NEUROPSYCHOLOGY OF AESTHETICS

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I. INTRODUCTION

The subject of this panel is "The Biological Foundations of Aesthetics." "Biology" is the study of life processes, which include their anatomy, physiology, pathology, ecology, paleontology, and the like, but in its broader sense it encompasses our own field of neuropsychology — the study of the relationship between the brain and behavior. Toward this end, we study the morphology, physiology, and pathology of the brain. We also study its ecology, that is to say, the relationship between brain, behavior, and the physical and social environment, and we even draw on paleontological evidence in studying the evolution of brain-behavior relationships.

Compared to "biological," the term "aesthetic" is rather more difficult to define. The dictionary (Merriam-Webster *International Unabridged Dictionary*, 1957) defines it as: "Of or pertaining to the beautiful, as distinguished from the merely pleasing, the moral, and especially the useful; as a purely aesthetic reaction, aesthetic criteria, or pleasure" (p. 42). The question is, what do we mean by "beautiful," and where do we draw the line between the "beautiful" and the "merely pleasing"? Just what is it that we propose to do a neuropsychological analysis *of*?

In our neuropsychological analysis of the aesthetic, or beautiful, we shall restrict ourselves to the aesthetics in art, in particular, to the visual arts of drawing and painting. Of course, there is no reason in principle for limiting our analysis in this way. The "arts" are many and various, ranging from drawing and painting to sculpture and architecture, and from music and dance to literature and poetry (in Korea, we have also enjoyed some of the products of this country's exquisite culinary arts), and so we could address ourselves to any

one or another of these domains, as other papers in this symposium have done. There also is no reason, *a priori*, to suppose that whatever may be the biological foundations of *visual aesthetics* will be the same for all the arts, except, perhaps, in the sense that whatever underlies "aesthetic creativity" may be common to all. Our only reason for focusing on visual aesthetics — on drawing and painting — is that this is where most of the relevant neuropsychological research is concentrated. Finally, there is no reason in principle for confining our analysis to the aesthetics in *art*. We mean that an aesthetic sense exists in the sciences, too. As the dictionary tells us, "aesthetic" also means "appreciative of, or responsive to, the beautiful in art *or nature* . . . " (p. 42, emphasis added). That quality is well-expressed by Jules Henri Poincaré (1854-1912), the French mathematician, physicist, and author:

> The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing, and if nature were not worth knowing, life would not be worth living . . . I mean that profounder beauty which comes from the harmonious order of the parts and which a pure intelligence can grasp . . . It is, therefore, the quest of this special beauty, the sense of harmony of the cosmos, which makes us choose the facts most fitting to contribute to this harmony, just as the artist chooses from among the features of his model those which perfect the picture and give it character and life" (Poincaré, 1913, pp. 366-367).

Our presentation, which we call "The Neuropsychology of Aesthetics," will begin with the question, "What do we mean by "aesthetic," or "beautiful"? After that, we shall present a primer on neuroanatomy. This will be just enough to get us started, to make our initial presentation of the research evidence understandable to all — there will be more anatomy as needed later on. Following this will be a brief review of early theory and research on the "neuropsychology of aesthetics." Then, we shall turn to current theory and

research, with an emphasis on what we call *hemispheric specialization*, meaning the contributions of the left and right hemispheres of the brain to aesthetic appreciation and production. Our focus throughout will be on two populations — non-artists and artists. Two kinds of studies will be examined: clinical studies of neurological patients and normative studies of healthy individuals. Several questions will be addressed in this review of current research.

The first question is whether there are certain faculties of mind that can be neurologically specified and that are of special importance in the conceptualization, execution, and appreciation of a work of visual art as distinct from work of some other, non-artistic, kind. In other words, can we identify specific neuroanatomical mechanisms and even specific neuroanatomical loci for these faculties? Do they engage certain brain regions more than others, and, more particularly, regions in one hemisphere more than the other? And if we can identify such mechanisms and neuroanatomical loci, will they prove to be universal? Will they help us to understand why, as Professor Turner says in his introdution, "human beings across the whole range of human cultures find certain objects, sounds, movements, stories beautiful"?

If we can specify these faculties and their neurological bases for the general population, do these descriptions also apply to artists, or is there a distinct neuropsychological profile associated with artistic talent? We shall address this question by asking to what extent neuropsychological mechanisms underlying aesthetic experience and production will allow us to explain the changes that take place in artistic works when artists become brain-injured. Another way to address the question, to be taken up in the next parts

of our presentation, is to ask whether artists are over-represented in subgroups of the general population that we already know have distinct neuropsychological profiles.

Following our discussion of these issues, we shall turn to a different kind of question, and that is whether neuropsychological theory and research on aesthetics can be put to practical use, in particular, whether it can help us become better artists, to realize such potential as we may all enjoy. In the last few years, many educators have called for and have claimed success in such ventures. We shall focus on the most visible and commercially successful of them — the book *Drawing on the Right Side of the Brain*, by the American art teacher Betty Edwards. We intend our discussion, however, to have implications for the whole genre.

Finally, in the last part of our presentation, we shall offer suggestions for new hypotheses and new directions for neuropsychological theory and research on aesthetics.

II. COMPONENTS OF THE "AESTHETIC SENSE"

The first question, then, is, what do we mean when we say that a drawing or a painting is "aesthetic" or beautiful? What gives it this quality? And — a different question — what does it take to create a picture that would be judged "aesthetic" or "beautiful"? How is such a picture conceived and executed? We are under no illusions that we can answer these questions in any definitive sense. After all, they have challenged aestheticians for millennia. The most that we can do, as neuropsychologists who study higher cognitive processes, is to re-frame these questions in ways that we can deal with operationally.

We shall begin by dividing the components of aesthetic experience and production into three broad categories:

1. Sensory-Perceptual

The first category is the "Sensory-Perceptual." When we experience a picture as beautiful, our aesthetic perception arises from our theory of the properties of the external world and their inter-relations. We mean that our aesthetic experience emerges from certain processes of the mind applied to certain qualities of the external world.

So, to start, a basic question is, what are the qualities of the external world that the mind represents? In terms of the visual arts, the qualities are those contained within the picture frame — colors, forms, or both, and the variations within these dimensions. In the case of color, we mean variations in hue, brightness, and saturation. (For example, there are said to be several dozen varieties of green in Henri Rousseau's *The Dream*). Variations in form include length, width, curvature, orientation, texture, and, as a second-order dimension, "depth" of surface.

So far, we have named two superordinate and separable components: color and form. In addition to their individual contributions, it is important to consider how the variety of properties of color and form are represented along the axes of the picture — the lateral (left and right), vertical (top and bottom), and longitudinal (front and back). The reason is that certain spatial layouts can heighten or reduce our aesthetic response. We shall show that certain spatial layouts enhance the aesthetic appeal of a picture relative to its mirror image because of asymmetric properties of the two hemispheres.

[Illustrations will be shown]

There is also the dimension of predictability. The design of the picture must be neither too predictable, or redundant, so that creating a model is too easy, nor must it be too

unpredictable, or non-redundant, so that creating a model is too difficult or even impossible. The term "predictable," as used in *information theory*, refers to the liklihood that information contained in one part of the picture can be used to predict what will be found in another part.

Still another dimension that contributes to a picture's aesthetic appeal is complexity. All of the individual components must create a picture of sufficient complexity to keep us aroused and interested and, therefore, to make the perceptual feat worth achieving. Indeed, stimulus complexity has been called "the most relevant dimensional factor in the appreciation of an esthetic pattern by the subject" (Moles, 1968, p. vi., referring to work by Noll, 1967). This may be another way of saying that a picture that is sufficiently complex challenges us to find an harmonious and self-consistent perceptual models, the achievement of which brings deep emotional reward. (In the sciences, as well, we favor and regard as beautiful those theories that self-consistently and harmoniously account for a large number of phenomena.) Finally, as the gestalt psychologists have taught us, the whole is different from and greater than the sum of its parts. It may be this transcendent quality of a picture that is its most important aesthetic ingredient.

2. Emotional-Affective

The second category is the "Emotional-Affective." We mean that in every aesthetically-pleasing work of art, there is some quality that moves us emotionally, that engages our feelings. (In common parlance, we would say, "a quality that moves us in our heart and not just our head, although, as neuropsychologists, we know that the emotions are *only* in our head.) We mean that these are part and parcel of the aesthetic perception, part of the perception of the colors and forms of the picture. Certain colors and forms, moreover,

are especially potent in eliciting emotional responses. For example, smiles evoke pleasant emotions, frowns unpleasant, negative emotions, and even the critical features of these expressions — the rounded forms and angular forms, respectively — can evoke the same emotions in a non-representational work of art.

[Illustrations will be shown]

3. Motor-Executive

Sensory-perceptual and emotional-affective components comprise the "input" from the external world. They are all that can be contained within the picture frame. The *artist*, of course, also needs the physical skills to express these components onto the canvas. This last category, which we call the motor-executive, or "output," is probably the one that most clearly defines the artist, at least in the popular view. For example, many persons may be able to imagine beautiful scenes or to create them in their dreams (or so they seem while they dream), but only a fortunate few can construct these scenes on a canvas or in some other medium. It is, indeed, a *construction* rather than the copying of a mental image. As Ernst Gombrich says in his great work *Art and Illusion* (1961, 2nd ed.), when we make art, we do not have an "innocent eye" that produces the image, which we then merely copy onto the paper.

III. A PRIMER ON NEUROANATOMY

To make our review and analysis understandable to all, we first shall need to present some neuroanatomy. Our presentation, therefore, will begin with a description of the important landmarks of the brain — the major fissures, gyri, and lobes of its *gray matter*, and the major tracts of its *white matter* — with more detail as needed in later parts.

IV. EARLY THEORY AND RESEARCH ON THE NEUROPSYCHOLOGY OF AESTHETICS

Following this primer on neuroanatomy, we shall be ready to present the neuropsychological evidence. We shall note that the neuropsychological study of aesthetics is by no means a product of our own time and that precedents can be found in virtually every historical period, or at least as soon as the brain, and not some other part of the body, was understood to be the site of mind. To set the stage for our review, we shall give a brief account of prior work, beginning with the early 19th-century phrenological theory of the Austrian anatomist and physician Franz Joseph Gall (1819, 1835; Gall & Spurzheim, 1810). The part of Gall's theory of special interest for us is that among the "faculties of mind" in his theory, for each of which he posited a specific neuroanatomical locus, there were several of relevance to art — color, locality (or spatial relations), order, and constructiveness (the propensity to build).

[Illustrations will be shown]

The system even allowed for the analysis of artistic specialization for artist and viewer alike. For example, Gall supposed that color was a particular necessity for painters and dyers, and that persons with a large organ of form would be fond of seeing pictures, especially portraits. Artistic specialization also depended on having particular faculties in combination. Thus, "the sense of locality, combined with that of arts and colors, produces the landscape-painter" (Gall, Vol. IV, p. 276; see also Vol. I, 1835, p. 41).

Gall was a localizationist, not a "lateralizationist." That is, he assumed that each hemisphere contained a complete set of organs, each set duplicating the other, and that the

only requirement for competent mental activity was for the hemispheres to work in synchrony. This required a physical connection between the hemispheres, a role that Gall assigned to the corpus callosum.

Following our review of Gall's theory, we shall turn to the theories of the era of "hemispheric specialization," or "lateralization of function," ushered in by the work of Paul Broca (1865), who declared that "we speak with the left hemisphere." The first person in Broca's era to focus on *non-verbal* aspects of mind was the British neurologist John Hughlings Jackson. In 1874, drawing from new clinical evidence, Jackson postulated that the right hemisphere, more particularly, the right posterior region, played a special role for visual recognition and visual memory, and that "imperception" — "loss or defect of memory for persons, objects, and places" — was as characteristic of posterior right-hemisphere disease as motor aphasia was of anterior left-hemisphere disease (see also Jackson, 1876).

In our review, we shall describe Jackson's work, along with other early studies linking non-verbal spatial functions, some with relevance for aesthetics, to the right hemisphere. We also shall mention some of the important early developments in the study of hemispheric contributions to emotion.

V. RECENT METHODOLOGICAL ADVANCES IN THE STUDY OF HEMISPHERIC SPECIALIZATION

Following our review of early theory and research on the neuropsychology of aesthetics, we shall offer a brief overview of current methodological advances in the study of localization as well as lateral specialization of higher cognitive functions. Although much current information comes from the same kinds of studies as were performed in Broca's

time, namely, comparisons of cognitive deficits in patients with left lesions and patients with right lesions, much also has been learned from two new kinds of studies. One is of patients who have undergone a *callosotomy*, the cutting of the corpus callosum. The procedure and some of the relevant neuroanatomy will be explained.

[Illustrations will be shown]

The other kind of study is of neurologically normal people for whom a variety of so-called *non-invasive* behavioral methods for assessing lateral functional specialization have been newly developed or adapted from clinical tests. For studies of the kind most relevant to the neuropsychology of *visual* aesthetics, the method of choice is the *divided visual field* paradigm. The paradigm will be explained, again with some of the relevant neuroanatomy.

[Illustrations will be shown]

VI. HEMISPHERIC SPECIALIZATION FOR PERCEPTION, EMOTION, AND EXECUTIVE FUNCTIONS

With this introduction, we shall be ready to present the case for the "neuropsychology of aesthetics." Throughout, our special interest will be to assess the respective contributions of the left and right hemispheres to the sensory-perceptual, emotional-affective, and motor-executive components of aesthetic perception and production. The subjects in these studies are people from the general population who, as a *group*, are not known to have distinguished themselves in any artistic work. They are neither artists themselves nor 'appreciators' of art in the sense of being connoisseurs. Our review (for now) also will be restricted to studies of right-handers, since right-handers as a group are far more homogeneous than left-handers in cerebral organization and generally show clearer lateralized effects. We also shall draw from

studies, where available, on patients with unilateral lesions, callosotomy patients, and neurologically normal people.

A. Sensory, Perceptual

Beginning with studies of sensation and perception, research will be presented on the contributions of the left and right hemispheres to visual and spatial functions. One of the main conclusions to be drawn from this review is that the right hemisphere is superior to the left in many aspects of these functions. The evidence goes beyond this point, however, in suggesting that the right hemisphere actively seeks to achieve an understanding of and to build a model of spatial relationships. The left hemisphere, in contrast, appears to surpass the right hemisphere in representing featural details, especially if they are easily named or described. The evidence will also show that the right hemisphere plays a leading role in representing the spatial relations of features that comprise a face.

B. Emotional-Affective

So far, our review will have concentrated on studies of lateral specialization for sensory-perceptual faculties. We also suggested that an aesthetically pleasing work of art ought to move us emotionally, engaging our feelings, and not just our eyes. The next part of our presentation will begin with a review of clinical studies relating side of lesion to changes in emotion — in our ability to perceive or to recognize, or discriminate, emotional information, and in our ability to express it. The main conclusion to be drawn from this research is that the right hemisphere is superior to the left in the perception and expression of emotional information, including emotion in faces, and that the left hemisphere interprets stimuli more positively than the right.

C. Execution, Production

Following this examination of the proposed sensory-perceptual and affective-emotional components of aesthetics, the next question will be, how does the artist create a picture that evokes these aesthetic responses in the viewer? This question will be approached on several levels.

1. How Is The Hand Connected to the Brain?

The first level is the strictly neuroanatomical: how is the hand connected to the brain? Here, more neuroanatomy will be presented, this time pertaining to hand-motor connections, and the main point will be that the motor and sensory pathways are predominantly crossed, so that the final output to each side of the body comes predominantly from the opposite side of the brain. Contributions to this output may, however, be relayed across the corpus callosum from one to the other hemisphere.

[Illustrations will be shown]

2. Why Is One Hand Normally More Skilled Than The Other?

The second level pertains to motor dominance, or *handedness* — why one hand is normally more skilled than the other, and why the vast majority of persons are right-handed (90 percent by most estimates), whereas only a small minority are left-handed (10 percent). We shall discuss possible asymmetries in the spinal cord and brain stem and in the specialization of the left hemisphere for the control of skilled movements.

3. Studies of Drawings by Patients With Unilateral Lesions

This review of the neuroanatomy of hand control and praxis will help us understand why most people are right-handed. It also will help us understand why virtually all right-

handers not only write but *draw* with the right hand despite the superiority of the right hemisphere in so many of the perceptual and emotional processes that are important for artistic production and drawing. The reason is that both acts require very fine control of the sequences of movements of the digits coordinated with movements of the wrist and arm, movement sequences for which the left hemisphere is specialized. With this introduction into the neuroanatomy of hand-motor control, handedness, and praxis, we also shall have laid the groundwork for understanding some of the things that can go wrong when someone with a unilateral lesion tries to draw a picture. In cases of unilateral damage to motor-control regions, the contralateral hand is often paralyzed and cannot be tested for skilled movements. However, when the left hemisphere is damaged, the ipsilateral left hand manifests apraxic disorders. In contrast, after right-hemisphere damage, the right hand displays no apraxic disorders. Evidently, the intact left hemisphere, via interhemispheric pathways, normally contributes important components of motor regulation to the left hand, whereas the right hemisphere apparently contributes nothing to the motor regulation of the right hand. Therefore, with left-hemisphere damage, even if the individual switches to the unparalyzed left hand, there is likely to be a compromising of the ability to formulate and to execute the necessary higher-order sequential commands required for drawing a picture or making a construction.

To illustrate these points, we shall show illustrations of drawings made by patients with unilateral lesions, either in the left hemisphere or the right hemisphere.

VII. HEMISPHERIC SPECIALIZATION IN ARTISTS

Following our review of studies of right-handers from the general population, we shall examine neuropsychological organization in artists. The neuropsychological literature on artists consists almost totally of studies of the drawings and paintings of artists who have suffered unilateral lesions, and it is only from comparisons of their drawings and paintings, before and after their injuries, that we can say anything about neuropsychological organization in artists. Even here, we are severely limited because there are hardly more than a double-handful of such cases in the literature. Still, despite these limitations in methodology and sample size, these studies of artists' drawings have one advantage rarely if ever found in the study of the drawings of non-artists. Only the former allow for direct pre- and post-morbid comparisons.

Spatial Layouts

Previously we asked whether certain spatial layouts are more pleasing to the eye, making the picture more aesthetically appealing, and, if so, whether we could identify the characteristics of neuropsychological organization that produce more aesthetic responses to some layouts than to others. Are artists more sensitive to these layouts than non-artists, and do they more consistently incorporate these designs in their works?

Summary

An examination of the pre- and post-morbid drawings will show that the post-morbid drawings still reveal a high level of aesthetic appeal, even when the artist has been compelled to use the non-dominant hand, and that the drawings show changes in style and composition consistent with evidence from studies of the general population, which we shall highlight. If

the neuropsychological literature on hemispheric specialization offers many clues into the nature of brain-behavior relationships in aesthetic production and appreciation, it offers few if any clues into what distinguishes the artist from the non-artist *neuropsychologically*. There is another way, however, to approach the question, which is to ask whether artists are over-represented in subgroups of the general population that we already know to have distinct neuropsychological profiles. We shall examine this question in the next several parts of our presentation.

VIII. ARTISTIC ABILITY AND HANDEDNESS

One subgroup of the population that is neuropsychologically different (but also very diverse) and is said to show an over-representation of artists is left-handers. The most famous and most-often cited examples are Michelangelo and Leonardo. Of course, two left-handed artists, even if they are Michelangelo and Leonardo, do not establish a link between left-handedness and artistic ability. Is there, therefore, any real evidence for this link, and, if so, can we specify the neuropsychological reasons for such linkage? To examine this question, we shall review the evidence pertaining to the differences between the neuropsychological organization of ordinary right-handers and left-handers. The evidence will show that for language, manual praxis, and probably visuo-spatial functions, the direction and degree of cerebral lateralization is more uniform in right-handers than in left-handers. For example, a larger minority of left-handers than right-handers show bilateral representation of functions that are lateralized in the majority.

With this evidence in hand, we shall review studies that *do* suggest a higher representation of left-handers among artists, or at least among art students. We shall explore

the possibility that differences in how neuropsychological organization of left- and right-handers may, indeed, put some left-handers at an advantage for artistic production.

IX. ART AND AUTISM

Left-handers comprise a neuropsychologically heterogenous but otherwise normal subgroup of the general population. That is, to whatever extent and for whatever reason artistic talent may be over-represented among left-handers, or perhaps among only certain subgroups of left-handers, artistic talent does not stand out remarkably from the left-hander's other intellectual capacities. The left-handed artist, in other words, is not an "artistic savant," well above the norm in artistic talent, well below it in virtually all other domains, even to the point of clinical retardation. There is another subgroup of individuals, however, who reportedly have uncommonly fine artistic abilities but who otherwise *are* significantly retarded. We are referring to the so-called "autistic" individual. In this part of our presentation, we shall consider whether such a characterization of autistic individuals is supportable or whether the characterization is based, instead, on questionable criteria. (For example, the works of many artistic savants, like those of musical and memory savants, do not show the 'constructiveness' of the normal artists but instead are typified by extremely close fidelity to the physical stimulus. (A drawing of a house might include such details as the pull rings at the bottom of window shades.) In any case, we shall ask whether and how the appearance of an artistic savant contributes to our understanding of the neuropsychology of art.

[illustrations will be shown]

X. WHAT ARE THE NEUROANATOMICAL, NEUROPHYSIOLOGICAL, AND NEUROCHEMICAL BASES FOR HEMISPHERE SPECIALIZATION? ARE THEY DIFFERENT IN ARTISTS AND NON-ARTISTS?

As neuropsychologists, we affirm that all behavioral variations are processes of the brain and are functions of its anatomy, physiology, and chemistry. Given this, to what extent have we identified those neural systems of critical relevance to aesthetic experience and expression? Do differences in *these* systems differentiate aesthetic from non-aesthetic experience and expression and artists from non-artists? We shall highlight some of the neuroanatomical variations between hemispheres amd in the communicative pathways between the hemispheres.

XI. CAN NEUROPSYCHOLOGICAL DATA BE USED TO ENHANCE ARTISTIC PERFORMANCE?

At this point, we shall have completed our review of the evidence for hemispheric specialization in the perceptual, cognitive, emotional, and expressive aspects of art. We shall be ready to ask whether any of the evidence suggests ways for enhancing artistic competence in the non-artist.

Like neuropsychological theories themselves, applications of these theories to education are hardly new. They have followed on the heels of virtually every neuropsychological theory in every era. Again, to set the stage for current-day attempts, we shall begin with accounts of some of these earlier programs. This will include a review of educational applications inspired in the phrenological era and in the era of lateral specialization that followed.

Even as new research has revealed errors in certain earlier educational applications, new applications have been invented. Of all the scientific developments to come to light in our era, what has most captured the educators' fancy pertains to the talents of the right side of the brain. Whereas earlier research on the language functions of the left hemisphere drew educators' attention to the left hemisphere and to disabilities in such basic language skills as reading and writing, the more recent revelations about the right hemisphere have inspired concern among educators for nonlinguistic (or at least not obviously linguistic) skills. A mythology has developed that entire disciplines such as music, art, and mathematics are provinces of the right hemisphere, along with visualization, imagination, creativity, and intuition. This has led many educators to believe that deficient interest or skill in music, art, visualization, creativity, empathy, and all other presumably non-logical, non-linguistic abilities either reflect over-development of (or over-reliance on) the left hemisphere or underdevelopment of the right. Out of this conviction has emerged a strong educational movement designed to train the right hemisphere. Edwards' (1979) *Drawing on the Right Side of the Brain* is but one example.

In our presentation, we shall ask whether or not the exercises that Edwards proposes are effective in enhancing artistic performance and, if so, whether they are for the reasons Edwards proposes, that is, whether her analysis of aesthetic experience and expression accurately reflects the neuropsychological evidence.

XII. CONCLUSIONS, NEW DIRECTIONS, HYPOTHESES

The evidence suggests that it is mistaken to suppose that 'drawing ability' is exclusively a product of the right hemisphere. Instead, it shows that both hemispheres

contribute, albeit in different ways, to the aesthetic process. This raises the issue, which has received very little research attention, of how the hemispheres integrate their specialized abilities in the service of the aesthetic process.

If, as the evidence suggests, artists and non-artists do not differ greatly in cerebral lateralization, might the important difference lie instead in inter-hemispheric integration? In other words, do artists enjoy a greater measure of communication between their cerebral hemispheres? If such a functional difference were to be established, then we would ask whether it is only the corpus callosum that is involved or other commissures as well, and how these functional differences are reflected in their anatomy.