Art Making in Schizophrenia: A Vision Science Perspective

Daniel Graham and Steven Silverstein

1 Introduction

Schizophrenia is a disorder characterized by psychotic symptoms (e.g., symptoms indicating reduced reality testing, such as hallucinations and delusions), disorganization (loose associations in speech, odd and out-of-context movements), negative symptoms (anhedonia, flat affect, low motivation), and cognitive impairment, as well as significant functional decline. It is also a highly heterogeneous disorder, with great variability in age of onset, number of lifetime psychotic episodes, long-term course of illness, and degree of recovery of normal role functions. In addition, it is possible for two people to meet criteria for the diagnosis of schizophrenia while having non-overlapping symptoms, and symptom expression can vary significantly across cultures [1]. Schizophrenia is known to be highly heritable, although most people with the condition do not have a parent or sibling with the condition. It is found in slightly less than 1% of the population worldwide [2–4] and appears to have been in existence since early in human history. The causes of schizophrenia have been studied for decades, but an understanding of them remains elusive. It is now generally thought that many genes can contribute to the development of schizophrenia, each with a small contribution [5]. Epigenetic factors, such as the influence

D. Graham (✉)
Department of Psychological Science, Hobart and William Smith Colleges, Geneva, NY, USA
e-mail: GRAHAM@hws.edu

S. Silverstein
Department of Psychiatry, University of Rochester Medical Center, Rochester, NY, USA

Department of Neuroscience, University of Rochester Medical Center, Rochester, NY, USA

Department of Ophthalmology, University of Rochester Medical Center, Rochester, NY, USA

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of interpersonal and environmental stress and toxins on gene expression, are also thought to be important in mediating gene x environment interactions [6]. Traditionally, biological theories have emphasized dopamine (DA) dysfunction [7]. However, it is becoming clear that excess dopamine is primarily found in the striatum, whereas dopamine activity in cortical regions appears to be reduced [8]. Also, newer theories emphasize the role of glutamatergic dysfunction (e.g., NMDA receptor hypofunction) [7], GABA-ergic (i.e., inhibitory interneuron) dysfunction leading to excessive neural excitation [9], as well as imbalances in acetylcholine [10] and histamine [11]. Because all of these neurotransmitter systems interact, disentangling primary causes from downstream effects has been and continues to be challenging. There is also evidence that the neural findings in schizophrenia may be secondary to changes in vascular function, and that changes in the vasculature (e.g., reduced density of blood vessels) may be a secondary effect of a neuroinflammatory process [12, 13]. This evidence has led to the perspective that schizophrenia is a multi-system disease, involving dysregulation of multiple homeostatic mechanisms [14, 15]. Evidence for this includes overlap between schizophrenia candidate genes and genes involved in cardiovascular function [13], as well as an increased prevalence of metabolic and cardiovascular conditions even at the first episode of psychosis [16]. While the behavioral changes (e.g., delusional ideation, speaking back to auditory hallucinations) in schizophrenia are typically the most striking aspects of the condition, effects such as cardiovascular disease play a major role in the shortened lifespan of patients with the condition [17]. Regardless of the sequence and interactive nature of the potential causes of schizophrenia, there is no doubt that the condition affects multiple brain regions involved in perception, cognition, and sense of self and the world, and that understanding and treatment of people with lived experience of it needs to take into account these changes in brain and mind.

Despite the psychiatric, physical (e.g, increased rate of serious medical illness, even at first episode; [3, 16]), cognitive, economic, and social challenges associated with schizophrenia, people with schizophrenia are over-represented among artists [18–20]. Nevertheless, people with schizophrenia face great challenges in producing art, especially in institutional settings. At the outset it is important to note that most people with schizophrenia probably do not regularly perform visual art making on their own. Yet some do, and their artwork and art making process are an important and growing interest among researchers in a variety of areas of psychiatry, neuroscience, and other areas. However, interest in artwork by people with schizophrenia [21, 22], and with milder versions of psychotic symptoms (e.g., schizotypal symptoms) [23, 24] has a long history.

2 Visual Artwork by People with Schizophrenia

For decades before schizophrenia acquired its modern name and description [25], several European mental institutions displayed small collections of visual artworks by patients. But these works were typically viewed by the psychiatrists who collected them as curiosities, and were displayed along with escape tools and casts of patients' abnormal body parts as parts of the Wunderkammer tradition (i.e., cabinets of curiosity in central European aristocratic homes) that stretched back to the early Enlightenment era.

Concerted scientific study of art by people with schizophrenia began with a group of pictures collected from patients in a Heidelberg institution by psychiatrist Karl Wilmanns. With Wilmann's encouragement, the collection grew rapidly and systematically under the aegis of Hans Prinzhorn (1886–1933). Prinzhorn was a psychiatrist who studied art history as an undergraduate at the University of Vienna. Prinzhorn's goal of encouraging visual art making among psychiatric patients was not conceived as a form of therapy. Rather, the goal was to promote individual expression [26]. His hope, and expectation, was that the resulting works would be seen as reflecting the artists' actual perception, experience, and cognitive state.

By 1921, the collection contained around 5000 images, which were analyzed in Prinzhorn's landmark work *Artistry of the Mentally Ill* (1922). The book aimed to connect art historical formal analysis of the works with patterns of thought and behavior in patients, both to characterize general patterns found in the disorder, as well as idiosyncrasies of individual cases.

The works were by largely untrained artists, including, perhaps most famous among them today, Adolf Wölfli, a Swiss artist who likely had schizophrenia, and was also the subject of a biography by psychiatrist Walter Morganthaler [27]. Prinzhorn [28] describes, with apparent wonder, one of Wölfli's works (Fig. 1) as showing how:

> *a completely uneducated person with strong symbolic tendencies creates a form language for himself. For him the sheet is not intended for spatial depiction but for decorative division with flat stereotypical forms, each of which is given a distinct range of meaning by countless repetition. Similar pictures suggest that the large figure is a sort of guardian angel with wings. The drawer means himself by "St. Adolf, Great-God-Father." He repeats the snake and "birdie" motif, which was always very important to him, as often as possible by using the interstices. The "bell" motif on the edge shows that the sheet is also to be read as music, the "bells" indicating the meter. The suggestive effect of arbitrary colorfulness can hardly be shown more impressively than in this picture.*

Fig. 1 A work of Adolf Wölfli analyzed by Hans Prinzhorn. Public Domain

3 Critique of the Prinzhorn Approach

Despite Prinzhorn's clear engagement with formal properties of the work, there is an important difficulty in this approach. Like many other artists with schizophrenia whose work was part of the Prinzhorn collection, Wölfli was both untrained and mentally ill. Thus, the violation of art historical conventions is difficult to disentangle from the effects of the disorder. Indeed, Prinzhorn himself was well aware of this problem, but lacked the tools of modern vision science that could have helped him to move beyond it.

Nevertheless, modernist art historical narratives of works by people with mental illness tend to attribute to these images qualities associated with the disease, such as novelty-seeking, flexible associations, and lowered inhibitions. These impressions, which have little scientific basis, are of a piece with similar interpretations of other forms of "primitive" art (e.g., [29]).

Analyzing the artistic qualities and allusions of a work by an artist with schizophrenia is freighted with cultural biases rooted in Kantian philosophy and the notion of "fine arts". Indeed, treating the entire category of "art" as somehow distinct from other types of visual production is not supported by neuroscientific evidence, which has yet to show systems for the processing and appreciation of art that are separate from those of other stimuli [30].

4 Quantitative Study of Visual Artwork: Enter Vision Science

Yet, an artwork still holds important clues to the artist's visual experience. Artwork often seeks to depict objects and scenes from the physical world. One approach is to examine the "artistic transform" or the mathematical relationships between colors, intensities, and spatial distributions of photons in the world and those in corresponding artworks. Although direct comparison of a scene and its corresponding depiction is occasionally possible (see 31–33]), in the case of artwork by people with schizophrenia we would be left with just a few idiosyncratic transforms. Moreover, artwork—especially by people with schizophrenia, like Wölfli—is often dense with abstraction and bears little resemblance to a particular scene from the natural world, despite containing recognizable objects and spatial relationships of parts of scenes.

However, if we look at statistical properties of images in aggregate we can begin to make progress. The idea is to examine general statistical properties of a corpus of art images produced by larger groups of people with schizophrenia in comparison to diverse corpora sampled from the wide sweep of art history. This approach is sensible because there are constraints on low-level statistical properties of natural images, and, in turn, of artwork. Constraints on natural scenes are in a sense "assumed" in the architecture of human neural processing of vision (see e.g., [34]). These constraints result in regularities in artwork as well (though artwork has additional constraints including, typically, 2-D representation, lower dynamic range of

luminance, etc.). Put another way, humans share the same visual world, which possesses certain regularities, and should on average capture these regularities in art—at least to the extent that humans share low-level visual processing capabilities.

An important consideration in this discussion is the role of visual system changes in schizophrenia in relation to affective and higher cognitive changes that can also determine the nature of art that is produced. For example, people with schizophrenia, as a group (albeit a group with significant inter-individual variability) have been shown to experience less positive affect and more negative affect [35], have looser (i.e., less typical context-based) verbal associations [36], are more perseverative [37], have more intense visual imagery [38], have less visual and cognitive inhibition and more access to default mode network activity [39, 40], and experience more of the taken for granted (i.e., pre-reflective) aspects of mental experience [41], in addition to other cognitive and phenomenological changes [29, 42, 43]. This raises the questions of what comes first, and what is the relative importance of any of these factors (including basic visual changes) in art-making in schizophrenia. For example, while basic perceptual changes can lead to altered experience of the world, which can lead to delusional explanations and anxiety, it is also possible that phenomenological changes in the experience of the self and world can lead to shifts in vigilance and visual attention, and mood, that could affect perception. These issues are currently unresolved, and have not been a focus of research in schizophrenia. In the current chapter, our focus is on possible changes in the visual system that could account for the visual characteristics of art of people with schizophrenia. Our assumption is, based on much prior work, that these changes are part of the fundamental neurobiology of the disorder. However, the relative contributions of cognitive and affective factors to the art of people with schizophrenia, and to the perceptual changes that are reflected in that art, require further study. For example, visual hallucinations in schizophrenia appear to involve hyperconnectivity between the amygdala and visual cortex [44], and to the extent that these hallucinations influence the direction of visual art productions, these would then reflect both visual and affective changes.

5 Natural Image Statistics and Low-Level Vision

Natural scenes show strong pairwise correlations across space: neighboring points in scenes are likely to resemble one another in terms of light intensity, and this relationship decreases as the two points are moved further and further apart. This relationship holds across image scales: we can zoom in or out in a scene and we will find the same correlation (equivalently, we can consider a pair of "points" to be of almost any spatial size). This is termed $1/f$ behavior, since the Fourier spatial frequency amplitude spectrum typical of natural scenes falls as $1/f^p$ where p is about 1 for almost any natural scene. This means that the contrast energy is greatest for low spatial frequencies (large-scale structure) and falls off linearly with slope p at higher frequencies (when plotted in log-log coordinates).

In both representational art as well as abstract art, humans largely recapitulate the average spatial frequency spectra of natural images, generating slopes of about 1 [31, 32, 45–47]. In addition, artists largely recapitulate biases in spatial frequency amplitude across orientation, which is to say biases in edge and contour orientation. For example, horizontal lines are common in natural images. Their presence leads to greater average contrast in corresponding spatial frequency components, at least at low spatial frequencies, and therefore greater spectral amplitude for these orientations. As Schweinhart and Essock [33] and Essock and Schweinhart [48] have shown, artists depicting a particular scene largely reproduce this bias (as well as the bias for vertically oriented edges and contours, e.g., trees), in comparison to contrast energy at oblique orientations, though they found that this bias also existed in high spatial frequencies in art. This finding is consistent with our knowledge of visual system processing of scenes, which is likewise biased in terms of spatial filter orientations (e.g., [49]). Beyond the Fourier domain, edges and contours in general do show lower biases (i.e., lower orientation anisotropies) in artwork than in scenes but the differences are small and depend on image content [47].

We can explain these findings because artwork is designed for viewing by the eye, and therefore its structure is constrained by the properties of the world and by the evolved visual processing strategies that operate in that world. Consider an unnatural image: white noise. Humans have almost never sought to make such images by hand, which lack pairwise correlations [50]. In a white noise image, like Fig. 2, all pairs of points—regardless of their separation—have the same average correlation in intensity. Because neural mechanisms such as center-surround

Fig. 2 White noise patterns. Each pixel has been assigned a random intensity in these images. Thus, there is no average spatial correlation between pixel values. In contrast, natural scenes possess strong correlations between pixels, which fall off as a function of the distance separating the pixels. The lack of such regularities makes images very difficult to perceive, as in the white noise. For example, are these two images the same or different? The answer would be immediately obvious for almost any pair of natural scenes but is challenging for images lacking spatial correlations. (Answer: the two images are identical but the right image has been rotated by 90 degrees). Images by Daniel Graham

receptive field organization in the retina instantiate this and other assumptions of statistical regularities [51, 52], and because these neurons serve largely to feed the brain information about local deviations from natural scene regularities [52], the brain struggles to process such images. They are consequently "imperceptible" [50].

6 Visual Dysfunction in Schizophrenia

Given basic regularities in scenes and artwork, as well as neural systems adapted to such regularities, how might disease-related visual dysfunction affect these relationships? Visual dysfunction in schizophrenia has been observed at least since Kraepelin [53–55]). In recent years, psychiatrists, psychologists and neuroscientists have increasingly focused on the visual dimension of the disorder using modern neuroscientific tools. Though visual hallucinations have long been associated with the disorder, occurring in about 25–30% of patients, more subtle visual dysfunctions and their neural underpinnings have been increasingly demonstrated.

One of the most striking observations as to the importance of visual processes in schizophrenia is that very few, if any, congenitally blind or early blind persons have been recorded as having schizophrenia, with this inverse relationship being particularly strong in cases of cortical (vs. eye-related) blindness [56–58]. There is evidence that this potentially protective trait is specific to schizophrenia, and that other forms of sensory loss do not confer a protective effect against schizophrenia (and may actually increase risk, as in the case of deafness; [56, 59, 60]). One explanation for this could be that functional reorganization in the brain due to congenital/early (C/E) blindness augments specific perceptual and cognitive skills, in which deficits develop in schizophrenia, thereby reducing risk for developing psychosis. For example, C/E blind people show recruitment of visual cortex regions for somatosensory and auditory processing, which seems to correspond to enhanced performance of tasks involving touch, sound localization, speech discrimination, and other auditory tasks compared to controls (see e.g., [61]). In contrast, people with schizophrenia show lower average performance on sound localization and discrimination tasks compared to controls [56]. In those with C/E blindness, the recruitment of these areas for non-visual tasks may protect individuals from what might otherwise be core vision-related aspects of the disorder. It may be that without vision, there can be no visual dysfunction, and perhaps no schizophrenia. While direct evidence of this from animal models is lacking, it is consistent with findings of increased visual cortex plasticity in dark-reared mice [62, 63], and with the theory that congenital blindness is associated with increases in NMDA receptor functioning [64], which is the opposite of what is typically found in schizophrenia [65–67].

In sighted people, however, schizophrenia-related visual dysfunction can be highly consequential. There is now substantial evidence that the neurochemical effects of the disorder alter basic spatial processing in the retina and dorsal thalamus. Importantly, these dysfunctions would change the basic spatial statistics of the visual world as represented in the visual system of someone with schizophrenia. The interesting question for present purposes is, are these changes reflected in artwork by people with schizophrenia? We will present recent evidence relating to this

question. Importantly, by examining low-level statistical regularities common to the natural world, this work mitigates the possible conflation of violation of convention and effects of visual dysfunction.

What, then, is the evidence regarding basic visual dysfunctions in schizophrenia? Most (but not all) studies of contrast sensitivity show deficits among people with schizophrenia ([68–71]; see [54, 55] for a review). This means that, compared to control participants, people with schizophrenia require a larger difference in luminance between two adjacent image patches in order to detect a perceptual difference from uniformity. Deficits have been shown behaviorally using grating detection tasks [68, 72] and grating discrimination tasks [73], as well as with electrophysiological [68, 74–77], and fMRI approaches [78–80]. Studies have generally found greater deficits at low spatial frequencies (large-scale image structure; [68, 69, 71–73, 75]). Others have shown deficits across a wider range of spatial frequencies including lower and higher frequencies [70, 73, 81, 82]. However, the picture is further complicated by effects of medication, which are not fully understood. Data from unmedicated first-episode patients have shown enhanced contrast sensitivity, whereas data from people with more years of being ill (whether medicated or not) show reduced contrast sensitivity [54, 55]. In any case, contrast processing deficits appear related to specific neuro-biochemical dysfunctions [68, 74, 78], although again in complex ways [54, 55].

What can these deficits tell us about art making? Interestingly, compared to controls, contrast processing deficits have been shown to be greater at higher luminance levels, i.e. well above absolute luminance thresholds [70]. Since most natural vision is also suprathreshold, this suggests that these deficits may be more than just a laboratory curiosity, and in fact would impact patients in most natural situations. These deficits might be especially salient in art making because making a representational work requires not only careful observation of light and contrast in a scene but also on the canvas, and indeed of the relationships between the canvas and the scene. And even when there is no referent tableau, the canvas itself must be highly scrutinized using spatial vision.

To complement laboratory studies of visual performance on spatial frequency detection tasks in patients (and models of neural underpinnings of performance differences), researchers have studied visual artwork by people with schizophrenia as a window into their naturalistic visual experiences. To the extent that art by people with schizophrenia differs systematically from art more generally, the question arises of whether we can possibly explain such differences in terms of low-level statistics of contrast in artwork.

7 Using Knowledge of Visual Deficits and Image Statistical Measures to Study Visual Art Making in Schizophrenia

Graham and Meng [83] first studied potential effects of contrast sensitivity deficits in schizophrenia on art making. They measured the spatial frequency amplitude spectrum of digitized images, where amplitude corresponds to contrast at a given

spatial frequency, averaged across orientations. They collected 12 high-resolution images of paintings by people with schizophrenia in the NARSAD Artworks collection. In addition, they studied a corpus of 39 works by an artist with schizoaffective disorder, Karen Sorenson. Both sets showed average spatial frequency amplitude spectra that fell as $1/f^p$. However, the slopes of the spectra were significantly steeper (more negative value of p) compared to a corpus of Western painting (Fig. 1). This implies that artists with schizophrenia compensate for lower contrast sensitivity at low spatial frequencies by increasing contrast energy in this range in particular. At the same time, other basic image statistics did not show consistent patterns of difference between the artists with schizophrenia and controls. For example, pixel intensity variance, which is related to total contrast energy, was not significantly different between the schizophrenia and control groups. Graham and Meng [83] also asked if there were differences in terms of anisotropies in edge orientation: these would not be expected since proposed neurochemical and neurodynamic models of spatial frequency deficits do not predict biases of deficits in terms of orientation. Supporting this hypothesis, they found that the image sets did not show significant differences in overemphasis of edges and contours at particular 2D orientations. Instead, the schizophrenia and control groups both largely recapitulated statistical biases for horizontal and vertical orientations found in natural scenes (see Table 1) (Fig. 3).

As with the study of contrast sensitivity deficits, an important question in the analysis of artwork by people with schizophrenia is again the effect of medication. In Graham and Meng's [83] study, measurements across the corpus of the artist with schizoaffective disorder (Karen Sorenson) also allowed analysis of the influence of medication since the artist recorded the medication being taken during the production of each work. Graham and Meng [83] did not find differences in amplitude spectrum slope across paintings made during treatment with four different antipsychotic medications. Because Sorenson maintained consistent medication during this time, a comparison with no medication was not possible; in fact, Sorenson reports that she takes medication largely to provide the energy and focus needed for art making [84]. In any case, longitudinal studies are needed that examine large samples of artists with schizophrenia over time at different chlorpromazine (or

Table 1 Mean statistics by image class, with standard error in parentheses

Image set	Amplitude spectrum slope	Anisotropy index	Pixel intensity mean	Pixel intensity variance	Pixel intensity skewness	Pixel intensity kurtosis
Artists with Schizophrenia	–1.421* (0.045)	0.307 (0.006)	150.8* (7.3)	2386.3 (199.2)	–0.063 (0.163)	–0.410 (0.278)
Sorenson paintings	–1.425* (0.017)	0.293 (0.001)	109.3* (6.3)	2824.7 (220.4)	0.466 (0.137)	–0.071* (0.194)
Control group	–1.229 (0.014)	0.302 (0.002)	119.6 (3.5)	2464.5 (150.5)	0.046 (0.096)	1.054 (0.25)

*indicates significant differences ($p < 0.05$) in these statistics compared with the control group, calculated according to a two-sample t-test

Data from Ref. [83]. CC-BY

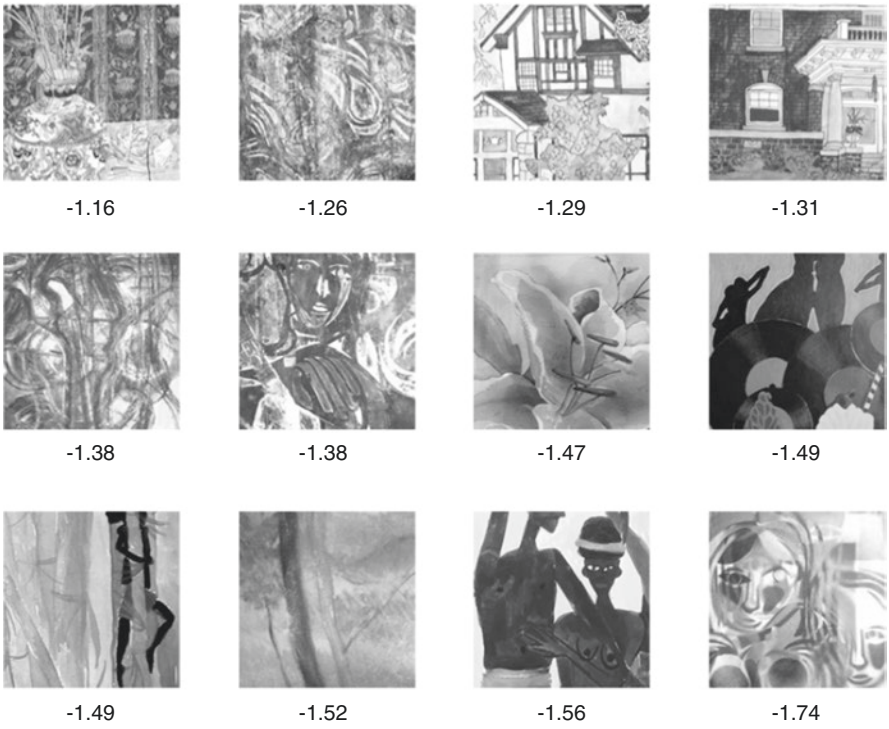

Fig. 3 Portions of the paintings by artists with schizophrenia analyzed in this study, shown with calculated amplitude spectrum slopes. From Graham and Meng [83]. CC-BY

olanzapine) equivalent doses of medication, and on and off medication, as well as at different phases of illness (e.g., prodromal, acute, stabilization, stable; see discussion of Louis Wain, below).

Redies and colleagues [85] performed a similar analysis on a larger data set comparing spatial frequency spectrum slope for 14 artists diagnosed with or presumed to have schizophrenia whose work is included in the Prinzhorn collection (see Fig. 4). These images were compared to large samples of Western art. They measured the spatial frequency power spectrum, which is the square of the amplitude spectrum, which falls with a slope of about −2 for natural scenes. As with Graham and Meng [83], Henemann et al. [85] compared the mean slope for the schizophrenia group to that of several corpora of Western artwork. These control works were organized into separate sets of media (graphic and painted works), and the type of medium does seem to affect this analysis. They found that the schizophrenia group had amplitude spectrum slopes that were significantly steeper (increased contrast energy in large-scale structure) than the control sample of graphic art (drawings, lithographs, etc.). On the other hand, the slope of the schizophrenia group was significantly shallower (increased contrast energy in fine detail) than that for the Western paintings (a grouping that did not include graphic works). However, unlike

Fig. 4 Images by an artist with schizophrenia, Paul Goesch, from the Prinzhorn Collection, which were among those tested by Henemann et al. [85]. The Fourier power spectrum slope of these images (labeled a-f) is shown in the accompanying plot along the horizontal axis (vertical axis corresponds to the sigma for linear fits, indicating deviation from linearity). Red dots indicate other images by this artist. These can be compared to slopes for works by artists assumed not to have been affected by schizophrenia: pink dots indicate oil paintings; green dots indicate graphic art; and light blue dots indicate "Bad Art" (i.e., works deemed kitsch). Reproduced from Henemann et al. [85], CC-BY

Graham and Meng [83], the Henemann et al. [85] sample of schizophrenia works included both paintings and graphic works, as well as calligraphy. Thus, these results are somewhat ambiguous because of the effects of artistic media. Paintings overall have a lower (more negative) slope compared to graphic works, likely due to the inclusion of more shading and chiaroscuro in painted media. Because the proportion of paintings versus graphic works in the schizophrenia sample is not specified, it is hard to draw conclusions from these data. In addition, two of the artists had unknown diagnoses. Henemann et al. [85] did find significant differences in edge orientation biases (i.e. anisotropies in edge orientation energy) between the schizophrenia works and both graphic and painted Western art. However, these differences were small.

8 Repetition and Micrographia

Going back at least to Prinzhorn, observers have remarked on the repetitive, finely detailed elements of many artistic productions by people with schizophrenia. Are these visual traits characteristic of art by people with schizophrenia? There are a variety of hypotheses one could put forward.

Micrographia and repetitive marks would leave traces in spatial frequency spectra. A large area filled with small, ordered marks would boost relative amplitude of high spatial frequencies. All else being equal, this would lead to a flatter amplitude spectrum (p closer to zero). More generally, repetitive marks—especially grids of points—would boost specific spatial frequencies corresponding to the frequency of the grid. However, there was no evidence for this effect in Graham and Meng's [83] data, and it is not possible to discern if the effect was present in Henemann et al.'s [85] data due to confounds introduced by differences in media.

However, several other factors could be at play. In one view, repetition and micrographia may not be primarily related to visual dysfunction. The Prinzhorn collection artworks tested in the Henemann et al. [85] study were produced by institutionalized people, which could have contributed to repetitive elements and/or micrographia. This is because these artists may be more likely to use graphic media that are close at hand like pencil and crayon, rather than oil pigment, and these media facilitate creation of small marks as well as repetition, whereas paint is less conducive to such patterns since the brush needs to be loaded with pigment frequently. It is possible that repetitive imagery could be in part a side-effect of antipsychotic (dopamine D_1 and/or D_2 receptor antagonist) medication, which can cause Parkinson-like symptoms, including micrographia (small writing). However, examples of repetitive imagery such as Wölfli's predate the use of antipsychotic medications. It is also possible, however, that repetitive drawing/painting behavior could be due to excessive dopaminergic tone in the basal ganglia, and perseveration could be due to reduced frontal lobe dopaminergic activity [86], both of which have been observed in schizophrenia [8, 87, 88].

The possibility that contrast sensitivity deficits are broadly distributed across spatial frequency, rather than being limited to low spatial frequencies, may also be relevant. At suprathreshold levels [70]. contrast sensitivity deficits are of similar relative magnitude at low (0.5 cycles/degree), medium (4.5 cycles/degree) and high (11 cycles/degree) spatial frequencies (and at very short and longer presentation times). In this case, artists with schizophrenia may selectively boost contrast at low and/or higher spatial frequencies to make image structure visible to themselves, depending on the needs of the artwork: representing scenes may require boosting contrast at lower frequencies, while works that make use of fine detail could require boosting higher frequency contrast, in part with repetitive or grid-like patterns. In aggregate, these effects may cancel out. In any case, larger and more careful study of the effects of media and image content on art making in schizophrenia is warranted.

9 Perceptual Disorganization

Repetitive elements may also reflect a perceptual organization deficit leading to an excessive focus on detail at the expense of the whole/Gestalt. For example, relative to controls, schizophrenia patients, especially those with disorganized symptoms (e.g., fragmented thought and speech, unusual movements) have trouble integrating

separated contour segments into shape representations (reviewed in [89–91]). This implies that patients are less able to integrate image elements, especially across larger areas of space, into object representations a hypothesis that has been confirmed in an fMRI study of perceptual organization in schizophrenia [92]. Although artists with schizophrenia such as Wölfli show a clear ability to execute a composition across extended areas of space, there is often evidence of fragmentation and reduced integration within a given area of space.

These effects may contribute to altered representations of whole objects and scenes in art by people with schizophrenia. Subjective experience of this impairment can be seen in the following statements from patients (cited in [93, 94]): "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" [95]; 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" [96]. In the two images below, painted by the daughter (unknown diagnosis) of a mother with schizophrenia, fragmentation is seen in the form of what Jung [97] called "lines of fracture", which he believed revealed psychic "faults" that revealed severe alienation from feelings, and that were found in the art of people with schizophrenia and others (including Picasso) with similar issues of alienation from self and others (i.e., schizoid features). In our view, this type of fragmentation in the art of people with schizophrenia may also reflect a reduced perception of wholeness in faces and other objects, and therefore represent an attempt to express the feeling of fragmented perception and the sense of emotional distance it causes.[1] In schizophrenia, the experience of fragmentation in vision is also observed in scene perception, such as 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." [98] (Fig. 5).

There are several potential sequelae of perceptual organization failures in people with schizophrenia that are also relevant to art production. One is that, as a result of the lack of an overall Gestalt, individual details in an object (or individual objects in a scene) may capture attention and become infused with excessive meaning. A second consequence is that the distinction between what is figure and what is ground can become unstable, leading to a sense of disorientation, and also heightening a focus on normally irrelevant details. The perceptual organization impairment is also found in moving stimuli. For example, medicated individuals with schizophrenia have higher thresholds for detecting coherent motion of random dot patterns [99].

[1] In some respects, the fragmentation observed in face portrayals of people with schizophrenia resembles the fragmentation seen in prosopagnosia, a more severe condition characterized by an inability to integrate facial features into a coherent whole. While we could not identify scientific studies of this issue, reports and examples of art of people with prosopagnosia have appeared in the popular literature, e.g., https://www.bbc.com/news/stories-53192821

Fig. 5 Examples of portraits showing lines of fracture, which Jung [97] believed were characteristic of artwork by people with schizoid features. Works of Irene Kleinman, 1909–1980. Collection of Steven M. Silverstein

Other visual changes in schizophrenia that also may affect art creation include changes in intensity of light and color, reduced perceptual stability, an increased tendency towards metamorphopsia (changes in object form, including the appearance of one's own body) and prosometamorphopsia (changes in the appearance of faces), distorted experiences of space (e.g., flatter, deeper), and increased abstraction, among others (reviewed in [93, 94]). These perceptual changes are often frightening, and are accompanied by subjective changes of meaningful alterations in the self or the world, emotional consequences which can also affect the artistic representation of the world (see also [100]).

Possible examples of these changes have been hypothesized to have occurred in the art of Louis Wain (1860–1939), who is famous for his drawings and paintings of cats (and the subject of the 2021 fictionalized biographical film *The Electrical Life of Louis Wain*). As seen in Fig. 6, there are striking qualitative differences between his renderings of cats from early in his career compared to later in his life, when he was diagnosed with schizophrenia and spent long periods of time in psychiatric hospitals. His later images demonstrate many features commonly associated with art, and perception, in people with schizophrenia. There is controversy, however, over whether Wain actually had schizophrenia [102, 103], and the extent to which his art reflected changes in his mental functioning vs. changes in artistic style over time (which occurred with many artists living during the same era, including Picasso, Braque, Klimt, etc.). This and similar demonstrations must be considered

Fig. 6 A realistic drawing of a cat from early in Louis Wain's career (top) and a series of drawings from later in his life while in psychiatric hospitals (bottom). The images in the bottom panel demonstrate hyperintensity in color, distortions of form, integration of figure and ground, increased abstraction and (in the last 3 images) emergence of mandala-like characteristics, which are often interpreted as compensatory efforts to preserve psychic stability [101]. Note that the chronological order of the images in the bottom panel is not known, nor is the degree to which the level of abstraction corresponds to levels of psychosis vs. remission over time. Top and bottom images are in the Public Domain

Fig. 6 (continued)

tentative, interesting, and suggestive, until research data is obtained on the relationships between these perceptual changes noted above and artistic works in people with schizophrenia.

Although the quality and generalizability of the evidence reviewed above varies greatly, several summary points can be extracted from the discussion. These include that: (1) there are a number of significant changes in visual perception that could be expected to affect visual artistic productions in people with schizophrenia; (2) at the same time, since there is no perceptual or cognitive impairment, or symptom, that is shared by all people with the disorder, there is no characteristic of visual art that should be expected to be present in the art of all people with the disorder; and (3) even in cases when between-group differences in perceptual (or other aspects of the disorder) signs and symptoms are present, there is significant overlap between groups [104]. Therefore, art by people with schizophrenia is not *sui generis*. Given this, one intriguing possibility is that the strength of the visual deficit in an individual might be positively correlated with the amount of statistical variation in their artwork, albeit in a way that may be moderated by media, current artistic trends, medication, illness phase, scene content, and other factors.

10 Visual Deficits and Art Appreciation

We briefly turn to the question of how visual deficits might affect the appreciation of art. Chen et al. [105] investigated schizophrenia patients' aesthetic judgments of two famous Western artworks and one natural landscape photograph after manipulation of basic image properties. The idea is that, if schizophrenia patients experience visual deficits, they should be less sensitive to manipulations of images that align with those deficits. If this were the case, one might conclude that people with schizophrenia are less able to appreciate a work of art since they are less sensitive to certain forms of variability. However, Chen et al. [105] found that the effects of visual deficits do not show strong evidence of manifesting in aesthetic responses: some manipulations showed marginally significant differences in aesthetic ratings between patients and controls. In particular, patients' decrements in ratings compared to unmodified art and landscape images were smaller for certain

manipulations (removal of color; high pass filtering; and polygonization, i.e., local averaging of pixel values in polygon regions). However, population response differences were slight in these cases and no differences were found for other manipulations (low pass filtering and white noise addition). There is also known to be high subjectivity (high baseline inter-rater disagreement in aesthetic judgments of images, especially art and abstract images; [106, 107]) and high intra-individual variability[108] in aesthetic preference judgments, along with a small cohort in the Chen et al. [105] study (29 patients and 30 controls). It is also likely that changes in art appreciation after the premorbid phase will be influenced by the current severity of symptoms and overall disease burden, in addition to the chronicity of the illness. Larger, more systematic studies will be needed to determine if and how art appreciation is affected by visual dysfunction.

11 The Question of "Generalized Deficits"

It has been suggested that tests for sensory and perceptual deficits in schizophrenia may be confounded by a "generalized deficit": patients' performance could be due to general difficulty with cognitive tasks, rather than a specific sensory or processing deficit [109, 110]. However, there is now ample evidence from experimental paradigms that control for these confounds that visual deficits are often independent of generalized deficits [111, 112] and that a number of them precede the onset of the diagnosis by many years [15, 113–115] and can be found in young people at high risk for the disorder. In terms of art making, the large output of some—but certainly not all—artists with schizophrenia also argues against the notion that "generalized deficits" in schizophrenia limit or preclude artistic output, given the large degree of cognitive performance (e.g., planning and attention) needed to produce a finished work.

In addition, there is evidence that visual dysfunction can generate "superior," i.e., more veridical, perception of 3-D stimuli that normally cause illusions, in people with schizophrenia compared to both normal controls and people with bipolar disorder [116]. People with schizophrenia also appear less susceptible to pareidolia, i.e. mistaking face-like patterns for actual faces [117]. These findings may in fact have interesting implications for art making. If people with schizophrenia are more able to perceive what is actually in the photoreceptor array (cf. [118])—rather than what prior knowledge and visual processing tell us *should* be there—this may help to explain apparent differences in their art.

Putting these findings together, we propose that artists with schizophrenia might be less reliant on matching the brain's expectations of scene layout and appearance, and instead be able to capture idiosyncrasies of scene structure. This ability may also mean that artists with schizophrenia can escape representational expectations imposed by artistic convention—even if they are trained artists, and even if their work is abstract—since the visual world they experience may be less biased by prior experience [119].

A tentative example of this representational approach might be shown in the painting The Fairy Feller's Master Stroke (1855–1864) by Richard Dadd (Fig. 7),

who suffered long periods of psychosis linked to schizophrenia (though other causes of his psychosis cannot be ruled out). This painting, unlike most Western representational art, includes naturalistic occlusions and conjunctions and it lacks highlights around contours. Typically, Western representational art avoids potentially confusing occlusions and conjunctions [120] and it often uses simultaneous contrast to

Fig. 7 *The Fairy Feller's Master Stroke* (1855–1864) by Richard Dadd. Dadd, who suffered long periods of psychosis, is notable for its contravention of certain types of representational strategies typical in Western art, which may be characteristic of psychosis. Public domain

bring out contours. These techniques promote readability of images and may align with predictive strategies of object perception in the brain [121]. But such representations differ from typical natural scenes. In defying conventions and expectations, Dadd captures something perhaps closer to raw, idiosyncratic scene data.

But to make the images visible to themselves, artists with schizophrenia may need to boost contrast energy beyond what would be needed in an artist without schizophrenia. When and how these alterations are introduced may be individualized and depend on both illness-related factors and scene content and media. It will be interesting to see if these effects can be disentangled. It has already been demonstrated, however, in a computational modeling study of schizophrenia, that reduced strength of retinal cell activity of the type found in patients (reviewed in [122]) could lead to compensatory increases, at the level of visual cortex, in perception of features such as contrast and brightness [93, 94].

12 Art Making in Schizophrenia: A Wider View and a Case Study

Though it is beyond the scope of this chapter to discuss in detail, artistic activities are today seen as a promising avenue for therapy in schizophrenia and other mental disorders (see, e.g [123]., for a large review of evidence). Yet as Prinzhorn argued, people with schizophrenia may wish to simply express themselves, and to do so outside of a therapeutic regimen.

Even in the grip of psychosis, artistic production may continue, albeit in rigid forms. The need for expression is indeed an important aspect of art making in schizophrenia, but one that is difficult to study empirically. It can be helpful to consider case studies such as that of Henry Cockburn, an artist with schizophrenia (see Fig. 8) who has documented his life and art in a book co-authored with his father, journalist Patrick Cockburn [125]. Their joint work sheds light on some aspects of art making in schizophrenia such as repetitive elements. In a subsequent article in the *Independent* newspaper, [124], Patrick writes:

> *When Henry was sunk deep in psychosis, he would draw what he called "a rune" – a sort of ideogram – again and again on a piece of paper. When he was slightly better, this would change to his tag or graffiti name again drawn time after time on different sheets of paper. The next step in his return to rationality was the gradual appearances of people, houses, streets, cities, trees and birds in his pictures.*

A case study of this kind also helps psychiatrists and other practitioners, as well as the wider society, to understand how people with schizophrenia who create artwork wish to be viewed by society and understood as artists. As Henry [124] puts it,

> *When people ask me what my profession is I answer "I'm an artist". When people ask what my art is about, I say that it tells stories. Then when people ask what the stories are about I stumble.*

Fig. 8 *Hunted* by Henry Cockburn [124]. Used with permission of the artist. http://www.henry-cockburn.com/paintings/

13 Cautions in Studying Art Making in Schizophrenia

It is crucial in this area of inquiry that we not read too much into artwork by people with schizophrenia as this has historically lead in dangerous directions. In 1818, a British magistrate sentenced Jonathan Martin to lifetime confinement in an asylum in large part based on the court's viewing of Martin's "strange drawings." Moreover, the notion of "degenerate art," and the need to destroy it, were amplified by the Nazi regime in the 1930s with devastating consequences (see [126]). Indeed, following Prinzhorn's death in 1933, the collection's new director, Carl Schneider, used it to attack modern German artists as "degenerate." Schneider soon helped launch the regime's infamous T4 program that murdered hundreds of thousands of German and Austrian psychiatric patients including thousands of children, and sterilized hundreds of thousands more [127]. No study of art making in schizophrenia should be undertaken without serious consideration of this dark history or of the possibility of unintended stigmatization of those with the disorder resulting from such research.

14 Outlook

We have seen how vision science can inform cautious research into art making processes and their interplay with neural processing mechanisms in the visual system. The goal is to leave aside high-level interpretations of the content of artwork by people with schizophrenia and instead focus on basic visual structure relevant to natural human vision. If successful, we may gain greater insight into patients' natural experience of the illness as well as putative group-level differences in their patterns of art making. Further study is needed and will have the benefit of building on studies of basic statistical regularities in visual artwork created by people with schizophrenia.

Indeed, much remains unknown. How might other statistical regularities in artwork be affected by visual deficits? For example, all artists must compress the large range of luminances in a scene down to the far smaller dynamic range available in flat media with pigments [128]. This compression serves to make luminance distributions more Gaussian and less skewed. Though Graham and Meng [83] found no significant differences in pixel intensity skewness between controls and artists with schizophrenia, the images were not calibrated for luminance. It is important to determine the degree of covariation between between heightened affect and increased sensitivity to certain visual features such as color, contrast, (implied) motion, or high spatial frequencies, and conversely, between reduced affect or sad mood and reduced perception of these same features, as has been preliminarily observed in patients with major depressive disorder [129, 130]. Covariation of perceptual sensitivities, or degrees of compensation, with level of psychosis is another important an unexplored issue.

One method in vision science research that has recently been applied with increasing success to the study of visual art is the study of color statistics. This approach exploits new hyperspectral imaging systems that measure reflected wavelengths in many narrow bands, rather than in three sensors with overlapping sensitivity, as in standard imaging systems. A series of studies by Nascimento and colleagues has shown that artists statistically match viewers' expectations of color use across a canvas [131–134]. For example, Nascimento et al. [133] gave observers the opportunity to shift color palettes of abstract paintings systematically through a perceptually uniform color space, starting from an image with a randomly-shifted gamut (derived from hyperspectral images). After performing "gamut rotations," observers came close to matching the original color relationships of the painting (a similar result has been obtained for natural images; [135]). This result holds even when pixels are scrambled [136]. Interestingly, people with schizophrenia have been reported to have higher incidence of color vision deficiencies compared to the larger population [137] and patient reports of distortions of color perception are common [138]. There is evidence that color deficiencies are in general relatively subtle and idiosyncratic in schizophrenia, and partly due to medication ([139]; see also [140]). In addition, there is evidence for disturbances in cone photoreceptor function in people at increased genetic risk for schizophrenia [113, 141]. In principle it should be possible to link color vision deficits with differences in color

palettes used in artwork (as measured with hyperspectral imaging) to further clarify this issue.

With further study, we may ultimately be able to determine the extent to which alterations in visual art by people with schizophrenia relative to unaffected individuals reflect low level visual deficits as opposed to cumulative effects of low- and high-level deficits, possibly in combination with motor dysfunctions [142]. It will also be necessary to disentangle effects of medication.

Finally, and more generally, we would like to know what influences the proclivity of people with schizophrenia to make art in the first place. Data indicating an over-representation of people with schizophrenia (as well as people with bipolar and major depressive disorder) among artists has led to speculations that the perceptual and conceptual differences associated with these disorders are linked genetically to creativity [20]. If this is true, an important issue is how this trait would survive throughout evolution since most people with schizophrenia (especially men) don't have children. It has been proposed that at least some of the genes/alleles that predispose to schizophrenia allow people to perceive, structure, and conceptualize the world differently than others, and this can lead to being great artists, inventors, and other types of innovators, a status associated with increased mating opportunities. However, excessive expression of these genes (perhaps due to epigenetic factors) and/or too many of the schizophrenia-related alleles can be disabling when they create the syndrome we call schizophrenia, thereby reducing mating opportunities [18, 19]. A related line of thought suggests that personality traits such as high openness may promote creative behavior when paired with other traits. To the extent that these traits are relatively abundant in schizophrenia, they may help explain apparent evolutionary survival of creative enhancement in the disorder [143, 144].

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