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Artistic Production Following Brain Damage: A Study of Three Artists

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The cognitive neuroscience of aesthetics is in its infancy. Only recently has neuroscience joined a tradition of empirical aesthetics that dates back to Fechner in the 19th century [1]. With rare exceptions, it is not clear that neuroscientists consider aesthetics worthy of inquiry. Conversely, some aestheticians probably consider neuroscientific inquiry into aesthetics an abomination.

In this paper, we explore a specific domain within neuroaesthetics: the effects of brain damage on artistic production [2,3]. Neuropsychology has been instrumental in advancing our knowledge of various complex systems, such as perception, memory and language, but its impact on the study of aesthetics has thus far been relatively minimal. The limited data from which one might draw inferences on the subject are most often found in book chapters rather than in on-line journal articles, hindering their availability. Beyond the constraints of limited data and impediments to its access, fundamental questions about proper methods within the field remain unanswered [4]. Finally, a deep underlying concern is that perhaps the entire effort is misguided. Art, by its very nature, might resist the kind of reduction insisted upon by science. Alternatively, once filtered through the lens of science, art might lose the very qualities that make it a special human endeavor.

How might we make best use of the experiences of artists who have suffered brain damage in order to better understand the effects of brain damage on artistic production? One strategy is to examine instances in which brain damage produces a change in artistic output [5]. The effect of brain damage on the capacity to produce visual art contrasts sharply with that on many other human capacities. Diseases of the brain can impair

our ability to talk, move, recognize objects, apprehend emotions and make logical decisions. By contrast, while diseases of the brain can certainly alter the ability to produce art, the alterations are sometimes considered improvements. Cases of improved artistic abilities fall into a general class of paradoxical functional facilitations produced by brain damage [6].

In the clinical experience of author Chatterjee, relatively few visual artists continue to produce art after brain damage, rendering it difficult to find many pre- and post-morbid works of art for empirical study. However, several case studies of artists who experienced neurological disorders do consider changes in their artwork in the context of the location and extent of neural damage [7,8]. When such cases are examined, the analyses of post-morbid stylistic differences, although often detailed, generally lack quantitative and blind approaches in assessing changes produced by brain injury [9]. How can one be certain about changes in artistic production rendered by brain damage without a measure of the artwork itself? Claims about changes in art after brain damage are typically made post hoc. These claims are then supported by one or two illustrative examples.

An instrument for assessment of artistic change is desperately needed. We have argued elsewhere [10] that such an instrument should be componential—it should assess different components of artwork—and it should be quantitative, so that hypotheses can be tested formally. To address this need, we recently developed the Assessment of Art Attributes (AAA) [11].

The AAA assesses 12 descriptive attributes applicable to any piece of visual art: six attributes refer to formal/stylistic properties and six to content/representational properties. In the primary stage of the experiment, participants in this study were asked to do a preliminary assessment of 24 paintings from the Western canon. These are paintings by well-known artists but not their most famous works. Participants rated each painting with respect to each of the 12 attributes. This procedure ensured that the participants were familiarized with the specific attributes of interest. In the application stage of the experiment, participants were then presented with the work of the three artists we are interested in for this study and

ABSTRACT

We know little about the neurologic bases of art production. The idea that the right brain hemisphere is the “artistic brain” is widely held, despite the lack of evidence for this claim. Artists with brain damage can offer insight into these laterality questions. The authors used an instrument called the Assessment of Art Attributes to examine the work of two individuals with left-brain damage and one with right-hemisphere damage. In each case, their art became more abstract and distorted and less realistic. They also painted with looser strokes, less depth and more vibrant colors. No unique pattern was observed following right-brain damage. However, art produced after left-brain damage also became more symbolic. These results show that the neural basis of art production is distributed across both hemispheres in the human brain.

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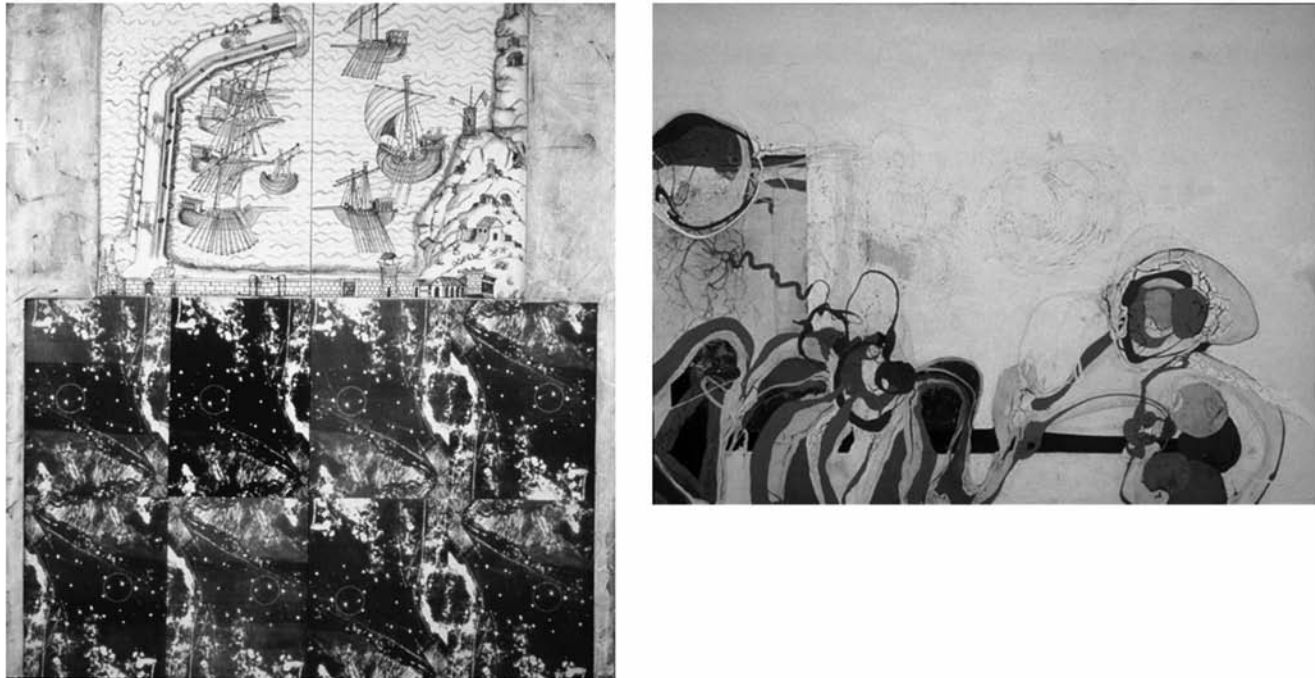


Fig. 1. Left: Katherine Sherwood, *Test Sites*, mixed media on canvas, 203 × 183 cm, 1992. (© Katherine Sherwood) Right: Katherine Sherwood, *Cart before the Horse*, mixed media on canvas, 208 × 274 cm, 2003–2004. (© Katherine Sherwood) Examples of paintings by Katherine Sherwood completed before her stroke (left) and afterward (right).

made the same ratings. These works were presented in random order, and the participants were not made aware of which paintings were created before and which after the artists' neurological injuries. Below we give brief descriptions of the three artists under consideration.

STUDY SUBJECTS

Katherine Sherwood

Katherine Sherwood is a practicing artist and professor at the University of California at Berkeley. She describes her pre-morbid work as highly cerebral [12]. She integrated images such as transvestites, medieval Solomon's seals, spy photos and bingo cards, incorporating themes such as sexual identity, militarism and luck. In 1997 she suffered a left-hemisphere stroke, which led to right-sided hemiparesis and aphasia. Although her language has improved significantly, she hesitates in conversation and speaks with an unusual cadence [13]. Motor control on the right side of her body has only recovered modestly, and she cannot paint with her right hand. She has since learned to paint with her left hand. Her post-morbid work is described as raw, intuitive and flowing [14] or as more abstract, gestural and expressionist [15]. David Ross, the director of the San Francisco Museum of Modern Art and former curator of the Whitney, called the new work "more visceral, and less intellectual" [16] (see Fig. 1).

Zlatio Boiyadjiev

Zlatio Boiyadjiev (1903–1976) was a highly regarded Bulgarian painter. In 1951 he also had a large left-hemisphere stroke, which led to aphasia and right-sided weakness [17]. Like Sherwood, he learned to paint with his left hand. Pre-morbidly, Boiyadjiev's work has been described as using deep earth tones and containing large solid figures. His style was considered natural and pictorial [18]. After the stroke, Brown [19] described Boiyadjiev's work as fantastic and sometimes bizarre, similar to dream cognition. The post-morbid work was described as richer, more colorful and dazzling, with fluid, energetic lines, displaying vigor and inventiveness. An example of Zlatio Boiyadjiev's pre-morbid paintings can be seen at <www.nationalartgallerybg.org/index.php?l=60&id=63>, and an example of his post-morbid work can be found at <<http://elenak.blog.bg/photos/24081/original/zlatu.JPG>>. We used both examples in this study.

Lovis Corinth

Lovis Corinth (1858–1925) was one of Germany's most popular painters in the early 20th century. He had a large right-hemisphere stroke in December 1911. After his stroke, his work initially showed signs of left-spatial neglect, a disorder characterized by a lack of awareness of left visual space [20]. Typically, spatial neglect is expressed with omissions and

deformities on the left side of the canvas. Alfred Kuhn, a contemporary of Corinth, provided the following observations just after Corinth's stroke regarding his post-morbid work:

The contours disappear, the bodies are often as if ripped asunder, deformed, disappeared into textures . . . also the faithfulness of portraits had ceased almost entirely . . . all detailed execution came to nothing. With wide stripes the person is captured in essence. Characterization is now exaggerated, indeed, often to caricature [21].

More recently, Blanke [22] described Corinth's paintings after his stroke as having broader brush strokes as well as less depth and spatial detail. Bázner and Hennerici analyzed shifts in Corinth's post-morbid style and noted that work produced several months after the stroke had little evidence of left-spatial neglect but described "increased subjectivity," "coarsening of structure" and "distortion of faces" [23]. Examples of Corinth's paintings used in the study are shown in Fig. 2.

The motivation underlying our investigation is as follows. Strokes are often limited to a single hemisphere of the brain, leaving the other relatively intact. For example, a right-hemisphere stroke damages right-hemisphere functions while sparing the structural and functional integrity of the left hemisphere (and vice versa for a left-hemisphere stroke).

As some functions are lateralized to either the right or the left hemisphere, a unilateral stroke will differentially affect certain abilities. Typically, the right hemisphere is thought to be dominant for visual and spatial processing and the left for language processing. In terms of aesthetics, the notion that the right hemisphere is responsible for creativity has led to the common belief that this hemisphere harbors artistic abilities [24,25]. Alternatively, if art is thought of as a medium of communication akin to language, one might expect left hemisphere damage to be severely disruptive. With this study, we hope to explore the question of hemispheric contributions to art production by examining the work of established artists who continued to paint after experiencing either a right- or left-hemisphere stroke.

We examine Sherwood's and Boiyadjiev's work to learn if there are consistencies in how their art changed following similar left-hemisphere brain damage. One would infer that a combination of left-hemisphere deficits and a right hemisphere released from constraints imposed by the left hemisphere renders these changes. To further limit inferences about laterality drawn from their work, we investigate Corinth's work simi-

larly. If there are consistent changes seen in Sherwood's and Boiyadjiev's paintings, are these changes specifically a consequence of left-brain damage or a consequence of brain damage in general?

METHODS

Sixty participants (37 men, 23 women) assessed the work of Zlatio Boiyadjiev and Katherine Sherwood, and 30 (28 men, 2 women) assessed the work of Lovis Corinth. Fifteen subjects participated in both groups. The average participant ages were 21.0 years and 20.2 years, respectively, for the two groups. All participants were given a questionnaire before testing that gauged their experience with visual art. Questions asked included number of studio art and art history classes taken, time spent making and looking at visual art and frequency of visits to art museums and galleries. Despite the fact that two different groups of participants rated the work of the three artists, all participants had similar degrees of familiarity with and knowledge of visual art.

The AAA is briefly described here [26]: Participants were shown 24 paintings from the Western canon, presented in random order. These paintings were created by well-known Western artists

but their most commonly depicted works were excluded (Table 1). Paintings were selected to cover considerable range in the six formal/perceptual and six content/representational attributes of interest. The six formal-perceptual attributes (Table 2) were: *balance* (more/less), *color saturation* (calm/vibrant), *color temperature* (warm/cool), *depth* (flat/deep perspective), *complexity* (simple/complex) and *stroke style* (controlled/loose). The six conceptual-representational attributes (Table 3) were: *abstractness* (abstract/representational), *animacy* (less/more), *emotionality* (less/more), *realism* (less/more), *representational accuracy* (accurate/distorted) and *symbolism* (literal/metaphoric).

All participants saw a training slide providing a description of each attribute and a hand-drawn pictorial training slide demonstrating the extremes for that attribute. They were given verbal instructions on how to proceed through the battery and were allowed to ask questions. After viewing training slides for each attribute, participants rated each of the 24 paintings on a 5-point Likert scale displayed at the bottom of the screen. No time limits were imposed in either trial.

Participants took the preliminary AAA before looking at the artwork of

Fig. 2. Left: Lovis Corinth, *Portrait of Professor Eduard Meyer*, oil on canvas, 140 × 180 cm, 1910–1911. (Image in public domain. Image source: <wikigallery.org>.) Right: Lovis Corinth, *Woman in a Hat with Roses*, oil on canvas, 60 × 50 cm, 1912. (Image in public domain. Image source: <commons.wikimedia.org>.) Examples of paintings by Lovis Corinth completed before his stroke (left) and afterward (right).



1	Vermeer, <i>The Letter</i>
2	Pollock, <i>Number One</i>
3	Cassatt, <i>Self Portrait</i>
4	Kahlo, <i>Two Fridas</i>
5	Cassatt, <i>On the Balcony During Carnival</i>
6	Cezanne, <i>Still Life with Kettle</i>
7	Buoninsegna, <i>Virgin and Child Enthroned</i>
8	Dewing, <i>The Piano</i>
9	Holbein, <i>Portrait of Dirk Tybis</i>
10	Henri, <i>Laughing Child</i>
11	Heda, <i>Still Life With Oysters, Rum Glass, and Silver Cup</i>
12	Dalí, <i>Gala and Tigers</i>
13	Matisse, <i>The Blue Room</i>
14	Rothko, <i>Red and Orange</i>
15	Picasso, <i>Reclining Nude</i>
16	Eakins, <i>The Gross Clinic</i>
17	Hopper, <i>The Gas Station</i>
18	Garsia, <i>Apocalypse of Saint-Sever</i>
19	Brueghel, <i>Netherlandish Proverbs</i>
20	Newman, <i>Eve</i>
21	Van Eyck, <i>Man in a Turban</i>
22	De Kooning, <i>Woman</i>
23	Pissaro, <i>Landscape with Flooded Fields</i>
24	Matisse, <i>Seated Riffian</i>

Table 1. 24 Paintings from the Western Canon Used in the AAA.

the artists under consideration for two reasons. First, we wanted to familiarize participants with the attributes before they looked at Sherwood's, Boiyadjiev's or Corinth's artwork. Second, if an individual was an outlier in judging a specific attribute (i.e. > 2 standard deviations from the group mean), that individual's judgment on that attribute was excluded from the subsequent group analyses. Thus, if a participant was an outlier on judging balance in the AAA, we assumed that his or her judgments of balance in any of the brain-damaged artists' work could not be relied upon.

For Sherwood we included 16 paintings, 8 produced before her 1997 stroke and 8 produced after. The paintings produced pre-morbidly had average dates of 9.8 years before the injury, and the post-morbid paintings were produced an average of 5.8 years after injury. For Boiyadjiev, we used 18 paintings, half of which were completed before his 1951 stroke. The paintings produced pre-morbidly averaged 8.4 years before the injury, and the post-morbidly produced

paintings averaged 11 years after injury. For Corinth, we included 20 paintings, half of which were produced before his 1911 stroke. The paintings produced pre-morbidly averaged 2.5 years before the injury, and the post-morbid paintings were produced an average of 2.0 years after injury.

To test the hypothesis that these artists' artwork changed in specific attributes, we obtained average ratings for each painting. Then the average ratings for all the pre- and post-morbid paintings were obtained from each participant for each artist. We compared these ratings using paired t-tests to test the hypothesis that the aggregate ratings on any given attribute changed in the paintings from before to after the artist had the stroke. To correct for multiple comparisons (the 12 attributes), we used a threshold for significance of $p < 0.004$.

RESULTS

Results are shown in Table 4. Sherwood's paintings following her brain injury were

judged as being less balanced, more vibrant and warmer, having less depth and using looser strokes. They were also judged as more abstract, symbolic and distorted as well as less realistic. Similarly, Boiyadjiev's paintings were judged to be less balanced and more vibrant, having less depth and using looser strokes. They were also judged as more abstract, distorted and symbolic as well as less realistic and less animate. Corinth's paintings were judged as having less depth and using looser strokes. They were also considered more abstract and distorted and less realistic.

DISCUSSION

Can we learn anything about the biologic bases of artistic production from studying the works of artists with neurologic injury? [27] While such artists sometimes produce striking works, these observations have not been used effectively in research. Here we present our attempts to bring structure to anecdotal observations by using the AAA. Importantly,

Balance	Visual harmony or visual "rightness"
Color Saturation (Tone)	Calm (more pastel) or vibrant (brighter) color palate
Color Temperature (Hue)	Warm (reds, oranges, yellows) or cool (blues, purples) color palate
Depth (Perspective)	Flat (two-dimensional) or deep (sense of three dimensions)
Complexity	Simpler (contained fewer elements) or more complex
Stroke	Loose or tightly controlled brush strokes

Table 2. Six Formal-Perceptual Attributes.

Abstractness	Abstract or concrete (representational) images
Animacy	More or less sense of the objects being alive
Emotion	More or less emotional expressivity
Realism (Fantasy)	Realistic or fantastic images (e.g., horse versus unicorn)
Objective Accuracy	Degree of depictive realism (likeness to a photograph)
Symbolism (Allegory)	Literal or symbolic content (e.g. a set of bones vs. skull and crossbones)

Table 3. Six Conceptual-Representational Attributes.

participants judged artworks while blind to whether particular works of art were produced before or after the artists suffered their brain damage.

At the outset, we should point out that the popular idea that the right hemisphere is the artistic hemisphere is wrong. Clearly, both hemispheres participate in artistic production, as evidenced by the fact that the art of these artists changed regardless of which hemisphere was damaged. The question is not: Which is the artistic hemisphere? as much as: How does each hemisphere contribute to art? In what follows, we describe our findings from assessing the works of Sherwood, Boiyadjiev and Corinth, discuss hemispheric laterality in art production and consider ways forward in such a program of research.

Sherwood describes her pre-morbid approach to her work as highly cerebral [28]. She expresses the sense that post-morbidly the images flow from her more easily. Her work has been described as rawer, more visceral and less intellectual. In concordance with such descriptions, our raters found her work following brain injury to be more abstract, more symbolic, more distorted, more vibrant, less realistic and depicted with looser strokes. Our raters also found her work to be flatter and to have warmer colors, changes not usually mentioned by critics describing her work.

Boiyadjiev's work has been described as having become fantastic and sometimes bizarre, with richer, more colorful forms and fluid, energetic lines [29,30]. Consistent with these descriptions, our raters found his work to be more ab-

stract, more symbolic, less realistic and more distorted as well as having a looser stroke style. They also found his work to be flatter and less animate, changes not mentioned by critics previously.

An important point can be made regarding the changes in Sherwood's and Boiyadjiev's work following their left-hemisphere strokes. A priori, one might be pessimistic about the prospects of identifying systematic effects of brain damage on art production. After all, artistic styles and content are so varied across different artists that one might be comparing changes in qualitatively different kinds of objects. Our observations of Sherwood's and Boiyadjiev's art suggest that this pessimism is not warranted. Sherwood and Boiyadjiev's artistic styles are quite different from each other. For example, Sherwood's paintings started out being substantially flatter than Boiyadjiev's paintings. Critically, both artists' paintings were judged as becoming flatter following their strokes, despite the fact that Sherwood's paintings *before* her stroke were more similar to Boiyadjiev's paintings *after* his stroke in depicting depth. Thus, it is not the case that individuals with left-brain damage produce a *prototypic style* of painting. Rather, it is more likely that left-brain damage produces a *prototypic shift* in style of painting.

Sherwood's and Boiyadjiev's paintings became more abstract, symbolic and distorted, as well as less realistic, and were painted with looser strokes, more vibrant colors and less depth. Correspondingly, Annoni et al. provide an account of two artists who experienced left-hemisphere strokes, one of whom produced post-

morbid work characterized by "increased abstraction [and] symbolism," while the second artist's post-stroke work, although more detail oriented, was characterized by the use of "bolder colors" [31]. Are these changes rendered by a combination of left-hemisphere deficits and right-hemisphere predispositions no longer fettered by left-hemisphere inhibitions? The right hemisphere is thought to encode meaning with a looser structure as compared to the left hemisphere's predilection for making fine distinctions [32]. Thus, one might reasonably hypothesize that more abstract, symbolic and less realistic depictions are an expression of the right hemisphere's predisposition to organize ideas with looser boundaries. To test this hypothesis, we examine Corinth's work.

Corinth's paintings after his stroke were described as "deformed," with attempts at producing faithful portraits having "ceased almost entirely" [33]. Blanke [34] describes a broadening of brush strokes, a lack of depth, less spatial detail and several deformities on the left side of his self-portraits. Our raters found Corinth's paintings to be more abstract, more distorted and less realistic and also to exhibit looser strokes and a flatter perspective.

One point to consider is the effect of focal brain injury on motor skills, specifically for Sherwood and Boiyadjiev, two right-handed artists who after left-hemisphere strokes began to paint with their left hands. The left-hemisphere stroke did affect Sherwood's and Boiyadjiev's motor skills on the right side. Could systematic shifts in their artistic styles be accounted for solely by the shift to painting with the left hand? From these data, we are agnostic about whether some pictorial aspects of the artwork, such as manner of brushstroke, occurred because of hemispheric brain damage or because of their use of the left hand. However, such a shift is unlikely to explain the use of increasingly vibrant colors or changes in conceptual attributes of their artwork, such as greater symbolism or abstraction.

When Sherwood's, Boiyadjiev's and Corinth's paintings are considered together, we find the following changes were found in all three artists. Their paintings became more abstract and distorted and less realistic and accurate. They were also rendered with looser strokes, less depth and slightly more vibrant colors. Thus, none of these changes can be ascribed to laterality of brain function. Also, their paintings did not change in complexity or emotionality. It remains to be seen whether these

Table 4. Ratings of paintings on each of the 12 attributes of the AAA. Those attributes in which the change was significantly different ($p < 0.004$) are shown in bold.

Attribute	Sherwood		Boiyadjiev		Corinth	
	Before	After	Before	After	Before	After
Depth	2.0	1.7	3.3	2.5	3.0	2.8
Stroke	2.5	3.6	2.5	3.5	2.8	3.5
Saturation	2.5	3.1	2.8	3.1	3.0	3.2
Hue (warm)	3.3	2.9	2.9	3.3	2.9	3.0
Simplicity	3.0	3.2	3.0	3.0	3.1	3.1
Balance	2.1	3.3	2.8	2.3	2.7	2.8
Abstractness	3.1	2.0	3.6	3.1	3.7	3.2
Realism	3.1	1.6	3.8	3.1	3.6	3.3
Accuracy	3.1	4.2	2.6	3.3	2.8	3.3
Animacy	2.6	2.3	3.1	2.8	2.9	3.0
Emotion	2.1	2.4	2.5	2.5	2.7	2.7
Symbolism	3.0	3.8	2.3	3.0	2.7	2.8

attributes would be susceptible to change with other kinds of neurological illness.

All the changes observed in Corinth's paintings were also observed in those of Sherwood and Boiyadjiev. Thus, we do not have any evidence that chronic right-hemisphere damage produces specific patterns of change in artistic production. By contrast, both Sherwood's and Boiyadjiev's paintings became more symbolic. The hypothesis that artists with left-brain damage, because of an unfettered right hemisphere, would engage meaning more loosely, was confirmed, specifically in the use of symbolism.

Our approach points to ways in which research in the neuropsychology of art production might progress. Using the AAA it is possible to describe artistic change quantitatively and componentially and to have the artwork assessed in a blinded fashion. Individuals with degenerative neurologic disease can also have changes in their artistic styles [35,36]. Most famously, de Kooning's painting after the onset of Alzheimer's disease was considered to have become simplified [37]. The work of the artists with focal brain damage studied here did not change in complexity. If art by individuals with Alzheimer's disease is demonstrably simplified [38], one could use our methods to contrast the effects of degenerative disease (diffuse neuronal dysfunction) and stroke (focal brain damage) on artistic production. We are optimistic that our method can be used to systematically investigate the biological basis of art production.

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