental hypothesis of phenomenological psychiatry – that perceptual changes are related to disturbances in the sense of self – has yet to be investigated actively. From this context, we offer suggestions for future research and suggest general research designs that may be useful for advancing progress in this area.

Introduction

Since the 1990s, there has been a systematic effort to find common ground between phenomenological and neurobiological understandings of conscious experience. One result of this work has been an increased effort to characterize phenomenological disturbances in schizophrenia and to understand the way in which these both drive, and are caused by, neurophysiological changes. To date, however, progress has been impeded by at least two factors. First, there has not been a reliable and valid method to elicit, categorize, and quantify abnormal perceptual and other experiential phenomena. Methods: In this brief paper, we review the main types of disturbances in space and object perception in schizophrenia – as described by phenomenologists, clinicians from other theoretical orientations, and experimental psychopathologists – as a first step in a research agenda to achieve a better integration of the clinical and experimental literatures. Results/Conclusion: This review indicates that in some cases the cognitive and neurobiological mechanisms of altered space and object perception in schizophrenia are relatively well understood, while in other cases there exist only plausible hypotheses. In still other cases, however, almost nothing is known. Moreover, a fundamental hypothesis of phenomenological psychiatry – that perceptual changes are related to disturbances in the sense of self – has yet to be investigated actively. From this context, we offer suggestions for future research and suggest general research designs that may be useful for advancing progress in this area.

Keywords
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such as accuracy and reaction time in laboratory tasks and brain activity during task performance as indicated by functional magnetic resonance imaging (fMRI) or event-related potentials (ERPs). As a result, our field is at the same time: (1) rich in phenomenological concepts but poor in phenomenological assessment tools; (2) rich in laboratory data on perceptual and cognitive impairments but poor in an understanding of how these relate to the altered subjective experiences of people with schizophrenia; and, therefore, (3) for the most part, at a loss to understand how experiential changes in schizophrenia are related to the cognitive neuroscience of the disorder.

With this paper, we hope to accelerate the dialogue that is needed to advance progress on the latter issue. Our starting point is the category of space and object perception from the EAWS (Examination of Anomalous World Experience) [1], the first standardized measure of non-self-related subjective experiences developed for use in this population. After a brief review of some of the phenomenological concepts that guided the choice of items in the space and object subscale, we review data on subjective reports of patients, laboratory data on these phenomena, and (depending on the phenomenon) their known or hypothesized neurobiological bases. We conclude with suggestions regarding research designs that could advance this field. We wish to note at the outset that we remain agnostic at this point as to whether changes in self-experience and world experience lead to perceptual changes, whether neurobiological changes lead to perceptual changes which then lead to altered self-experience and world experience, or whether all changes occur in parallel. However, we do believe that gaining a better understanding of the nature of the changes that occur in schizophrenia, and of their biological bases, in addition to using more sophisticated research designs (see Discussion) can help address this issue of causality.

**Phenomenological Psychopathology**

Perception of space and objects is a traditional focus within phenomenology. Similarly, disturbances in these aspects of perception among people with schizophrenia have long been discussed within phenomenological psychopathology, an approach to psychiatry that draws significantly from the philosophical work of Husserl, Heidegger, and Merleau-Ponty, and that emphasizes the basic nature of subjectivity and its alterations in various forms of psychopathology. From this perspective, space and object perception disturbances in schizophrenia are related to a transformation of the whole field of perception, secondary to a basic alteration in being in the world.

The phenomenological perspectives of the writers noted above suggest that self-experience and world experience are intimately connected. This suggests that, in virtually every perception, there should be a strong correlation between basic self-disturbances [2] and disturbances in the perception of space and objects. According to this view, destabilization of the sense of self is associated with a disruption in the way external stimuli are experienced. At one extreme, this can render objects of perception as accidental occurrences that do not correspond to ongoing internal or external activity, and that lack affordances, meaning, and inherent stability.

Binswanger [3], for example, argued that we perceive space in two forms: as oriented space with the body as a center of reference (with its up and down, left and right, close or far, etc.) and as attuned space, where experience is modified by one’s internal state and mood (leading to experiences of space in terms of qualities such as fullness or emptiness, expansion or constriction, poverty or richness, and varying degrees of meaningfulness). According to Binswanger and others, attuned space in schizophrenia loses its homogeneity, consistency, and taken for grantedness, which can lead to delusional mood or to revelatory experiences (e.g., the feeling of the end of the world) [4]. Minkowski [5] discussed another spatial disturbance in schizophrenia: the intrusion of mathematical space into oriented space, what he called morbid geometrisv. In morbid geometrism, mathematical order and symmetry dominate over oriented and attuned experiences of space. Everything becomes rigid and static, lacking flow and extension in time.

Distortions in the perception of objects are thought to be another consequence of the basic alteration of being in the world. Objects can thus be perceived with changed intensity, quality, or veridicality. They can also be perceived as fragmented or as lacking in stability of form, size, or color. The perceived relationships between objects and their context can also be disturbed as noted by Matussek [6], who was heavily influenced by Gestalt psychology. Matussek saw the weakened influence of context on the perception of objects as resulting in overemphasis and predominance of certain perceptual qualities over other properties of objects, and the emergence of abnormal significance that is perceptually experienced as an integral part of the object.

The distortions in the perception of space and objects described by Minkowski, Binswanger, Matussek, and others have also been noted in autobiographical accounts
by people with schizophrenia, and in descriptions of patients by other psychiatrists and psychologists (see below). Despite this wealth of clinical evidence, there has been little empirical research on these issues from a phenomenological perspective. Hopefully, availability of the EAWE will encourage more such research, including studies that would improve understanding of why, when, in whom, and under what circumstances these perceptual and experiential changes emerge and remit. In the discussion that follows, we provide an overview of the major topics within the experimental literature in this research area and link these to specific EAWE items. Our goal is to highlight possibilities for future research integrating cognitive neuroscience and phenomenological approaches to space and object perception in schizophrenia. Due to space limitations, we only focus on examples of disturbed visual processing, but it must be noted that analogous disturbances to these can be found in auditory, haptic, olfactory, and gustatory processing.

Perceptual Fragmentation

One of the most well studied aspects of disordered space and object perception in schizophrenia is that of fragmentation or reduced perceptual organization. Examples of this (with corresponding EAWE sections in parentheses) include: “I have to put things together in my head. If I look at my watch I see the watch, watchstrap, face, hands, and so on, then I have got to put them together to get it into one piece” [7] (1.4.1); and “For I saw the individual features of her face, separated from each other: the teeth, then the nose, then the cheeks, the one eye, and the other. Perhaps it was this independence of each part that inspired such fear and prevented my recognizing her even though I knew who she was” [8] (1.4.1). Fragmentation can also extend to scenes as a whole, as shown in this example: “I only saw fragments: a few people, a kiosk, a house. To be quite correct, I cannot say that I see all of that, because the objects seemed altered from the usual. They did not stand together in an overall context, I saw them as meaningless details” [6] (for definition see EAWE subtype 1.4.2).

Over 60 laboratory studies have demonstrated reduced perceptual organization in schizophrenia [9–11]. These abnormalities arise by the first psychotic episode and become more pronounced with increasing chronicity [11]. They have not been found in other psychiatric disorders [12–16], and, among people with schizophrenia, they are associated with histories of poor premorbid functioning, disorganized symptoms, and poorer treatment response, suggesting they are an aspect of a more severely ill patient subtype [17]. Research on the neurobiology of these impairments suggests that they involve reduced binding of visual features in areas of the occipital lobe with large receptive fields (e.g., V4 and lateral occipital complex) [9, 18], involving weakened synchronization of neuronal oscillations within the γ-band [19]. While in some cases, reduced perceptual organization appears to be independent of attention [20], in other cases there are clear effects of reduced effects of expectation on the structuring of the visual field [13], suggesting poor integration of top-down signals and of gain (from attention) with sensory input.

There are a number of hypothesized sequels of reduced perceptual organization in schizophrenia. One of these is excessive attentional capture by irrelevant background details, as discussed by Matussek and as in the following example: “Sometimes an object stands out. Then, my eyes have to fix this detail, like being spellbound, although I don’t want to attend to it” [21, p. 57] (EAWE subtype 1.4.3). Another consequence is confusion between figure and ground. As noted by Freedman [22] about several of his patients, “they said they became as sensitive to irrelevant, background stimuli as they were to relevant, foreground ones, thus failing to perceive the distinction between figure and ground” (for description see EAWE subtype 1.8.6). At the extreme, background can take precedence over figure, and lead to experiences such as this: “The air is still here, the air between the things in the room, but the things themselves are not there anymore” [23, p. 136] (EAWE subtype 1.8.6). While the causes of these figure-ground disturbances are not known, it is possible that they reflect weakened responses in visual cortex cells that signal border ownership of objects [24].

Another hypothesized consequence of reduced perceptual organization is the loss of perceptual stability (see EAWE subtype 1.5.2 and see next section), which can be seen as a consequence of abnormally frequent efforts to update what is being perceived due to weak and easily contaminated gestalts. Examples of this include “He told me that he frequently saw the shape of things change before his eyes” [25], and “I don’t see entire objects, things or people… Objects no longer appeared stable. They

\footnote{1 While more research is needed on the issue of diagnostic specificity, perceptual organization has been found to be normal in other psychiatric groups that have been studied, including patients with substance abuse, bipolar disorder, psychotic disorders other than schizophrenia, and body dysmorphic disorder. See citations for this point above for further information.}

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would glimmer fitfully and become displaced, making every-thing appear as if it were in a state of flux” [26, p. 146] (EAWE subtype 1.5.2). Because activation of semantic codes related to objects depends on a stable gestalt [27, 28], further effects of fragmentation and instability are delays in accessing the identity and meaning of objects, and/or activation of inappropriate semantic codes. An example of this is: “It was as if the function or importance of familiar objects had drained out of them, leaving them purposeless, empty shells, to which the patient could not react” [22] (EAWE subtype 1.16). In short, there is much evidence of perceptual fragmentation in schizophrenia, and this may lead to further perceptual changes and alterations in the experience of objects and the world, as well as to delusions. It is important to note, however, that reduced perceptual organization is only one potential cause of abnormal object perception in schizophrenia. Other factors, such as poor visual acuity [29], reduced contrast sensitivity [30], and reduced depth perception [31], all of which are found in schizophrenia, would also be expected to contribute.

Metamorphopsia and Loss of Stability

Several sections of the EAWE cover changes in the size, form, or color of objects, or metamorphopsia. Examples of this include: “Things shape themselves; the round holes in the window-frames (the fastenings) become heads and seem to be biting at me” [32, p. 66] (EAWE subtype 1.6.3); and “Sometimes their features changed as he looked at them, so that they first appeared to be one person, then another” [22] (EAWE subtype 1.6.3). Some distortions involve increases or decreases in object size as in this example: “I was sitting listening to another person and suddenly the other person became smaller and then larger and then he seemed to get smaller again…” [7] (EAWE subtype 1.6.2). Other distortions involve uneven changes in object dimensions (i.e., dys-megalopsia), as in the following statement: “The objects appeared somewhat distorted, higher on the one side and lower on the other” [21, p. 52] (EAWE subtype 1.6.4).

Changes in stability can be consequences of reduced perceptual organization, as noted above. Although somewhat speculative, it is also possible that changes in the perceived size of objects in the foreground or background could be the cause of disturbances in distance perception that have been reported by people with schizophrenia. For example, statements such as the following could be due to the effects of size constancy mechanisms operating after target objects become larger or smaller: “Things seemed so far away; everything was in a distance” 21 (1.7.1), and “All things seemed to have got closer, as if looking through a telescope” [21] (EAWE subtype 1.7.1). However, some aspects of distance perception may reflect primary disturbances in perception of space, as discussed below (this section) and in a later section on space perception.

In general, there has been very little research on these specific phenomena. However, metamorphopsia is a category of visual disturbance on the Bonn Scale for the Assessment of Basic Symptoms [21]. This scale is sensitive to schizophrenia and to the at-risk state. For example, Klosterkötter et al. [33] reported that visual disturbances showed a high sensitivity for predicting later conversion to schizophrenia. What is needed now are data on the degree to which each type of visual symptom predicts conversion to psychosis or other outcomes. It is also not known what causes these disturbances. Changes in size and color could be partly due to momentary weakening or intensification of size and color constancy mechanisms, but there are currently no data to support this view. While some data exist demonstrating size constancy abnormalities in schizophrenia [34], and their expected brain function correlates [35], it is not clear whether similar mechanisms are operative in disturbances of spatial perception outside of a laboratory context. It is also not clear whether and to what extent changes in perception are driven by emotional factors, and, if so, how this operates. Certainly, examples such as inanimate object parts changing into biting heads suggest an increase in emotion-driven modulation of sensory input, but this is an unexplored area in schizophrenia research.

It is also possible that distortions such as those noted above are facilitated by reduced adaptation or weakened habituation in the face of prolonged stimulus exposure. Although admittedly speculative in this case, reduced adaptation to visual stimuli has been reported in schizophrenia [36], and this could lead to what appears to be unusual salience in objects, which, when combined with emotional reactions, could lead to changes in appearance. A potential example of this is the strange-face-in-the-mirror illusion, in which prolonged staring at one’s face in a mirror during low-light conditions leads to perceptions of distortions of one’s face, as well as grotesque faces, archetypical faces, dead relatives’ faces, and animal faces. This illusion is heightened in people with schizophrenia [37] and in adolescents with schizotypal features [38]. A task for future research is to clarify whether this and other examples of perceptual instability in schizophrenia are due to reduced adaptation, and/or whether other mechanisms...
are involved. It will also be important to explore the extent to which instability interacts with reduced perceptual organization, as described above. This combination of impairments would produce overly frequent efforts to reorganize the stimulus field, increasing the likelihood that the reorganized representation would be increasingly contaminated with overly salient percepts along with their associated (and irrelevant) information from visual context, memory, expectations, or emotions.

**Abnormal Intensity of Perception**

Many people with schizophrenia report increases or decreases in stimulus intensity. Examples of these include: “Colours seem to be brighter now, almost as if they were luminous” [39, p. 105] (EAWE subtype 1.1.1), and “Colors are dimmer and so is the significance” [32, p. 81] (EAWE subtype 1.1.2). The causes of these changes are not well understood. One possible cause is increased or reduced activity of the sensory transducers. For example, several studies of schizophrenia have demonstrated reduced electrical activity as early as the retinal photoreceptors [40]. However, no study has reported excess activity at this level, even though a known consequence of excess retinal dopamine is an increase in the cone photoreceptor response (related to color perception and central vision), and decreases in rod responses (related to achromatic and peripheral vision) [41], which are consistent with reports of hyperintense color perception [39] and reduced achromatic contrast sensitivity [30] and peripheral vision [42] in schizophrenia. Another potential factor is changes in contrast gain control or the ability of thalamic and cortical regions to sufficiently amplify weak stimuli and suppress intense stimuli to keep perception within a tolerable range. There is much evidence for both reduced amplification [43] and reduced suppression [44] in schizophrenia. There are also homeostatic processes, such as divisive normalization, that serve to keep the overall level of activation at a stable level across a brain region. Breakdown in homeostatic regulation could cause some of the reported phenomena. To date, however, little work has been done on this issue in schizophrenia.

**Vision Loss**

Vision loss in schizophrenia ranges from blurred vision to temporary blindness. Loss of acuity can be seen in reports such as: “My vision has decreased. I see everything hazy and foggy like through a veil” [21, p. 47] (EAWE subtype 1.2.1). Examples of partial seeing have also been reported, such as the following: “When somebody shows me his whole hand, I can see only the upper part of the last three fingers. The part above a line that runs diagonally from the forefinger to the little finger is cut away” [21, p. 48] (EAWE subtype 1.2.2). More extreme cases, of temporary blindness, can be seen in these examples: “Whenever I want to focus on an object, it disappears before my eyes” [21, p. 47] (EAWE subtype 1.2.3), and “The way, the hen and the room suddenly were invisible” [21, p. 47] (EAWE subtype 1.2.3).

The causes of these changes are not understood. It is interesting to note, however, that reduced acuity and other ocular problems (e.g., strabismus) are found to an elevated degree among children of mothers with schizophrenia, and that these impairments in childhood predict later schizophrenia whereas other childhood sensory impairments do not, regardless of familial psychopathology [45, 46]. Because one effect of strabismus is to suppress input from the weaker eye, many people with schizophrenia may be predisposed to having reduced vision, especially in the context of other changes such as weaker efferent signals from the retina (as noted above) or a reduced density of cells in the primary visual cortex [40].

**Hallucinations**

At the other extreme from vision loss is the perceiving of stimuli that do not exist. Visual hallucinations (covered in EAWE item 1.3) are well documented in schizophrenia and are reported to occur in ~27% of patients [47]. The neural basis of these is still not well understood [47, 48]. However, patients experiencing visual distortions are more likely to experience visual hallucinations than patients who do not experience visual distortions [49]. This suggests that some of the same mechanisms may be involved in both classes of phenomena. In addition, because co-occurrence of visual and auditory hallucinations is common in schizophrenia, with occurrence of visual hallucinations in the absence of auditory hallucinations being very rare in this condition, it is likely that similar mechanisms are involved in all of these sensory distortions. On the other hand, it is noteworthy that visual and auditory hallucinations are rarely fused in schizophrenia: they are typically experienced at different times, and when experienced at the same time they are usually unrelated to each other [reviewed in 47]. An important task for future research is to determine the common and spe-
cific mechanisms involved in visual versus other sensory hallucinations.

A less commonly discussed visual change in schizophrenia is palinopsia or the recurrence of previously seen objects after they are no longer present. Examples of this include: “Sometimes, I still see things that are not there anymore, e.g., a car that has already passed by. They remain before my eyes for a while... like a visual echo” [21, p. 52] (EAWE subtype 1.1.3); and “A hat, initially seen on one person, recurred, in its proper position, on others” [26, p. 105] (EAWE subtype 1.1.3). The specific relationship between palinopsia and visual hallucinations has, to our knowledge, not been reported, although it would appear that the former occurs more rarely than the latter [50]. This would suggest that visual hallucinations are not simply extreme manifestations of visual distortions, but rather that there are mechanisms that are shared by both phenomena as well as mechanisms that are specific to each.

**Distorted Experience of Space**

As noted above, the experience of space can become distorted for some patients. Examples of this include: “One day for many hours, a malaise infects me. Faint spatial irregularities distort my perceptions, deepening stairs and telescoping school corridors” (EAWE subtype 1.7.1) [51]; and “I couldn’t throw things in the waste-paper basket any more, I always aimed too short or too long. I had lost my feeling for the distance” [21, p. 52] (EAWE subtype 1.7.3). There are multiple reports of space becoming nearly 2-dimensional, as in: “I see things flat. Whenever there is a sudden change I see it flat. That’s why I’m reluctant to go forward. It’s as if there were a wall there and I would walk into it. There’s no depth...” [7, p. 230] (EAWE subtype 1.7.3). In other cases, space seems to expand, as in this example, “I still saw the room. Space seemed to stretch and go on into infinity, completely empty. I felt lost, abandoned to the infinites of space” [32, p. 81] (EAWE subtype 1.8.5). Sometimes, the experience of space can be more subtle, as in the following: “Then I felt that the autumn landscape (was pervaded) with a second space. It was fine and invisible, hardly detectable. The second Space was dark, empty, frightening; it was difficult to say precisely what it was like” [52, p. 266] (EAWE subtype 1.8.7). At the other extreme, patients may experience themselves as merging with objects in space. Examples of this (both unpublished) include “As I was looking at the packet of cigarettes in my hand, I suddenly wasn’t sure whether the packet was part of my body or not” and “While I was riding the bike, I suddenly felt a kind of melting into my bike, as if the bike and I had become one” (EAWE subtype 1.17).

Experiences of altered space perception in schizophrenia have not been studied in a rigorous fashion. However, it is well known that areas of the parietal lobe are important for a sense of space and for a sense of one’s body in space [53]. For example, reductions in parietal lobe activity have been reported in experienced meditators, who can experience a sense of loss of body boundaries and of engulfment in an expanded space, and of merging with objects in space [reviewed in 54]. Changes in parietal activity (e.g., tissue loss, reduced activation, and increased activation compensating for reduced frontal activation) have been shown in schizophrenia [reviewed in 55], but, so far, these changes have not been related to altered experiences of space. It will also be worthwhile to study effects of dopaminergic alterations on space perception, given the significant changes in this domain reported in patients with Parkinson disease [56].

An intriguing hypothesis comes from findings that during saccadic eye movements, the ability to localize objects in space is suppressed, leading to a compression of visual space. This effect is heightened in schizophrenia [57] and is thought to be related to abnormal corollary discharge or signaling generated by eye movements that allows for accurate prediction of sensory input after eye movement. Disruptions in oculomotor corollary discharge have been recently reported in schizophrenia [58], and this could account for repeated mismatches between space as perceived and space as expected to be perceived, which may contribute to subjective spatial disturbances. It is also possible that disturbances in size constancy are related to altered space perception in schizophrenia by making distances between objects appear smaller or larger than they do for other people. To date, however, this hypothesis has not been tested. Finally, as noted above, elevated rates of strabismus have been found in people with schizophrenia [59], in children at risk for schizophrenia [45, 46], and in people with social phobia [60]. Because strabismus leads to suppression of input from the weaker eye, it is associated with reduced binocular vision and reduced depth perception. This is, therefore, a further potential contributor to altered experiences of space, especially to the experience of space as flat, or to feelings of expanded space as resulting from compensatory efforts to reorient oneself in the world. Its association with social phobia also indicates that loss of depth perception can have emotional consequences. An issue that needs fur-
ther study, however, is why this trait disturbance becomes exacerbated during psychotic episodes. One possibility is that emotional disturbance exacerbates strabismus, or even causes it temporarily, in some patients. This hypothesis has received support from 2 case studies [61]. What is still completely unclear though is whether and how the effects of strabismus contribute to the specific types of experiences reported by patients described at the beginning of this section.

Conclusion

The evidence reviewed above suggests that there are a wide range of disturbances in schizophrenia related to the perception of space and objects. In some cases, such as reduced perceptual organization, there is a large empirical literature on the types of stimuli and patient characteristics (e.g., symptoms or premorbid history) that determine when this occurs and on its neurobiology. In other cases, such as with metamorphopsia and increased/reduced stimulus intensity, there are plausible neurobiological mechanisms that may be responsible, but empirical work linking the subjective changes to underlying mechanisms has not yet been done. In still other cases, such as partial blindness, almost nothing is understood about what causes this in people with schizophrenia. Thus, there is a clear research agenda ahead. We suggest, however, that rather than only simply examining the cognitive and biological characteristics of patients who do or do not report specific perceptual abnormalities (as is now the norm), a more fruitful approach would be one of neurophenomenology, as described by Varela and colleagues [62].

One aspect of a neurophenomenological approach would be the studying of brain states and their unfolding during conscious experience, as reported by the subject. This has been used to study the correspondence between neural synchrony and the subjective experience of visual stimuli [63]. It has also been used to study brain states that occur when a patient with schizophrenia indicates that a specific experience (e.g., a hallucination) occurs [64]. Alternatively, data on each trial of a perceptual task can be assigned to 1 of 2 or more conditions depending on what a patient reports that he/she sees after a stimulus presentation [63]. Progress towards studying brain states associated with altered space and object perception, along with characterization of the developmental and clinical factors associated with people who experience them, can move psychiatry closer to a fuller understanding of the relationships between altered brain function and altered experience [65].

Other issues to investigate include the possibility of bidirectional relationships between perceptual changes and other experiential and neurobiological changes, the prognostic significance of these changes, and their response to treatment, among others. This future body of research, embedding knowledge of phenomenological changes in space and object perception into the larger body of evidence and understanding regarding schizophrenia and its development, will be accelerated by the extensive and growing research literature on laboratory demonstrations of altered space and object perception in the disorder. Finally, research linking abnormal perceptual experiences with an altered sense of self has yet to be conducted, but this is needed to examine the hypothesis that perception of the self and the world emerge from the same substrate and become disordered in parallel.

References
