

# The neuropsychology of visual artistic production

Anjan Chatterjee\*

*Department of Neurology and the Center for Cognitive Neuroscience, Hospital of the University of Pennsylvania,  
3400 Spruce Street, 3 West Gates, Philadelphia, PA 19104, USA*

Received 22 April 2003; received in revised form 28 October 2003; accepted 17 March 2004

## Abstract

What happens to visual artists with neuropsychological deficits? This review will examine artistic production in individuals with a variety of syndromes including achromatopsia, neglect, visual agnosia, aphasia, epilepsy, migraine, dementia and autism. From this review it appears that artists are not spared visual–motor deficits despite their special graphic abilities. Rather their talents allow them to express visual deficits with particular eloquence. By contrast, the effects of aphasia on art are variable. In addition to deficits, neuropsychological syndromes may be associated with positive phenomena. Such phenomena induced by epilepsy or migraines can serve to inspire artists. This review also makes clear that artists with neuropsychological deficits do not necessarily produce art of lesser quality. Rather, their art may change in content or in style, sometimes in surprising and aesthetically pleasing ways. The neuropsychology of visual art also touches on a few central questions about the nature of artistic expression itself. For example, what forms can artistic representations take? How are visual features used descriptively and expressively? What roles do knowing and seeing play in depiction?

© 2004 Elsevier Ltd. All rights reserved.

*Keywords:* Visual cognition; Artists; Cognitive neuroscience; Art; Aesthetics

## 1. Introduction

How do humans represent the world? This question has preoccupied neuropsychology for many years, particularly in the context of the breakdown of these representations. The proposition I explore in this paper is that the work produced by artists who have suffered from brain damage can contribute to our understanding of these representations. Artists are especially adept at making their internal representations manifest. This ability should continue to be true and potentially revealing after brain damage, provided the artists' motor skills are not too compromised.

Several factors make it difficult to know what to make of observations in brain-damaged artists. The data themselves are observational and are not sheltered by experimental methods. Furthermore, artistic talents vary greatly raising the question of whether general principles can be extracted from something that is premorbidly so variable across individuals? Beyond the question of talent lies the problem of artistic styles and content. When considering different artistic traditions, is the same kind of cognitive behavior even being scrutinized?

Despite these non-trivial limitations, and the inherently tentative nature of any conclusions to be drawn, I propose that art is worth considering as a neuropsychological probe. First, I outline the effects of selective neuropsychological deficits on the production of artists. Second, I consider the way in which productive neuropsychological phenomena may be a source of artistic inspiration. Third, I look at the relationship of diffuse cognitive impairment to artistic production.

Two distinctions are worth keeping in mind when thinking about artistic production and neuropsychological deficits, points to which I return later in the paper. The first distinction is between description and expression. Artists may choose to visually describe how they represent something. Alternatively, they may subordinate descriptive accuracy to expressive goals. Generally, descriptions emphasize representations of the world and expressions emphasize representations of an artist's internal state. At issue here are the effects of brain damage on descriptive and expressive modes of production and stylistic shifts between the two. The second distinction is between perceptual and conceptual motivations in producing visual images. Images may be derived directly from percepts or they may be evoked from memories and knowledge of the world. Furthermore, the content of images may vary along a perceptual to conceptual axis. Some images display specific scenes or objects

\* Tel.: +1-215-662-4265; fax: +1-215-349-5579.

*E-mail address:* anjan@mail.med.upenn.edu (A. Chatterjee).

in the world, richly endowed with sensory information including light, color, form and texture. Others are abstracted simple or prototypic or even symbolic images. Relevant to the ensuing discussion are the effects of perceptual and conceptual neuropsychological deficits on artistic depiction that lie along this continuum of perception to conception.

This paper is not intended to describe a brain-based theory of art. Elsewhere, I have discussed (Chatterjee, 2002, 2004) how cognitive neuroscience might advance empirical aesthetics. Here, the goals are modest. I hope to bring together this literature, much of which is dispersed in books and is hidden from search-engines. Rather than describing observations that converge into a single coherent theoretical position, I raise themes evoked by these observations, themes relevant to the nature of artistic expression.

## 2. Selective neuropsychological deficits and artistic production

How are neuropsychological deficits manifest in the output of visual artists? One could postulate that artists have special visual–motor skills. Their visual–motor systems might be organized differently than that of other people, either because of inherent talents or because of years of practice. Consequently, brain damage might produce unusual and even unpredictable effects on their output. In what follows, I review the effects of achromatopsia, unilateral spatial neglect, visual agnosia and aphasia on artwork. This review suggests that artists remain susceptible to visuo-spatial deficits as are other individuals, but because of their skill, they are often quite eloquent in expressing these deficits.

### 2.1. Achromatopsia

Achromatopsia is the relatively rare disorder of a selective visual deficit in processing color. Sacks (1995a) described the experience of an artist who developed achromatopsia after a traumatic brain injury. Although a discrete brain lesion was not identified, he selectively lost color perception. Everything appeared “dirty gray” to him. The artist was unable to imagine colors and his dreams and migraine auras were devoid of color following the accident. Before the accident, his paintings were quite abstract and colorful. Following the accident, he painted figurative as well as abstract images. His initial use of color was haphazard, and he eventually resigned himself to produce black and white paintings. His paintings demonstrate a remarkable preservation of form, contrast and composition, despite their absence of color. Eventually he re-introduced color into his paintings, but he used an extremely limited palette. He could still use his semantic knowledge of colors in picking the tubes based on their labels and mix colors in a way a non-artist would not have been able to. Thus, in this patient, the selective loss of color processing changed how he painted, but brain

damage by itself did not prevent him from continuing to be a successful artist.

### 2.2. Unilateral spatial neglect

Patients with unilateral spatial neglect fail to orient to or respond to stimuli in contralesional space. Neglect is more common and severe following right than left brain damage and these patients’ drawings often miss parts on the left (Chatterjee, 2003). Accomplished visual artists, despite their obvious skill and years of practice, are not spared these dramatic abnormalities (Jung, 1974; Schnider, Regard, Benson, & Landis, 1993). Jung (1974) described the paintings of four artists with left neglect. Lovis Corinth (1858–1925) was an important German artist who had a right-hemisphere stroke in 1911. As Corinth recovered, he continued to paint. However, examples of his self portraits and portraits of his wife show a clear change in style. Contours on the left seemed to “disappear”; details on the left were misplaced; and textures on the left blended into the background. Similarly, the artist Anton Räderscheidt displayed neglect in paintings after his 1967 stroke. He initially showed dramatic left neglect in a self-portrait 2 months after his stroke. This painting has a few brush strokes on the left, with an eye, ear and part of the face barely discernible. In subsequent paintings the face gradually becomes more recognizable and filled in with features, although even 8 months after his stroke Räderscheidt made greater use of color and detail on the right than on the left.

Left neglect in artistic production may affect specific attributes of visual images. Blanke, Ortigue, and Landis (2003) recently described the artwork of a 71-year-old artist with mild left neglect following a right parietal hemorrhage. Her drawings showed evidence of neglect on the left. Within these drawings she colored the right side completely and evenly, whereas on the left she used color minimally and without the same care. Thus, she produced the form of these images on the left and not its color. These observations contrast with observations made by Marsh and Philwin (1987). They described a painter IK with a left parietal glioblastoma multiforme and right neglect whose paintings cover the entire canvas with color, however, the right (contralesional) side lacked form and detail. Similarly, neglect for representations derived from perceptions and those from memory may dissociate. Halligan, Fink, Marshall, and Vallar (2003) reported a professional cartoonist who neglected the left side of images when drawing a subject from life despite being able to produce a complete image when drawing from memory.

Left neglect in artists can occur in three dimensions as well as two dimensions. Halligan and Marshall (1997) reported that neglect in a well-known English artist affected his sculpture in addition to his drawing and paintings. Neglect may occur in different reference frames: oriented to the viewer, to the object (Chatterjee, 1994) or to the environment. This artist demonstrated a remarkable form of

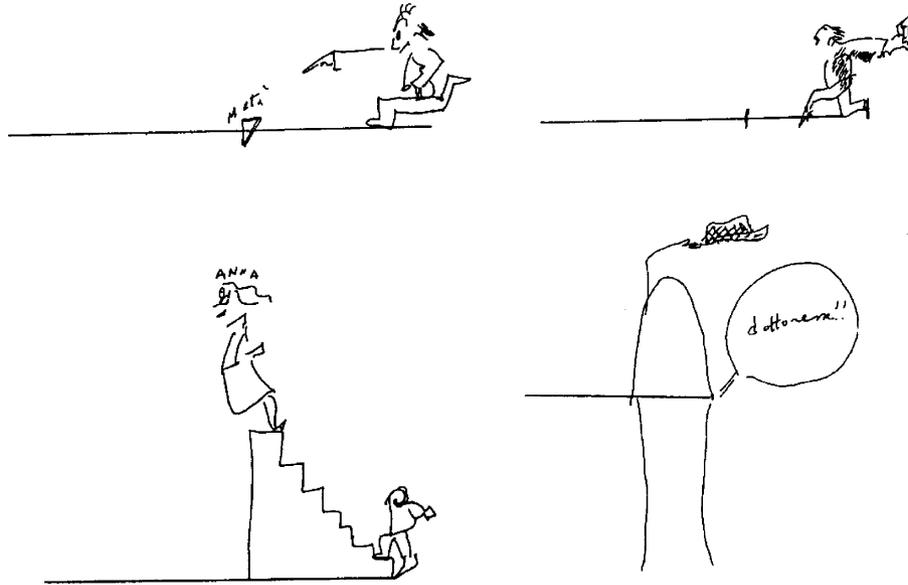


Fig. 1. Cartoons drawn by Fellini while performing line-bisection tasks. All cartoons are drawn on the right side. Reprinted with permission (Cantagallo & Sala, 1998, Fig. 3a, p. 168).

object-centered neglect. In sculpting a bust, he neglected one side of the head (the left side as he faced it), even though the bust was placed on a turnstile and rotated as he sculpted.

Recently, the great Italian film director Federico Fellini suffered from a right-hemisphere stroke and left neglect (Cantagallo & Sala, 1998). Fellini was also an accomplished cartoonist. In the first month after his stroke, he clearly showed evidence of neglect in cartoons that he drew spontaneously when given line-bisection tasks (Fig. 1). Fellini was aware of his left-sided paralysis and developed misoplegia (a hatred for this limb). Neuropsychological testing showed no deficits in general intelligence, language, or simple visual analysis. Some patients with neglect can process left-sided information to varying degrees, although the depth of this processing is a matter of controversy (Bisiach & Rusconi,

1990; Marshall & Halligan, 1988). Fellini seemed to be partially aware of the left side of images. For example, when shown an image in which one side was altered, such as a torn bank note, he had difficulty detecting left-sided differences. Yet, when forced to choose one of the bank notes, he invariably chose the untorn one. Within 2 weeks of his stroke Fellini clearly had verbal awareness of his neglect. For example, he asked that his visiting card be changed to “FF, Scoagulato, Emiparetico, Eminattento, Emianestesico” (FF, Unclotted, Hemiparetic, Hemi-inattentive, Hemianaesthetic). While many of Fellini’s cartoons demonstrated left neglect, some also demonstrated his partial awareness of his left-sided deficits. For example, he drew a cartoon with an elephant on the left asking the question “Can I stay here, doctor?” of a doctor behind a desk on the right (Fig. 2), and



Fig. 2. Cartoon drawn by Fellini, in which an elephant on the left asks “Can I stay here? Doctor?” The elephant’s most distinctive feature, its trunk, appears missing in the left. Reprinted with permission (Cantagallo & Sala, 1998, Fig. 6, p. 354).



Fig. 3. Fellini asks, “where is the left?” Reprinted with permission (Cantagallo & Sala, 1998, Fig. 9, p. 180).

another with a man asking the question “Where is the left?” (Fig. 3). His cartoons also communicated his psychological state. In one cartoon he drew a large doctor on the right and himself on the left as a very small figure (Fig. 4). This image was interpreted by the authors (Cantagallo & Sala, 1998) as reflecting his feelings of inadequacy in the face of his medical problems.

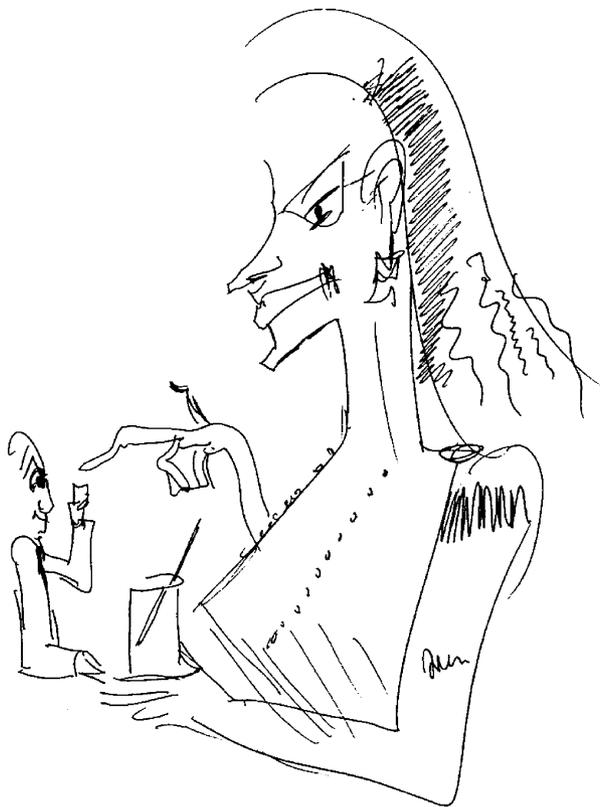


Fig. 4. Fellini depicts himself as a small figure on the left of the large and imposing doctor.

As they recover, artists with neglect may draw or paint on the left sides. In these cases, the style of their artwork seems to change. Thus, Reynold Brown, whose artwork was exhibited in Chicago in a symposium called “Art and the Brain” began to show bolder strokes and less of an emphasis on exact detail (Heller, 1994). Similarly (and discussed further in a later section), Loring Hughes (Heller, 1994) and Lovis Corinth were judged to paint more expressively following right brain damage.

Thus artists with neglect demonstrate contralesional neglect in their art. Their art may also demonstrate neglect for specific visual attributes, occur in different reference frames and hint at some degree of awareness of contralesional space.

### 2.3. Visual agnosia

One might expect that patients with visual agnosias that are unable to recognize objects would also not be able to draw objects. This expectation is not quite accurate. Rather, the nature of the processing deficit that gives rise to the agnosia seems to determine the nature of these patients’ production. Lissauer’s classic distinction between apperceptive and associative agnosias (Lissauer, 1890) highlighted the fact that agnosias lie on a continuum between perceptual and conceptual deficits. The nature of artistic production in patients with agnosias seems to be determined by whether the deficit is closer to the percept or the concept of the object.

Wapner, Judd, and Gardner (1978) described a 73-year-old amateur artist, JR, who suffered from a stroke. From the data provided, it is likely that JR’s stroke involved the left posterior cerebral artery and possibly also the right posterior cerebral artery. Following the stroke he had a right homonymous hemianopsia and a memory disorder. General linguistic and cognitive capacities were preserved. On formal IQ testing he had a WAIS verbal score of 123. His main problems were visual. JR could read words only letter by letter. Everything appeared dim to him, and he had poor retention of visual forms. He was unable to see illusory contours formed by Kanizsa figures. Most importantly, he had difficulty recognizing single objects when presented visually or interpreting visually complex scenes and partially occluded figures. During testing, he often mentioned the overall shape of an object and then tried to deduce the object by identifying parts and describing their possible functional uses. Thus, the underpinnings of JR’s agnosia were more perceptual than conceptual. His drawings after his stroke retained many of his premorbid stylistic techniques, such as showing shadows and perspective (Fig. 5). However, he drew laboriously. He often lost his place in the middle of his drawings. Because of his inability to recognize what he was drawing, he would often elaborate some details and omit others (Fig. 6). Sometimes he redrew features, such as a five-legged rhinoceros or a plane with many propellers. He also had great difficulty when copying visually complex images. He could not always distinguish objects from their background and would incorporate elements of the



Fig. 5. Drawing of a Raggedy Anne doll by the artist JR with a perceptual visual agnosia. Despite the image being fragmented, depth and shading are incorporated in the drawing. Reprinted with permission (Wapner et al., 1978, Fig. 3, p. 352).

background as part of the object he was drawing. He used verbal strategies to compensate and help guide his drawings. Thus, when asked to draw a telephone, he constructed it with the following reasoning: “It needs a base for it to stand on, a place to speak into, something to hear with a wire to plug in for communication and a place to dial.” Needless to say, this strategy was not particularly effective. JR’s vision, which fragmented following his stroke, was accompanied by a similarly piece-meal production. He rendered specific features of objects accurately, but lacked the sense of how these features fit into an overall structure and composition.

JR’s deficit contrasts with the visual agnosia of another artist MH, reported by Franklin, van Sommers, and Howard

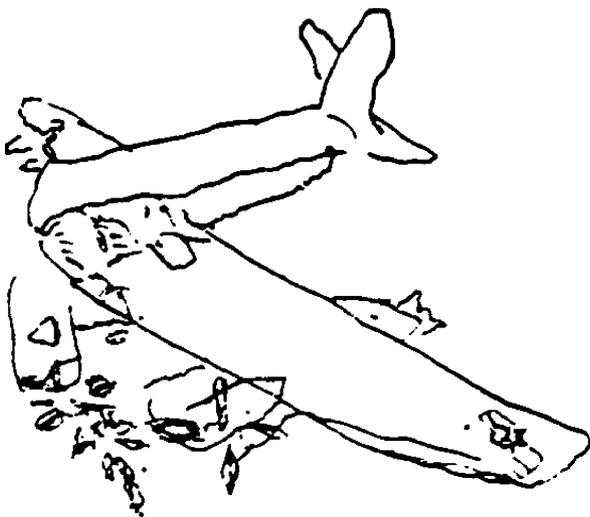


Fig. 6. Drawing of a plane by JR. Parts of the plane are missing. Some features such as the propellers are drawn without being clearly attached to other parts of the object. Reprinted with permission (Wapner et al., 1978, Fig. 5, p. 354).

(1992). MH was a 77-year-old artist who probably had a semantic dementia<sup>1</sup> (although in 1985, when she was evaluated semantic dementias were not widely recognized). MH had significant word finding difficulties in spontaneous speech and was unable to name pictures of common items. She was also impaired in her ability to make semantic associations with pictures or words. Her CT scan showed disproportionate atrophy around the left peri-sylvian cortex, consistent with the diagnosis of a semantic dementia. MH had been a successful commercial artist all her life, and was still able to draw after the onset of her cognitive impairment. The most striking feature of her output after her illness was how the quality of her drawings varied depending on the context in which she drew. When she copied a complex image, such as a portrait originally painted by Botticelli (Fig. 7), or drawing a portrait of one of the medical staff, she rendered her images beautifully. She used perspective and shading and composed her work well. Unlike Wapner et al.’s patient JR, MH did not lose track of the overall form of her drawings. Her drawings of everyday objects from real life, such as a briefcase or a comb, displayed similar competence. However, her drawing skills deteriorated dramatically when she was only given names of objects to draw. Many of her drawings were unrecognizable, and others were crude and less assured than when she drew from what she saw (Fig. 8). Her drawings of even simple geometric forms also deteriorated if the model was removed and she had to draw after a short delay. Thus, MH agnosia lay closer to the conceptual end of the perceptual/conceptual continuum, with the added feature of an impaired short-term visual memory deficit. She was able to draw well when presented with a rich visual model. However, her drawing skills collapsed when guided by semantics (triggered by a word) or memory (after a short delay).

Schwartz and Chawluck (1990) described a similar patient, Susan G, who probably also had a semantic dementia (although in this case the semantic deficits were also accompanied by social disinhibition). Susan G began to have symptoms in 1979 and was examined in detail from 1984 to 1986. Two PET scans during this period showed left temporal lobe hypoperfusion. Susan G could recognize words and grammatical violations in simple phrases. However, she had profound deficits in her knowledge of the meaning of words. Evaluation of her visual processing revealed that she could classify objects perceptually but could not elaborate conceptually on these percepts. Like MH, Susan G’s recognition deficit lies closer to the conceptual end of the conceptual–perceptual continuum. Before her illness, Susan G was a successful commercial artist and sold paintings of animals. Within the onset of her illness the quality and sub-

<sup>1</sup> Semantic dementia is often classified as a subtype of fronto-temporal dementia (FTD). I have elected to describe two cases of semantic dementia here, rather than in a later section on FTD, because the pattern of artistic production is quite different from that of more typical dysexecutive FTD. Additionally, the art is thematically related closely to the effects of object recognition/knowledge deficits.



Fig. 7. Drawing by patient MH, with a semantic dementia, showing extremely skilled abilities in copying from a rich model, in this case a portrait originally made by Botticelli. Reprinted with permission (Franklin et al., 1992, Fig. 11.4, p. 186).

tlety of her paintings noticeably declined. Remarkably similar to MH, her drawings continued to be competent when copying a model, but deteriorated when she had to draw without the model before her, or when she was asked to draw the object from a given word. These drawings were simple and often unrecognizable if she drew without a visual model immediately before her.

Thus, from the limited data available, the art of patients with visual agnosias seems to be largely determined by whether their deficit is closer to the perceptual or the conceptual end of object recognition processes. If the deficit is at the perceptual end, patients are likely to not produce the overall form and composition of images, but continue to render individual features of objects. By contrast, patients with deficits at the conceptual end are still able to draw very well if copying from a rich source, but fall apart when having to draw from memory or if guided by their knowledge of the world.

#### 2.4. Visual imagery deficits

Is the ability to generate visual images in one's "mind's eye" necessary to produce art?

From a case described by Botez, Olivier, Vézina, Botez, and Kaufman (1985) the answer seems to be, it depends on whether the art is copied or generated spontaneously. They describe a 38-year-old teacher and psychotherapist who did

charcoal drawings from models as a hobby. He was highly intelligent, but had a congenital visual imagery deficit. He was unable to image people, places and objects, or distances between and dimensions of objects. While he could not visualize his car, he recognized it by remembering some detail. He had very poor memory for topographies, and would get lost in unfamiliar environments—although he did well in Manhattan because of its rectangular and symmetric layout. He was bothered by the fact that he could not visualize his wife or children, although he could name identifying features such as the color of their hair and eyes. He could not recognize people that he had seen just once. His dreams were vague, in grey and black and his dreams contained voices without accompanying visual images. Because of his poor visual imagery, he learned everything through language. He had considerable difficulty recalling past events and had no visual memory of places he visited on vacation. His CT scan showed dilation of the right lateral ventricle and possibly some thinning of the posterior third of the corpus callosum. His pattern of drawings resembles those of the two patients with semantic dementia, MH and Susan G, described above. He drew mostly from models. When he had a model to copy, his drawings were competent and included considerable detail. However, when the model was removed from view his drawings were simple and schematic. When given names of objects to draw, his drawings were also poor. For example, the heads of animals he drew spontaneously, whether a pig

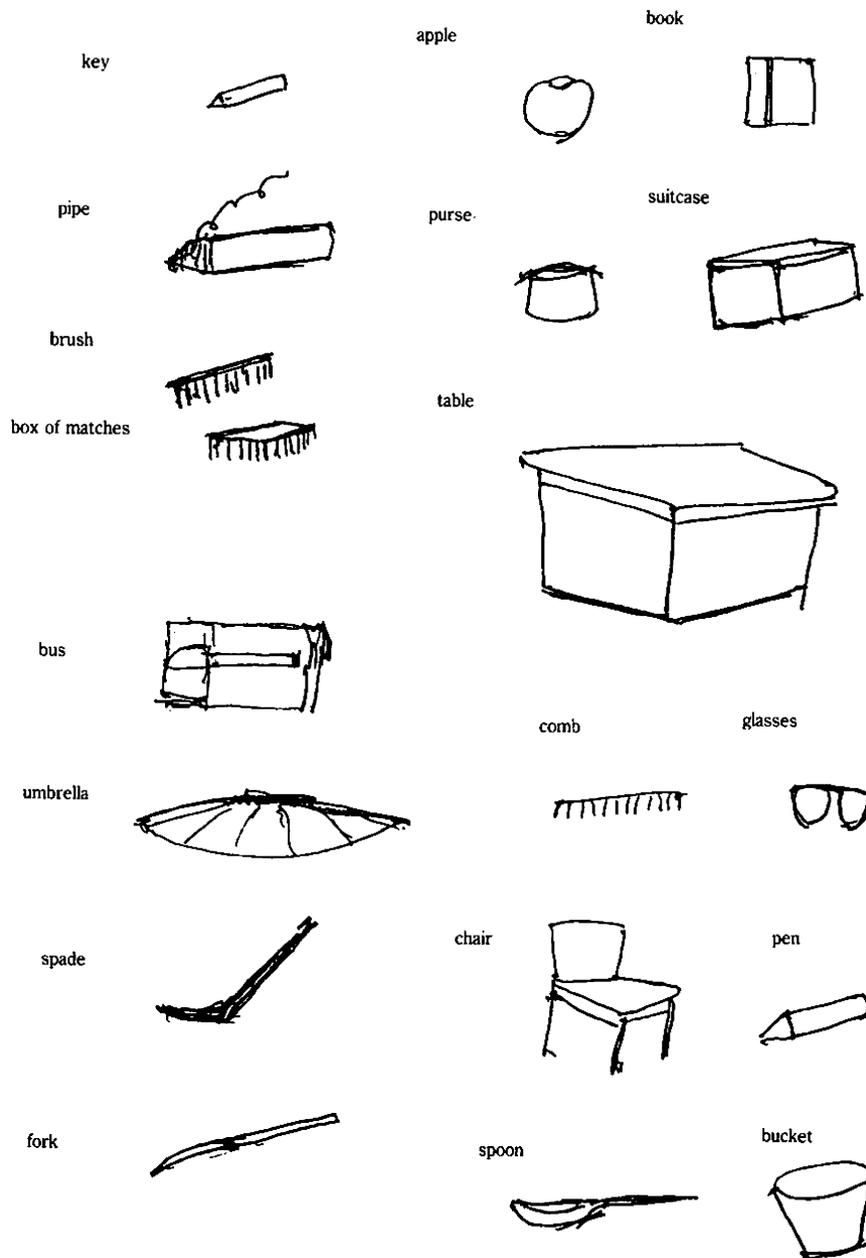


Fig. 8. Simple schematic drawings produced by MH, in response to words. Some drawings, such as the bus, are unrecognizable. Reprinted with permission (Franklin et al., 1992, Fig. 11.7, p. 189).

or a rabbit, would resemble a coarse human face. Thus, this case demonstrates the kinds of dissociations between perception and imagery that have been reported in neuropsychology (Behrmann, Moscovitch, & Winocur, 1994; Chatterjee & Southwood, 1995; Coslett, 1997), also plays out in artwork. When producing a drawing guided by perception, this patient did well. However, when producing a drawing based on imagery, he deteriorated.

### 2.5. Aphasia

Artistic production can be considered a form of communication. What happens to such production when patients have

profound difficulties in communicating verbally as happens in aphasias? The data suggests that the impact of aphasia on artistic production is quite variable.

Brown (1977) described a 73-year-old professional artist with a conduction aphasia from a right-hemisphere lesion (a crossed-aphasic) and found no change in her sketches or illustrations. Alajouanine (1948) described a French painter with an aphasia whose artistic skills and style also did not change after his stroke. The painter seemed to intuit the general meaning of conversations, but he had word finding problems and made many paraphasic errors. His technical skills in artistic production were not impaired by his stroke. Connoisseurs thought he may have gained a “more intense

and acute expression.” The artist described his condition as follows:

There are in me two men, the one who paints, who is normal while he is painting, and the other one who is lost in the mist, who does not stick to life . . . . When I am painting I am outside of my life; my way of seeing things is even sharper than before; I find everything again; I am a whole man. Even my right hand that seems strange to me, I do not notice when I am painting. There are two men, the one who is grasped by reality to paint, the other one, the fool, who cannot manage words any more.

In contrast to these patients, some aphasic artists have shown striking changes in their style after strokes. One such example, the Bulgarian painter Zlatio Boiyadjiev who had a left-hemisphere stroke was described by Zaimov, Kitov, and Kolev (1969) and discussed further by Brown (1977). Boiyadjiev’s pre-aphasic style was natural and pictorial and he used mostly earthy tones. After his stroke his paintings became richer, more colorful, with fluid energetic lines demonstrating great vigor and inventiveness. Much of the imagery was bizarre and fantastical. Brown speculated that this kind of painting might reflect the right hemisphere’s looser sense of semantic boundaries.

Kaczmarek (1991) reported what may be the clearest example of a change in artistic style following aphasia in a Polish artist RL. RL was an Associate Professor at the Faculty of Arts in Maeria-Curie Sklodowska University in Lublin. He produced highly symbolic paintings for which he had received several awards. For example, his painting *Quo Vadis* includes letters, number and ideograms. The painting has the start date of World War II and the radiation sign in the center, with elements reminiscent of bones in the lower part of the image. After his stroke he was no longer fluent and could describe an event using only a few words. He could repeat simple phrases and followed simple commands. However, he continued to produce highly skilled charcoal drawings after his stroke. He produced easily recognizable self-portraits and landscapes for which he found purchasers. He complained that his mind was blank and he could not return to his pre-morbid style of symbolic painting.

Thus, aphasia is probably too broad a category from which to draw general conclusions about its effects on visual art. Some patients seem not to be affected, others become more expressive and others change the content of their production. Further work needs to be done in which the deficient components of language are identified in aphasics and these components themselves are linked to changes in art.

### 3. Productive neuropsychological phenomena as sources of artistic inspiration

Can neuropsychological phenomena help generate art? Neuropsychological phenomena are usually thought of in terms of deficits. However, various positive phenomena are

also associated with neuropathological states. Most germane to this discussion are the striking visual auras that can accompany epilepsy and migraines. Can these auras serve as inspiration for visual artistic expression?

#### 3.1. Epilepsy

Patients with epilepsy may have vivid visual auras as part of their ictal phenomenology. Sacks (1995b) described the artwork of Franco Magnani, an Italian painter based on San Francisco, whose art may have been ictally inspired. Magnani painted hundreds of detailed scenes of Pontito, a small town in Tuscany. Some of these paintings were displayed in an exhibit on memory at the Exploratorium in San Francisco in 1988. Many of the paintings were accompanied by photographs of the same scene in the small town taken by Susan Schwartzberg, demonstrating the remarkable similarity of the painting to the actual scene. Remarkably, Magnani had not been in Pontito in years. He had an eidetic memory as a child, but was not particularly disposed to paint. When he was 31, he had a febrile illness (which sounds like an encephalitis) associated with a delirium, and probable seizures and psychosis. Following this illness his personality changed profoundly. He talked incessantly about Pontito and seemed incapable of shifting from this topic. He began to have vivid dreams of Pontito. These scenes also forced themselves on him when he was awake. At this time he first felt compelled to paint, despite having no previous artistic training. He found that he could paint these detailed scenes from his memory. His paintings are devoid of people and have a timeless quality to them. They are detailed, with only minor shifts in perspective and scale when compared to photographs taken of the same scenes. Magnani experienced “flashes” of particular scenes, which triggered most of his paintings. These flashes were not confined to vision. The feeling of the walls or the sound of church bells or the smells of the village could accompany these visions. Although Magnani was not investigated neurologically, Sacks speculated that he had partial complex seizures and suffered from the kind of inter-ictal personality disorder described by Waxman and Geschwind (1975). Individuals with this personality change are described as being “sticky, obsessive, hyper-religious and often hypergraphic.” Sacks speculates that Magnani also suffered from such a personality change and rather than being verbally hypergraphic, he compulsively expressed himself in hundreds of paintings of Pontito.

#### 3.2. Migraine

In contrast to Magnani’s highly realistic images, paintings inspired by migrainous auras tend towards the surreal. Recently Podoll and Robinson (2000) described the influence of migrainous auras in the art of an internationally known contemporary Irish artist, Ignatius Brennan. He had migraines since the age of 11, and experienced episodes of visual loss, which were at times frightening, often with

zigzag clouds obscuring much of his visual fields. As he got older in his preserved islands of vision he saw triangles and rounded forms as well as mosaic illusions. He also saw various visual distortions, including micropsias and macropsias and parts of objects changing in relation to other parts. Brennan observed:

I started with pictures of my migraine experiences unconsciously rather than deliberately, when I was at art school. I used to do a lot of drawings of landscapes at that time and often found that I would be drawing clouds not just in the sky, but everywhere, which was I think a reference to the visual voids experienced during visual loss. I also used serrated zigzag shapes in my drawings, symbolizing the experience of a whole being broken up . . . . Clouds, zigzags and other imagery are part of my own personal visual vocabulary, but which certainly has come out of migraine experiences. I'm absolutely sure. I don't tend to do that deliberately, but when it suits a particular subject, e.g. to represent a feeling or a emotion, I make use of these images in different ways . . . .

De Chirico also used the geometric spectra often seen by migraineurs in his surreal paintings (Fuller & Gale, 1988). His series of paintings known as "metaphysical interiors" includes distortions, which may have been inspired by the metamorphosias sometimes experienced with migraines.<sup>2</sup>

Perhaps the oldest record of artistic inspiration from migraine auras comes from Singer's descriptions (Singer, 1958) of the mystic nun Hildegard of Bingen (1098–1180). She describes her visions as:

. . . having always seen this light in my spirit, not with external eyes, nor with any thoughts of my heart nor with help from the senses. But my outward eyes remain open and other corporeal senses retain their activity. The light which I see is not located but yet is more brilliant than the sun, nor can I examine its height, length or breadth and I name it the cloud of living light.

In all her paintings a point or group of lights are prominent. These lights shimmer and move in a wave-like manner. Often fortification spectra radiate from some colorful area.

Wilkinson and Robinson (1985) analyzed the artwork submitted to the first national Migraine Art Competition sponsored by the British Migraine Association and WB Pharmaceuticals. In the over 200 entries, 70% showed spectral appearances, 48% showed fortifications, 16% showed visual loss and 2.5% showed mosaic visions. These group observations give support to Brennan's insight that artists with migraines use a visual vocabulary derived from their visual experiences in their art.

Thus, while it is unlikely that epilepsy or migraines release latent artistic talents per se, they do seem to expand the repertoire of visual forms available to artists with these auras.

#### 4. Art of patients with diffuse cognitive impairment

What happens to artistic skills in the setting of diffuse cognitive impairment? Artistic production itself is a complex cognitive behavior (Van Sommers, 1989), involving at least vision, praxis, memory and executive functions. This list does not even consider the kind of emotional processing and inspirations that might give birth to such art. It would be reasonable to predict that disorders that impair cognitive systems diffusely would also impair the ability to make art. This prediction is not quite accurate. Rather, artistic skills in some of these conditions are relatively preserved or modified, and sometimes even enhanced.

##### 4.1. *Alzheimers' disease (AD)*

The influence of AD on artistic skills and styles has not been reported to any great extent. My clinical experience is that amateur artists with AD often give up their work. Patients with AD quite consistently become passive (Chatterjee, Strauss, Smyth, & Whitehouse, 1992) and are less likely to initiate or complete projects. However, when they do continue to draw or paint, they seem driven to simplicity.

Canu, Piras, and Martindale (2002) followed an 80-year-old Italian painter with AD. Premorbidly, she drew realistic charcoal landscapes. At the time of assessment, she had a Mini-Mental State Exam score of 17/30. Her drawings became simplified and schematic after the onset of her dementing illness. Furthermore the range of topics that she drew or painted became quite restricted.

Willem DeKooning is the best known artist who continued to paint after developing Alzheimer's disease (Storr, 1995). Friends and colleagues noticed forgetfulness in the late 1970s, which is when his disease probably began. In 1982, the artist Chuck Close visited him and found him to be inert and forgetful, until he entered his studio. In his studio he seemed more engaged and lively. DeKooning's ex-wife and assistants provided the structure and the setting in which he continued to paint until 1988. Towards the end of the 1980s he sustained energy to paint for only short periods and he could not concentrate.

There is general agreement among experts that DeKooning's late period constituted a new and coherent style. Earlier in his career DeKooning felt trapped in Picasso's shadow. By contrast, in this later period he was drawn to Matisse. In his late paintings exhibited in 1996 at the San Francisco Museum of Modern Art (SFMOMA), he emphasized line, color and form. Critics sense traces of forms from earlier work. His paintings were abstract and

<sup>2</sup> As examples, the authors cite the lithographs "Calligrammes" from 1930, and "Mythologie" from 1933, and the oil painting "the return to the castle" from 1969.

successively simpler. He used mostly primary colors such as red and blue on white. As described later, art critics find these later paintings particularly sensual and lyrical.

People with AD continue to produce artwork, it seems, only when sustained by the momentum of life long routines and when others provided the structure in which to continue their work. I am not aware of any AD patients that have developed new artistic habits after the onset of their illness.

#### 4.2. Frontotemporal dementia (FTD)

In contrast to people with AD, Miller and colleagues (Miller et al., 1998) reported that a subset of patients with fronto-temporal dementias (FTD) developed artistic skills in the early stages of their illness. Despite increasing cognitive decline and social impairment they remained preoccupied with fine details of faces, objects, shapes and sounds, and these preoccupations are reflected in their art. Additionally, the art of people with FTD share some common characteristics. In every case the art was visual, and was realistic rather than symbolic or abstract. The images were so highly detailed that the authors considered them obsessive in quality. The patients were intensely preoccupied with their art and they were willing to compulsively repeat the work until they were satisfied.

The conditions under which patients with FTD develop artistic skills are not known. Clearly most FTD patients do not become artists. The obsessive-compulsive symptoms that sometimes accompany FTD may be necessary, but are probably not sufficient for the emergence of artistic preoccupations. Further research is needed to sort out what distinguishes these artistic patients from the vast majority of other FTD patients.

#### 4.3. Autism

Perhaps the most striking examples of exceptional artistic skills in the setting of general intellectual deficiencies are seen in some patients with autism. Selfe (1977) reported the first detailed description of one such child, Nadia. Nadia's social responsiveness as a baby was not normal. She did not respond to her mother and lacked social empathy. As she got older, her relationships with other children seemed like an obsessive concern for their presence, rather than any substantial interaction with them. Her language development was delayed and her speech patterns were frequently echolalic and ritualistic. Despite these developmental abnormalities, Nadia was amazingly skilled at drawing. By the age of 3.5 years, she was drawing remarkably life-like horses in perspective (Fig. 9). Her drawing abilities were not an accelerated version of other children's abilities. She did not go through a process of drawing simple schematic objects before learning to draw realistically (Fig. 10). Rather, her artistic skills were highly developed at the outset and did not change much over time. She drew lines deftly. Her movements were rapid, firm and without hesitation. She drew intensively, but only for a few minutes at a time. She produced line drawings and showed no interest in color. She seemed oblivious to the page on which she drew. She would sometimes start at the middle or bottom of the page, and rather than try to "squeeze" the image on the page (Fig. 11), she would terminate it when arriving at the end of the page, even if that meant drawing only half a head. Nadia tended to draw horses and riders and a few other select subjects. Although her drawings were taken from other drawings, she did not copy them. Her reproductions might appear a day or so later, and although recognizable as a version of the original, they could be changed in size or orientation. For subjects that she



Fig. 9. Drawing by the autistic child Nadia, when she was 3 years and 5 months. Reprinted with permission (Selfe, 1977, Fig. 1).

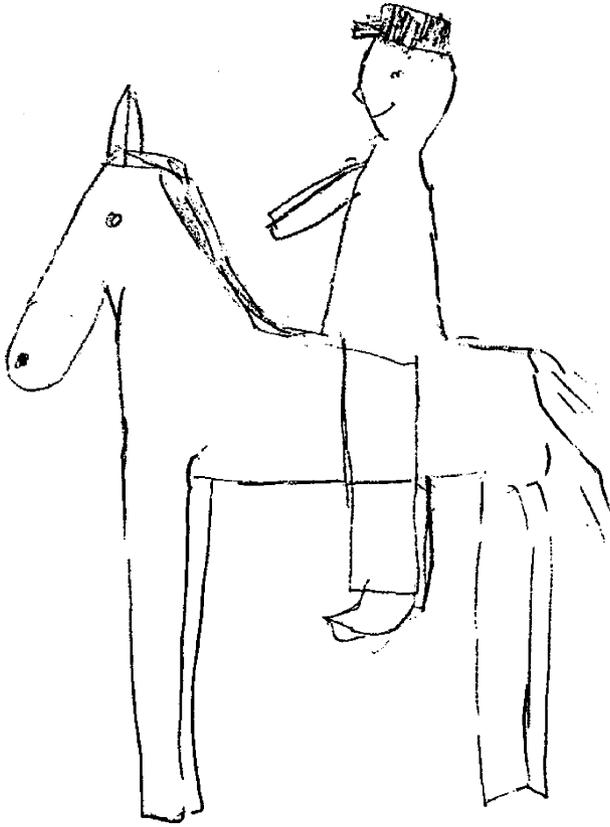


Fig. 10. Drawing of person on a horse by an average 6-year-old child. Reprinted with permission (Selfe, 1977, Fig. 9).

drew frequently, such as horses, her drawing seemed to take on composite characteristics of images she had seen. Even when she occasionally drew from life, she never looked at the original once she began to draw.

While Nadia was exceptional, she is not unique. Steven Wiltshire, described in detail by Sacks (1995c) has published several books on his artwork. Many of Sacks' observations of Wiltshire are reminiscent of Nadia. Wiltshire, whose verbal IQ was estimated at 52, also drew amazing line drawings at an early age. From the beginning, he depicted perspective accurately and could reproduce minute details after apprehending an image almost at a glance. Like Nadia, he drew what he saw rather than make use of symbols. Yet his drawings were not simple replicas. He seemed to introduce minor variations in the objects. Wiltshire, like Nadia and other autistic artists, developed powerful preoccupations with a few select images, in his case cars and buildings. The compulsion to draw these objects does not extend to a compulsion to draw in general.

About 10% of autistic children (Rimland & Fein, 1988) and a few other children with general cognitive impairment (idiot-savants) (Morishima & Brown, 1976) seem to have special gifts. A subset of these savants are gifted visual artists. Drawings of autistic children that are not selected for exceptional abilities, are not notably better than those produced by other children with learning impairments (Eames & Cox, 1994; Fein, Lucci, & Waterhouse, 1990; Lewis &



Fig. 11. Drawing of person on a horse by Nadia when she was 5 years and 6 months. Reprinted with permission (Selfe, 1977, Fig. 24).

Boucher, 1991). Artistically gifted autistic people seem to have two distinguishing characteristics, one having to do with their personalities and the other with their perceptual motor skills. O'Conner and Hermelin (1991) found that the tendency for repetition and preoccupations with certain behaviors seemed important in artistically gifted autistic people. Hermelin and colleagues (Hermelin, Pring, & Heavey, 1994) also found that gifted autistic individuals had better than normal perceptual-motor skills. They could analyze and resynthesize components of a jigsaw puzzle better than control subjects. They also demonstrated greater visuo-motor flexibility as evidenced by better mirror drawing abilities.

Thus, some people with autism have exceptional drawing skills. At a very early age they are able to draw in perspective, and seem able to focus on what they see. This ability is clearly not impeded by their general impairments, and (as we discuss later) may even be helped by their relative lack of verbal and semantic engagement with their environment.

## 5. From neuropsychology to implications for artistic expression

What inferences can we make about the nature of artistic expression from the neuropsychological observations

reviewed here? Neuropathology does not necessarily entail poor artistic production. Rather, neuropsychological deficits can mold the form that art might take, sometimes with surprising and even appealing results.

### 5.1. Visual styles and expressions

Artists employ a wide range of styles in which different subjects are chosen and in which different visual attributes are emphasized. Zeki (1999a, 1999b) proposes that artists, particularly in the twentieth century, are like visual neuroscientists. Both try to understand the way in which we know the visual world. He suggests that artists have independently discovered the modules of the visual brain. Some artists like Matisse emphasize color, and others like Calder emphasize motion. If artists “experiment” to understand how we apprehend the world, then these experiments would presumably be affected by brain pathology that directly affects how they apprehend the world.

Livingstone extends the idea of artists emphasizing different visual attributes in discussing interactions between the dorsal (where) and the ventral (what) visual stream (Livingstone, 2002). The dorsal stream is sensitive to contrast differences, motion and spatial position. Since shape can be derived from luminance differences, Livingstone argues that artists can use contrast to produce shapes, leaving color for expressive, rather than descriptive purposes (she gives the example of Derain’s portrait of Matisse). This idea raises the possibility that even when brain damage affects the descriptive use of line, color or form, these attributes might still be used expressively.

Sacks’ patient with achromatopsia initially used color in his paintings after acquiring his deficit (Sacks, 1995a). However, his use of color was ineffective and appeared haphazard. His loss of color knowledge impaired his ability to use color descriptively or expressively. After an early sense of helplessness, he began to use his new way of seeing the world expressively. While driving he saw a sunrise in which blazing reds were seen as black. He described it as follows: “The sun rose like a bomb, like some enormous explosion. Had anyone seen a sunrise in this way before?” Inspired by this image, he painted a black and white painting called *Nuclear Sunrise*. His subsequent black and white paintings were full of movement and vitality. Perhaps he gave greater expression to visual information represented by the dorsal stream, without being hampered by ventral stream processing. Eventually, he felt that his vision was further refined as he now saw the world as pure form, uncluttered by color. In experiencing his achromatopsia as a strange gift, he even rejected suggestions for retraining that might have restored some of his color vision.

The loss of the ability to use line and form descriptively, can give rise to a greater expressive openness. Heller (1994) reported the experience of an artist, Loring Hughes, after right brain damage. As might be expected with right brain damage she had more difficulty with the spatial relationship



Fig. 12. Portrait drawn by Loring Hughes before her brain injury. Reprinted with permission (Heller, 1994, Fig. 4, p. 277).

between the lines that she drew (Figs. 12 and 13). Heller says:

After damage to her brain . . . two things contributed to a new found freedom from inhibition. First, her difficulties with spatial relationships made it impossible for her to replicate the world on paper, and this forced her to accept and explore the world of her own emotions. As she



Fig. 13. Portrait drawn by Loring Hughes after her brain injury, when she had less of a sense of the spatial relationships of lines. Critics viewed these images as more emotionally expressive than her previous work. Reprinted with permission (Heller, 1994, Fig. 5, p. 278).

describes it, she gave up trying to reproduce things and turned, instead to her imagination . . . .

Two years ago, Loring was too ashamed to show her work. A year ago, she found herself getting comfortable with her new style. To her surprise, when she did start showing, the feedback from the artistic community was much more encouraging than before. Her paintings 'deliver an emotional wallop' according to art critic Eileen Watkins.

Similarly, Reynolds Brown and Lovis Corinth were judged to be more expressive in their paintings after their right-hemisphere stroke. Brown's paintings demonstrated the use of bolder strokes and less emphasis on detail. Alfred Kuhn characterized Corinth's work after his right hemispheric stroke in 1911 as follows (quoted in Gardner, 1975, p. 323):

When Corinth arose from the sickbed, he was a new person. He had become prescient for the hidden facets of appearance . . . . The contours disappear, the bodies are often as if ript 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 . . . models, no matter who they are, are now just objects to be painted . . . . Corinth always seems to be painting a picture behind the picture, one which he alone sees . . . at this point Corinth shifted from the ranks of the great painters into the circle of the great artists.

Thus, the neural basis for visual description and visual expression seem distinct. Deficits of descriptive abilities can sometimes give rise to greater expressive freedom and art that is viewed more favorably by critics. Expressionist movements in art are those images in which the imagery conveys considerable emotion. Little about the emotional states of these brain-damaged artists is known. Perhaps the shift from descriptive to expressive styles also reflects a release of emotions. Whether brain damage can shift an artist from an expressive to a descriptive style is not known. One could speculate that an expressive artist who developed an FTD, might become more descriptive in producing realistic and detailed art.

### 5.2. *Abstraction and simplicity*

A paring down of visual forms may be aesthetically pleasing. Why might this paring down be pleasing? Ramachandran and Hirstein (1999) propose that simplified abstractions may be tapping into visual primitives that are arousing even when we are not aware of the source of this arousal. They rely on work of Tinbergen (1954) on gull chicks to make this argument. These gull chicks respond to a beak with a red point at the end. However, they respond even more vigorously to a long stick with three red points at the end. The point is that they respond to a visual primi-

tive. This primitive no longer resembles the environmental stimulus that originally gave rise to it.

As his Alzheimer's disease progressed, DeKooning's art became increasingly simple. His forms were less complex and his palette was limited to a few primary colors and their complements. Garrels (1995), senior curator at the SF-MOMA states:

In the 1980s works, the essential procedures and techniques were not changed but simplified, and the vocabulary of forms was retained but clarified. Particularly in the works from 1984, the results are paintings of an openness and freedom not seen before, paintings that are extraordinarily lyrical, immediately sensual, and exhilarating.

Ironically, years earlier, in 1959, DeKooning observed "It seems that a lot of artists, when they get older they get simpler." His own art demonstrated that simpler does not mean simple. In the hands of a talented artist, this paring down of forms to simple abstractions by disease still retains great aesthetic force.

### 5.3. *Percepts, prototypes and primitives*

Highly realistic images can be recognized as specific things in the world. These realistic images contrast with icons or prototypes, which are easily recognizable as members of a class, but not as a specific object (a visual analog of the type-token distinction). Pamuk (2001) considers this distinction in his novel "My Name is Red" set in 17th century Istanbul. The Islamic prohibition on producing representational art, he suggests, turns on the difference between individuated and prototypic representations. By giving voice to a tree in an Islamic painting, Pamuk says (p. 51):

A great European master miniaturist and another great master artist are walking through a Frank meadow discussing virtuosity and art. As they stroll, a forest comes into view before them. The more expert of the two says to the other: "Painting in the new style demands such talent that if you depicted one of the trees in this forest, a man who looked upon that painting could come here, and if he so desired, correctly select that tree from among the others."

I thank Allah that I, the humble tree before you, have not been drawn with such intent. And not because I fear that if I'd been thus depicted all the dogs in Istanbul would assume that I was a real tree and piss on me: I don't want to be a tree, I want to be its meaning.

Patients with FTD seem inclined to paint highly detailed and realistic images. Magnani, the painter obsessed with Pontito also painted rich and recognizable images of this village, so much so that photographs could be taken from virtually the same vantage points as the paintings were imagined (Sacks, 1995b). By contrast, the drawings of the autistic savants Nadia and Wiltshire are more prototypic in their form. Thus Nadia's horses were inspired by images

she saw, but became amalgams of horses she had seen previously. Both Nadia and Wiltshire could draw after looking at the model for only a few seconds. After apprehending the object, they could quickly access and render a prototypical representation.

Representational figures also can be highly schematic, sometimes referred to as visually primitive. The terms “primitive” is used here to describe images that are simple renderings with minimal visual elements, such as lines and simple shapes, which convey an object or action without the rich sensory information conveyed in percepts or prototypes. Child-like schematic images may be of great artistic interest, as in the work of Klee or Miro. The extant data are limited, but the art of patients with AD and some patients with left-hemisphere damage shifts to such schematic simplification. Presumably, this schematic simplification reflects their pathological semantic simplification. However, it is possibility that these simplifications may still be visually interesting in an artistically talented person, a possibility that to my knowledge has not yet been reported.

#### 5.4. *Knowing and seeing*

When we look into the world, do we see what we apprehend through our senses or do we see what we know? This issue has pre-occupied psychology for many years. Gombrich (1960) also underscored it as a central issue in the history of Western art in exploring the reasons that styles of representing the world have changed so dramatically over the years. Gombrich’s basic postulate is that we bring enormous amounts of top-down information to bear on what we see. Sensations automatically trigger hypotheses for what we are seeing. These hypotheses are based on internal representations, which we test constantly during perception. Consequently, Gombrich argues that we are mostly aware of our own internal representations rather than the sensations that trigger these representations.<sup>3</sup> Shifting how we see from the conceptual to the perceptual is not easy. For example, children normally draw what they know to be true rather than what they see. Thus roads receding into the horizon are most often drawn with parallel lines and not lines converging into a distant vanishing point. Children know that the edges of the road do not, in fact, converge.

Artists need considerable practice and training to minimize this automatic visual hypothesis testing in order to better “see” the world. In this training artists develop visual vocabularies from which they literally draw on. In the examples of Magnani and partial-complex seizures, or DeChirico or Brennan from migraine auras, such visual vocabularies derive from positive neuropsychological phenomena. However, most artists develop such vocabularies by learning such techniques from teachers and artists that came before them.

<sup>3</sup> This simple characterization of Gombrich’s opinion in no way conveys the subtlety of his discussion in “Art and Illusion” [22].

What happens if artists do not have well-formed conceptual representations and consequently view visual forms without this automatic hypothesis testing? People with semantic dementia and autistic children are particularly germane to this question. Franklin’s patient with a semantic dementia was able to draw remarkably life-like images from a model if the model itself were rich and detailed. Conceptual knowledge does not seem necessary to being able to draw well. The examples of the autistic savants, Nadia and Wiltshire, suggest that impoverished conceptual representation of the world may actually help rendering what we see; something art teachers recognize when they give students exercises such as drawing things upside down or following contours of things to shift them away from what they know to what they see. Nadia drew horses using single-point perspective and depth (Figs. 9 and 11)<sup>4</sup> rather than as simple symbolic representations formed by lines and simple geometric figures as drawn by most children (Fig. 10). Consistent with the interpretation that she drew without knowing what she was drawing (at least in the way that others do), she often began her drawings at bizarre points. For example, at times she started at the neck of a horse rather than at its head unlike how other people draw horses. Language development can be considered a marker for conceptual development. So, it is especially intriguing that as Nadia’s language skills developed, her ability as an artist became more prosaic.

## 6. Conclusions

At the outset, I mentioned reasons to be cautious about the inferences one might make in reviewing the consequences of brain damage on art produced by artists. The data are descriptive, the reports are few, and pre-morbid artistic talents and styles vary greatly. Despite these limitations, a few general principles emerge of which I would like to highlight three. First, artists despite their visuo-motor gifts are not spared the kinds of neuropsychological visual deficits experienced by others. Instead, their skills allow them to manifest their deficits in particularly eloquent ways. Second, having a neuropsychological deficit that affects an artist’s production does not necessarily mean that the art produced is of less quality. The artists’ work may shift in content or style sometimes in surprising and even aesthetically pleasing directions. Thus, the lack of ability to use

<sup>4</sup> Gifted children in their teens can draw perspective the way Nadia could before the age of four. How is this ability to draw in perspective as part of normal development reconciled with Gombrich’s view that such techniques took centuries to develop? I would argue that we still do not “see perspective.” In the 20th and 21st century, we are surrounded by photographs, billboards, movie and TV images, in which three dimensions are forced into flat space. We have learned to recognize perspective from these images. When we look into the environment, it is this knowledge rather than the percept itself that forms the basis for visual hypothesis testing.

lines descriptively may give the artist license to use lines expressively. Third, neuropsychological observations themselves may tell us something about the nature of artistic production. For example, interactions of perception and knowledge in art can be probed in artists with perceptual and conceptual deficits. It should be acknowledged that these principles are inferred from observations of relatively few patients. Clearly, many more descriptions of the neuropsychology of artists are needed to determine if these principles have been drawn accurately (or expressively).

## References

- Alajouanine, T. (1948). Aphasia and artistic realization. *Brain*, 71, 229–241.
- Behrmann, M., Moscovitch, M., & Winocur, G. (1994). Intact visual imagery and impaired visual perception in a patient with visual agnosia. *Journal of Experimental Psychology: Human Perception and Performance*, 20, 1068–1087.
- Bisiach, E., & Rusconi, M. L. (1990). Breakdown of perceptual awareness in unilateral neglect. *Cortex*, 26, 643–649.
- Blanke, O., Ortigue, S., & Landis, T. (2003). Color neglect in an artist. *Lancet*, 361, 264.
- Botez, M. I., Olivier, M., Vézina, J.-L., Botez, T., & Kaufman, B. (1985). Defective revisualization: Dissociation between cognitive and imagistic thought. Case report and short review of the literature. *Cortex*, 21, 375–389.
- Brown, J. (1977). *Mind, brain, and consciousness. The neuropsychology of cognition*. New York: Academic Press.
- Cantagallo, A., & Sala, S. D. (1998). Preserved insight in an artist with extrapersonal spatial neglect. *Cortex*, 34, 163–189.
- Canu, E., Piras, M., & Martindale, C. (2002). Alzheimer's disease and neural network freezing: Creativity and cognitive incompetence in a painter with Alzheimer's dementia. Paper presented at the 17th Congress of the International Association of Empirical Aesthetics, Takarazuka, Japan.
- Chatterjee, A. (1994). Picturing unilateral spatial neglect: Viewer versus object centred reference frames. *Journal of Neurology, Neurosurgery and Psychiatry*, 57, 1236–1240.
- Chatterjee, A. (2002). Universal and relative aesthetics: A framework from cognitive neuroscience. Paper presented at the International Association of Empirical Aesthetics, Takarazuka, Japan.
- Chatterjee, A. (2003). Neglect. A disorder of spatial attention. In M. D'Esposito (Ed.), *Neurological foundations of cognitive Neuroscience* (pp. 1–26). Cambridge, MA: The MIT Press.
- Chatterjee, A. (2004). Prospects for a cognitive neuroscience of visual aesthetics. *Bulletin of Psychology and the Arts*, 4, 55–60.
- Chatterjee, A., & Southwood, M. H. (1995). Cortical blindness and visual imagery. *Neurology*, 45, 2189–2195.
- Chatterjee, A., Strauss, M. E., Smyth, K. A., & Whitehouse, P. J. (1992). Personality changes in Alzheimer's disease. *Archives of Neurology*, 49, 486–491.
- Coslett, H. B. (1997). Neglect in vision and visual imagery: A double dissociation. *Brain*, 120, 1163–1171.
- Eames, K., & Cox, M. V. (1994). Visual realism in the drawings of autistic. Down's syndrome and normal children. *British Journal of Developmental Psychology*, 12(2), 235–239.
- Fein, D., Lucci, D., & Waterhouse, L. (1990). Fragmented drawings in autistic children. *Journal of Autism & Developmental Disorders*, 20(2), 263–269.
- Franklin, S., van Sommers, P., & Howard, D. (1992). Drawing without meaning? Dissociations in graphic performance of an agnostic artist. In R. Campbell (Ed.), *Mental lives. Case studies in cognition* (pp. 179–198). Cambridge, USA: Blackwell.
- Fuller, G. N., & Gale, M. V. (1988). Migraine aura as artistic inspiration. *British Medical Journal*, 297(6664), 1670–1672.
- Gardner, H. (1975). *The shattered mind. The person after brain damage*. New York: Alfred A. Knopf.
- Garrels, G. (1995). Three toads in the garden: Line, color, and form. In *Willem de Kooning. The late paintings, the 1980s* (pp. 9–37). Minneapolis: San Francisco Museum of Modern Art and Walker Arts Center.
- Gombrich, E. (1960). *Art and illusion*. Princeton: Princeton University Press.
- Halligan, P. W., & Marshall, J. C. (1997). The art of visual neglect. *Lancet*, 350, 139–140.
- Halligan, P., Fink, G., Marshall, J., & Vallar, G. (2003). Spatial cognition: Evidence from visual neglect. *Trends in Cognitive Sciences*, 7, 125–133.
- Heller, W. (1994). Cognitive and emotional organization of the brain: Influences on the creation and perception of art. In D. Zaidel (Ed.), *Neuropsychology* (pp. 271–292). New York: Academic Press.
- Hermelin, B., Pring, L., & Heavey, L. (1994). Visual and motor functions in graphically gifted savants. *Psychological Medicine*, 24(3), 673–680.
- Jung, R. (1974). Neuropsychologie und neurophysiologie des konturund formsehens in zeichneri und malerei. In H. Weick (Ed.), *Psychopathologie Musischer Gestaltungen* (pp. 27–88). Stuttgart: FK Shattauer.
- Kaczmarek, B. (1991). Aphasia in an artist: A disorder of symbolic processing. *Aphasiology*, 5, 361–371.
- Lewis, V., & Boucher, J. (1991). Skill, content and generative strategies in autistic children's drawings. *British Journal of Developmental Psychology*, 9(3), 393–416.
- Lissauer, H. (1890). Ein Fall von Seelenblindheit Nebst Einem Beitrage zur Theori derselben. *Archiv fur Psychiatrie und Nervenkrankheiten*, 21, 222–270.
- Livingstone, M. (2002). *Vision and art: The biology of seeing*. New York: Abrams.
- Marsh, G. G., & Philwin, B. (1987). Unilateral neglect and constructional apraxia in a right-handed artist with a left posterior lesion. *Cortex*, 23(1), 149–155.
- Marshall, J. C., & Halligan, P. W. (1988). Blindsight and insight in visuospatial neglect. *Nature*, 336, 766–767.
- Miller, B. L., Cummings, J., Mishkin, F., Boone, K., Prince, F., & Ponton, M. et al., (1998). Emergence of artistic talent in frontotemporal dementia. *Neurology*, 51, 978–982.
- Morishima, A., & Brown, L. F. (1976). An idiot savant case report: A retrospective view. *Mental Retardation*, 14(4), 46–47.
- O'Conner, N., & Hermelin, B. (1991). Talents and pre-occupations in idiot-savants. *Psychological Medicine*, 21, 959–964.
- Pamuk, O. (2001). *My name is red*. New York: Alfred A. Knopf.
- Podoll, K., & Robinson, D. (2000). Migraine experiences as artistic inspiration in a contemporary artist. *Journal of the Royal Society of Medicine*, 93(5), 263–265.
- Ramachandran, V. S., & Hirstein, H. (1999). The science of art: A neurological theory of aesthetic experience. *Journal of Consciousness Studies*, 6, 15–51.
- Rimland, B., & Fein, D. (1988). Special talents of autistic savants. In L. Obler & D. Fein (Eds.), *The exceptional brain* (pp. 474–492). New York: Guilford.
- Sacks, O. (1995a). The case of the color blind painter. In *An anthropologist on mars* (pp. 3–41). New York: Alfred A. Knopf.
- Sacks, O. (1995b). The landscape of his dreams. In *An anthropologist on mars* (pp. 153–187). New York: Alfred A. Knopf.
- Sacks, O. (1995c). Prodigies. In *An anthropologist on mars* (pp. 188–243). New York: Alfred A. Knopf.
- Schnider, A., Regard, M., Benson, D. F., & Landis, T. (1993). Effect of a right-hemisphere stroke on an artist's performance. *Neuropsychiatry, Neuropsychology & Behavioral Neurology*, 6(4), 249–255.
- Schwartz, M., & Chawluck, J. (1990). Deterioration of language in progressive aphasia: A case study. In M. Schwartz (Ed.), *Modular deficits in Alzheimer-type dementia* (pp. 245–296). Cambridge, MA: The MIT Press.

- Selfe, L. (1977). *Nadia. A case of extraordinary drawing ability in an autistic child*. New York: Academic Press.
- Singer, C. (1958). The visions of Hildegard of Bingen. In *From magic to science*. New York: Dover.
- Storr, R. (1995). At last light. In *Willem de Kooning. The late paintings, the 1980s* (pp. 37–79). Minneapolis: San Francisco Museum of Modern Art and Walker Arts Center.
- Tinbergen, N. (1954). *Curious naturalist*. New York: Basic Books.
- Van Sommers, P. (1989). A system for drawing and drawing-related neuropsychology. *Cognitive Neuropsychology*, 6(2), 117–164.
- Wapner, W., Judd, T., & Gardner, H. (1978). Visual agnosia in an artist. *Cortex*, 14, 343–364.
- Waxman, S., & Geschwind, N. (1975). The interictal behavior syndrome associated with temporal lobe epilepsy. *Archives of General Psychiatry*, 32, 1580–1586.
- Wilkinson, M., & Robinson, D. (1985). Migraine art. *Cephalalgia*, 5(3), 151–157.
- Zaimov, K., Kitov, D., & Kolev, N. (1969). Aphasie chez un peintre. *Encephale*, 58, 377–417.
- Zeki, S. (1999a). Art and the Brain. *Journal of Consciousness Studies*, 6, 76–96.
- Zeki, S. (1999b). *Inner vision: An exploration of art and the brain*. New York: Oxford University Press.