ARTS IN THE BRAIN; OR WHAT MIGHT NEUROSCIENCE TELL US?

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Let's start by revisiting what may well be the most debated passage in the history of literary criticism, Aristotle's theory of catharsis as at once the goal and the pleasure of tragedy. The key lines appear early in the *Poetics*: "Tragedy, then, is an imitation of an action that is serious, complete, and of a certain magnitude, . . .in the form of action, not of narrative; through pity and fear effecting the proper purgation of these emotions" (22).

I shall not rehearse the long-standing dispute as to what Aristotle meant by "purgation" or "catharsis"—are we to take him figuratively, or is he being literal?, in which case we would be responding to tragedy with our guts. Rather, I should like to see how the knowledge about the brain that has been accumulating in recent years might create a context within which to view Aristotle's view of tragedy and, as this paper will develop further, to look at some influential discussions that have taken place in two other art forms, painting and music.

First, I state a key postulate within contemporary neuroscience: wherever we may think we perceive our reactions to events, whether in real life or in art, these reactions are processed not in the gut or the chest but rather in the brain and, in particular, in those parts of the brain that are dedicated to specific purposes. Take, for example, the two emotions, pity and fear, whose arousal and expulsion Aristotle sees as central to achieving the peculiar effect of tragedy. A key area in the brain generating fear is the amygdala.[1] Empathy for others, which seems close to what Aristotle meant by pity,[2] is also associated with particular regions of the brain, notably the ventromedial prefrontal cortex. And these areas do not act in isolation but are part of a complex network of interchanges.

The emotional disruptions that we experience from the arousal of pity and fear are of course felt within our body. The processes that neuroscience describes involve a network starting with signals sent by our senses to specific locations within the brain, from which new signals are eventually sent back to the body. Aristotle's goal in the *Poetics* is not, like that of a modern brain researcher, to map out our mental and emotional processes but rather to describe the ideal way of composing a tragedy. Since he sees the end of tragedy as the achievement of catharsis in its spectators, only certain plots, and certain types of hero giving shape to these plots, are able to attain this end. For instance, a tragedy centered around the fall of an evil ruler is unable, according to Aristotle, to excite either pity or fear (26). Nor would a plot that enacts the crushing of an innocent hero be able to tap these emotions. As Aristotle puts it, "pity is aroused by unmerited misfortune and fear by the misfortune of a man like

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[1] For a review of the amygdala's role in fear and other emotions, see Phelps and LeDoux. See also LeDoux's description of how the amygdala communicates with other sections of the brain (*Emotional Brain* 157-78).

[2] It could be debated whether Aristotle meant something like empathy ("I feel your pain," to cite the words of a former U.S. president) or sympathy ("I feel pity for your pain"). Whichever it was, the spectator is meant to experience a close tie to the hero. For the distinction between empathy and sympathy, see Keen 208-10.

ourselves" (27). And in order for the plot to set off the ideal mixture of pity and fear, Aristotle arrives at his celebrated description of the tragic hero, a figure caught between two extremes, someone neither wholly good or bad but one whose fall is brought about by "some error or frailty" (27), the so-called *hamartia*, sometimes rendered today as "missing the mark."

Indeed, all of Aristotle's further descriptions of the parts of a tragedy are directed to setting up the effect of catharsis. For instance, the plot, as he presents it, must be complex rather than simple (25-26, 30-31), one in which the turning point, or peripety, should ideally be coordinated with the hero's recognition of his situation (26, 31). And the play needs as well to give the audience a sense that its incidents follow one another inevitably, above all that they convey the illusion that they could probably happen in real life (25).

And yet is it possible to explain in contemporary terms how the confluence of pity and fear in an audience can result in feelings of satisfaction and well being? And how is it that feelings of pity or fear alone, from Aristotle's point of view, fail to do the trick? If I may cite anecdotal evidence from my own play-going, performances I have witnessed of works such as *Macbeth*, Ibsen's *Ghosts* and O'Neill's *Long Day's Journey into Night* have resulted in something of the experience that Aristotle described—yet I also recognize that these experiences were likely mediated by my long-standing acquaintance with the *Poetics* and its legacy in later criticism.

On the basis of a recent study of subjects with lesions in that part of the prefrontal cortex responsible for feelings of empathy (Koenigs *et al*), one could speculate that these lesions might well prevent such subjects from feeling the pity for the tragic hero that Aristotle stipulates as necessary for the experience of catharsis. Similarly, sociopaths, whose prefrontal cortices show a reduction in grey matter, could not be expected to respond empathetically to the hero's plight (Moll *et al.* 801). Moreover, a case study of a patient with calcified deposits in the amygdala revealed an inability to recognize fear either in herself or in others (Damasio 62-67); damage of this sort would likely not allow her to experience the fear that a tragedy within the Aristotelian mode seeks to awaken in the audience.

It is conceivable that researchers will be able to locate what happens within the brains of audience members at the climactic moments of a tragedy. As I shall indicate later in this paper, subjects watching a film have already been "wired" to gauge what was going on in their brains. Can one imagine that Aristotle's long-controversial theory may be clarified by means of a similar experiment in the theater? An imaging study comparing subjects' experience of empathy with those undergoing actual pain demonstrated that degrees of empathy can be measured in intensity just as pain can be measured (Singer *et al.*): does this mean that we may be able to test a play's success in engaging empathetic feelings toward its characters?

There is another aspect of Aristotle's theory of tragedy on which recent brain research may shed some light. I refer to the work done on so-called "mirror neurons" and "resonance behaviors" by a group of Italian neuroscientists in the late 1990s (Rizzolatti *et al.*). The first of these, as observed in monkeys and infants, consists of a subject imitating specific movements that it observes in another.

The second, and more complex, form involves a subject internalizing actions that it observes in order to understand these actions. More recent research on mirror neurons suggests that the imitative capacities that human beings display when they mimic the behavior of others may well account for the development of empathy and the evolution of culture.[3]

What this recent research further suggests is the mechanism by means of which an audience comes to empathize with a dramatic character that it watches onstage. One might note that Aristotle, two chapters before he presented his theory of catharsis, spoke of "the instinct of imitation . . . implanted in man from childhood, one difference between him and other animals being that he is the most imitative of living creatures" (21). Although this sentence seems consonant with the directions that the work on mirror neurons is taking, Aristotle's main concern in the rest of this chapter is not so much the reactions of the audience, as it is in the section on catharsis, but rather the way that writers organize their observations with literary devices to create a viable dramatic work. Thus, he uses the term *imitation* primarily to speak of the dramatist's final product as the "imitation of an action" (22).

And yet his discussion of the human instinct for imitation, together with the catharsis theory and his concept of the ideal tragic hero, also suggests the identification that takes place between the audience and

[3] For popular accounts of this work, see Winerman and Azar. For a detailed discussion of the relation of mirror neurons to the development of empathy in the course of human evolution, see Gallese, who was a member of the group (Rizzolatti *et al.)* that did the earlier experiments on mirror neurons.

the dramatic character, and this mode of identification is also central to what research in mirror neurons is uncovering.[4] Remember that Aristotle defines the tragic hero as "a man like ourselves" (27) in short, somebody with whom we can identify and whose movements and talk trigger imitative reactions within ourselves. If, say, we have empathetically followed the hero's development in the course of *Oedipus Tyrannus* or of some later tragedy, imagine the strong emotions we would share with him at the moment of his tragic self-recognition. At the same time, our consciousness of the as-if nature of our imitative reactions, of our understanding that we are only simulating what we observe in others, allows us to set a limit to our identification—with the result that, shaken up though we may be, we feel relieved (purged, shall we say?) to be able to return to our normal worlds.

To find similar correspondences between art and the brain, let us turn to painting, and to an example drawn from a treatise written almost two millennia after Aristotle's. I refer to a passage from Leonardo da Vinci's *Treatise on Painting*, in which the painter is advised to create the illusion of relief, that is, depth or contrast, even if it is achieved at the expense of beauty of color:

> Which is of greater importance: that the form should abound in beautiful colors, or display high relief? Only painting presents a marvel to those who contemplate it, because it makes that which is not so seem to be in relief [parere rilevato] and to project from the walls; but colors honor only those who manufacture them, for in them there is no cause for wonder except their beauty. . . . A subject can

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[4] The significance of mirror-neuron theory for an understanding of the relationship of text and audience is evident from the fact that four of the contributions to this volume—those by Patrick Colm Hogan, Suzanne Keen, Ellen Spolsky, and Lisa Zunshine—make use of this theory.

> be dressed in ugly colors and still astound those who contemplate it, because of the illusion of relief. (1: 63)

And in another passage, an implicit reference to earlier painters who sacrificed the realistic representation of forms for the sensuousness of color, Leonardo warns,

> What is beautiful is not always good. I say this in reference to those painters who so love the beauty of colors that, not without great regret, they give their paintings very weak and almost imperceptible shadows, not esteeming the relief. (1: 63-64)

Although Leonardo was an avid student of writings on optics, the observations he made between seeing objects in color and seeing them in relief is something he could not have learned from earlier theories but from his own experience as a practitioner of painting, not to speak of his role observing the practices of his predecessors. Yet this is a conflict that contemporary neuroscience can explain. The visual system, as Livingstone (49-52) and Marmor ("Eye and Art" 4, 7-8) have shown, has two distinct subdivisions, each of them deriving from a different stage of evolution. Our ability to view relief in a painting is dependent on that subdivision which we share with other mammals and which was developed at a relatively early stage to aid in depth perception and presumably to help discern other animals nearby; though sensitive to differences in brightness, it is also colorblind. The other, more recently evolved subdivision is common largely among primates and allows color to be recognized—that is, as an additional way of seeing the world beyond the perception of depth (Livingstone 24-45).

When Leonardo objects to the lack of relief in many late medieval and early Renaissance paintings, he refers to the inability of their painters to create sufficient difference in shading to allow viewers to note the depth in, say, the folds of garments, a subject to which he devoted a whole section of the *Treatise* (1: 203-08). Both in his practice and in his theoretical writings Leonardo recognized that gradations of luminance enable us to make distinctions between objects and between parts of objects.

Livingstone illustrates the differences between these two modes of seeing, the one centered around luminance, the other around color, by reproducing a series of pictures from an early Christian mosaic to the Post-Impressionists: each picture is printed both in color and in a black-and-white reduction (112-37). When seeing the picture in black and white, the viewer can more readily discern the degree of luminance contrast; and the greater the contrast, the greater the opportunity to recognize depth. To achieve the latter effect, a painter must find a compromise between the two subdivisions within our visual system, sometimes, as Leonardo recommends, sacrificing beauty of color in favor of depth.

Since the relative brightness of colors can be manipulated through the choice of pigments and the admixture of white, painters who, like Leonardo, seek to portray depth on a two-dimensional surface design their palette to emphasize contrasts in luminance. At the opposite extreme, as in some of Monet's misty scenes, luminance contrast is at a minimum, with the intended result that his surfaces look flat. At least since the Renaissance, and centuries before the two subdivisions of the visual system were explained by neuroscience, painters figured out how to mix colors to achieve whatever degree of depth or flatness they sought.

If the distinction I have shown between color and depth illustrates how painting is processed by distinct parts of the brain, a look at still another art form, music, can show how the same areas within the brain can be activated by a variety of experiences, aesthetic and otherwise. My example of music's effects on the brain dates from precisely three centuries after the lines I quoted from Leonardo's treatise. I quote from the review that the novelist and composer E.T.A. Hoffmann wrote of Beethoven's Fifth Symphony in 1810, two years after the completion of this piece:

> . . . Beethoven's instrumental music unveils before us the realm of the mighty and the immeasurable. Here shining rays of light shoot through the darkness of night, and we become aware of giant shadows swaying back and forth, moving ever closer around us and destroying everything within us except for the pain of infinite yearning, in which every desire, leaping up in sounds of exultation, sinks back and disappears. Only in this pain, in which love, hope, and joy are consumed without being destroyed, which threatens to burst our hearts with a full-chorused cry of all the passions, do we live on as ecstatic visionaries. (238)

Anybody familiar with the history of aesthetics will recognize here the characteristic vocabulary associated with the concept of the sublime—"mighty" [des Ungeheueren] and "immeasurable," words that conjure up an overwhelming and limitless power; negative words such as "pain," "destroyed," and "threatening" that counterbalance positives such as "exultation" and "ecstatic." Note also how imprecise Hoffmann's description is in comparison, say, with the statements by Aristotle and Leonardo quoted above; indeed, to make his point he uses images such as "rays of light" and "giant shadows swaying" in place of simple discursive prose.

Hoffmann's experience hearing this symphony is clearly in the tradition established in late antiquity by Longinus, who drew his examples of sublimity largely from Homer, and revived in the eighteenth century by such influential treatises as Edmund Burke's *Enquiry into the Sublime and Beautiful* (1756) and Immanuel Kant's *Critique of Judgment* (1790). By the beginning of the nineteenth century sublimity could be located in a wide variety of areas—landscape (in particular, the Alps or the English Lake District), epic poetry (above all, in Milton), music (in Handel's oratorios), drugs (as in De Quincey's *Confessions of an English Opium Eater*) and religious experience (in, for example, Chateaubriand's and Schleiermacher's apologies for religion).

But in the course of the nineteenth century it was in music above all that those who sought to experience the sublime found spiritual excitement. Beginning with Beethoven, in particular with the *Eroica*, whose length, loudness and expanded orchestra raised the stakes for sublimity as no earlier music had done, music could perform the trick more powerfully than other artistic genres, its most serious rivals being perhaps opium and the ascent of challenging mountain peaks.

Just as Burke and Kant had defined sublimity by opposing it to that far milder experience they called "beauty," so Hoffmann, in the paragraphs preceding and following the above quote, sets Beethoven, whom he associates with the traditional sublime vocabulary of "awe," "fear," and "terror" and "pain" against his two predecessors in the classical style: Haydn, whose realm he characterizes as "a world of love, of bliss, of eternal youth, as though before the Fall; no suffering, no pain";

and Mozart, whose symphonic writing, though it shows "dread lying all about us . . ., withholds its torments and becomes more an intimation of infinity" (237-38). Whatever magical qualities Mozart may reveal, he merely "intimates" but, unlike Beethoven, does not unleash the sublime.

In view of the vagueness and the need for metaphor with which sublime experience has traditionally been described, one might wonder how it could ever lend itself to scientific investigation. And yet a goodly amount of research on the effects of music has appeared in recent years. In 1980, even before functional magnetic resonance imaging (fMRI) had started, my Stanford colleague in pharmacology Avram Goldstein conducted a study of what he called the phenomenon of "thrills" that people experienced when listening to classical music. Goldstein defines a thrill as "a chill, shudder, tingling, or tickling," with "hair standing on end" or "goose bumps" (127), most of these terms being common in traditional descriptions of the sublime. His subjects, who included Stanford students in medicine and music and also employees of the Addiction Research Foundation, reported physical effects most often in the upper spine and back of the neck, from where these effects spread to neighboring parts of the body (needless to say, nobody "felt" the effects in the brain, from which they obviously originated). Subjects chose their own musical selections; Goldstein, in fact, found that these same subjects felt far fewer thrills when hearing the pieces selected by others. Subjects' reactions were self-reported, though Goldstein listened to pieces together with his subjects and recorded their indications of the intensity, frequency, and duration of thrill. In addition Goldstein administered naloxone, an opiate receptor antagonist, to his subjects and discovered that thrills were attenuated for some subjects taking this substance; as a result, he speculated that their emotional responses to music "may be mediated in some manner by endorphins" (126).

A subsequent paper, by a cognitive psychologist, Jaak Panksepp, expands on Goldstein's findings by measuring what he calls the "chills" (a term he prefers to Goldstein's "thrills"), and at one point he labels the phenomenon he is investigating a "skin orgasm" (203). Whereas Goldstein had used classical music, Panksepp asked his subjects, all of them undergraduates in an experimental-psychology class, to bring favorite examples of pop music, to be divided between those that the subjects judged "sad" and "happy" pieces. The maximum chills, as reported by his subjects, occurred at moments of high musical intensity—and also, it turned out, in the sad rather than the happy songs. Whereas Goldstein did not find significant gender differences among his subjects' reactions, female subjects in Panksepp's study felt stronger emotional reactions than males while listening to sad songs. As in Goldstein's study, subjects reacted more strongly to their own selections than to those selected by others. But Panksepp goes beyond Goldstein in speculating evolutionary origins to the chills set off by sad music in "the neural circuits for separation distress that lead young animals to cry out when they are lonely and lost" (198-99).

With the development of brain imaging, the chills that had earlier been described by means of self-reporting could be located in specific regions of the brain. In a positron emission tomography (PET) study published in 2001, Anne J. Blood and Robert J. Zatorre examined ten McGill University students, all of whom had had considerable earlier musical training. The authors, like Panksepp, preferred to use the word "chills" over "thrills." As with the studies described above, the students chose their own selections—though in this experiment all the examples were classical music. Each subject's selections were also measured in another student, who served as a control; as in the preceding study, chills proved stronger for those who had selected the music. The areas in the brain that showed activation were those normally associated with expectation and achievement of rewards. These areas included, among others, the ventral striatum, the amygdala, the hippocampus, and the dorsomedial midbrain. The authors conclude with a statement linking music-induced chills with activities normally seen as quite distant from music consumption: "We have shown here that music recruits neural systems of reward or emotion similar to those known to respond specifically to biologically relevant stimuli, such as food and sex, and those that are artificially activated by drugs of abuse" (11823).

The reward processing that this paper describes by means of a PET scan is corroborated in the higher-resolution imaging made possible by an fMRI in a paper of 2005 by Vinod Menon and Daniel J. Levitin.[5] Unlike the preceding paper, which used musicians as subjects, this one used college-age non-musicians—the purpose being to prevent expert bias from influencing the results. And again, unlike the two preceding papers, subjects did not choose their own musical selections. Controls were established not, as in the earlier papers, by playing selections for

[5] For a more popular account of this experiment and its relation to Goldstein's and Blood and Zatorre's work on this issue, see Levitin, *This Is Your Brain* 185-87.

other members of the group but rather by having the subjects listen to scrambled versions of the music: although pitch, loudness, and timbre remained the same, the order of notes was changed so that the music lost its temporal structure. The scrambled selections, it turned out, did not display the same degree of brain activation as the original pieces.[6] And in contrast to the Panksepp study, this experiment did not seek to distinguish the effects of happy and sad music.

The study demonstrated not only that its musical selections activated the regions of the brain associated with reward and affect, as the Blood and Zatorre paper had done, but that the higher resolution possible in fMRI scanning located an additional network of activations in widely separated areas—in this instance, the nucleus accumbens, the hypothalamus, insula, and orbitofrontal cortex. On the basis of these findings, the authors speculate that listening to music leads to increased dopamine levels analogous to the effects of a number of addictive drugs. I might add that the selections that Menon and Levitin used included the Beethoven Fifth Symphony and Mozart's *Eine kleine Nachtmusik*. One remembers that in Hoffmann's passage this Beethoven symphony is the prime manifestation of the sublime, while Mozart would likely count as an example of the beautiful, or of something in between. But the authors of the study did not test for differences in affect between these two

[6] The authors used the same musical selections, together with their scrambled versions, in another study that demonstrated that music is processed in areas associated as well with language processing. They conclude that both music and language display similar temporally ordered sequences; the scrambled musical selections, lacking as they do any meaningful temporal order, did not show the same activation as the originals. See Levitin and Menon, "Musical Structure."

composers. Would brain imaging be able to distinguish between the sublime and the beautiful? Or if both composers can induce similar chills, is the old dichotomy still useful at all?

Thus far I have sought contemporary scientific commentary to elucidate some celebrated commentators on several art forms from widely separated periods of time. When I chose the passage from Leonardo I was already aware of the research on how the brain processes color. But I deliberately chose the selections from Aristotle and Hoffmann before I had looked for recent accounts that might help explain the phenomena they were describing.

What conclusions might one draw from this juxtaposition of discourses—first, the language traditional to understanding the various arts, and, second, that of contemporary science? The most obvious answer is that the great artists and critics of the past knew what they were doing, that science simply helps corroborate what they (and we) knew all along. (Aristotle would not, by contemporary definition, be classified as an artist, while Leonardo was both an artist and critic, and Hoffmann was at once distinguished as a composer, conductor, fiction writer, and music critic.) If, say, Sophocles structured *Oedipus Tyrannus* to create what Aristotle called a "complex" plot in which peripety and recognition coincide, he did so knowing that he would thus overwhelm his audience with pity and terror (and with their consequent catharsis). And if Beethoven manipulated rhythms and volume in the Fifth, as well as delaying closure at the end in a thoroughly unaccustomed way, he knew he could awaken certain emotions that earlier music had left untapped. Do we need the confirmations of science to tell us what artists and critics of the past already understood, though albeit in the languages of their own time? It may well be that the high prestige of science in today's culture, especially in comparison with the declining prestige of the humanities, enables these confirmations to validate the importance of art in our lives.

But there is more we can learn about the arts than simply the fact that the effects of art can be observed emanating from specific networks in the brain and that these effects can be measured. Once it has been demonstrated that the emotions triggered by music are processed in the same areas as, say, drugs, food and sex, or that drama may tap regions that also play a role in the empathy we exercise in everyday life, art may well lose some of that magical aura it has often claimed, especially during the past two centuries. Art thus becomes the creation not so much of those lofty figures whom we seek to honor with the term *genius* but simply of those skilled enough in their various crafts to manipulate their consumers' brains to produce particular effects. Producing and consuming art, in short, becomes an activity as "natural" as, say, having sex or cooking and enjoying food.

And if art is seen as natural, one would ask next what role it has played in human evolution. The notion that music, for instance, possesses survival value for the species goes back to Darwin himself:

> I conclude that musical notes and rhythm were first acquired by the male or female progenitors of mankind for the sake of charming the opposite sex. Thus musical tones became firmly associated with some of the strongest passions an animal is capable of feeling, and are consequently used instinctively, or through association, when strong emotions are expressed in speech. (2: 336n.)

But the insight that Darwin briefly played with here has recently become a matter of lively debate. On one side one finds figures like Daniel Levitin, who extends Darwin's argument about the role of music in stimulating sexuality and, on the other, figures in cognitive psychology and linguistics like Steven Pinker and Dan Sperber, who find no evolutionary basis for music;[7] Pinker, in fact, goaded others into taking stands on the issue by once referring to music as "auditory cheesecake" (qtd. in Levitin, *This Is your Brain* 242). Steven Mithen, a specialist in prehistoric archaeology, has devoted a whole book, *The Singing Neanderthals*, to arguing music's place in evolution, above all through its relation to language learning. Walter Freeman, a neurobiologist, has assigned music, together with dance, a central evolutionary role in enabling the bonding necessary to create human societies.

If one accepts the view that music helped shape human evolution, one may ask if similar roles can be assigned to other arts. But that would not be a proper way to frame the question, for the division of the arts, as we know them, is a relatively recent phenomenon. As Mithen points out, music cannot be separated from language in the songs that mothers sang to their young (69-84);[8] nor can it be separated from dance in courtship rituals or, for that matter, from the visual art that decorated dancers' bodies and whatever they were wearing to help attract the opposite sex. The idea of art that stems, say, from a visit to the Louvre or from a performance of the Mahler Third in Disney

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[7] For a summary of these views, including Levitin's extended argument for music's role in evolution, see Levitin, *This Is your Brain* 241-61.
[8] Note that Darwin's statement above also stresses the association of music and speech when "strong emotions" are being expressed.

Hall is quite a different matter—even if our neural circuits still light up similarly to the way they did for our ancestors—from what it must have been in prehistoric days.

In view of the changes that our notions of what constitutes art have undergone—not to speak of the differences in the arts at any one time among diverse cultures—the passages by Aristotle, Leonardo and Hoffmann that I have linked to our present knowledge of the brain may seem quite limited in scope. After all, they refer to forms of art drawn from Western culture and dominant only during certain eras. Aristotle's favored form of drama, based on a coherent, compact plot that drives to a single powerful moment of catharsis, is wholly different from the various dramatic modes developed, say, in Japan, China, and India, and it is also quite foreign to the sprawling dramatic cycles performed in Western Europe during the Middle Ages. Leonardo's treatise is devoted to the proper execution of representational painting, while Hoffmann's music criticism, like that of all his contemporaries, can take for granted the naturalness of the tonal system—yet representation and tonality, as we look back historically, flourished only during a limited number of centuries within Western culture.

Note, for example, the profound change of style (not to speak of content if the two can even be separated) that marked the beginning of the twentieth century in all the arts. The rupture that we have come to call Modernism signaled the undoing of the aesthetic principles upon which the quotations I used earlier in this paper were based. The linear plot celebrated by Aristotle gave way, both in fiction and drama, to texts that moved in unpredictable directions and that often questioned their ability to render any real world. Poems abandoned easy coherence, nor did they make it easy for readers who treasured strong emotional responses; as H. Porter Abbott argues in his essay within this volume, a text by Gertrude Stein or Samuel Beckett is not relevant for "what it is *about*" but rather for "what it cognitively *is*." Paintings often refused to represent any discernible world, and, even when they pretended to be representational, gave up on perspective and the various tricks developed over centuries to create the illusion of reality. Music often abandoned tonality altogether, at times adopting chance operations; and even when employing the tonal system, it often held back from the sublime effects that had dominated during the preceding century.

Consider these celebrated lines near the end of *Adonais* (1821), Shelley's elegy for Keats:

> The One remains, the many change and pass;
> Heaven's light forever shines, Earth's shadows fly;
> Life, like a dome of many-coloured glass,
> Stains the white radiance of Eternity. (426)

Note the acid comment on this passage by F. R. Leavis as part of his program to rethink the history of English poetry from a Modernist perspective: "The famous imagery is happily conscious of being impressive, but the impressiveness is for the spell-bound, for those sharing the simple happiness of intoxication" (232). Leavis establishes a link between the effects of art and those of other stimulants that the various researchers on "thrills" and "chills" had made in studying reactions to music. And he firmly rejects these effects.

Contrast these lines with the opening of Ezra Pound's Modernist suite, *Hugh Selwin Mauberley* (1919):

For three years, out of key with his time,
He strove to resuscitate the dead art
Of poetry; to maintain "the sublime"
In the old sense. Wrong from the start— (61)

Not only does Pound explicitly distance himself (or his surrogate speaker) from the style of "the sublime," but his lines are designed to refuse any of the intoxicating effects that Leavis decries in Romantic poetry. Pound's prosy, ironic manner in this passage would likely affect different areas of the brain from Shelley's.

The empathy for the plight of tragic heroes that Aristotle saw as central to Greek drama and that persisted over the ages within diverse dramatic styles was resoundingly rejected by that avowedly anti-Aristotelian Modernist dramatist Bertolt Brecht. Brecht advocated a style of acting that sought to prevent his actors from identifying with the characters they impersonated, and he worked assiduously—often rewriting plays such as *Mother Courage* and *Life of Galileo*—to keep his audiences from identifying or empathizing with his heroes. Audiences were expected not to allow their emotions to be engaged but rather to think rationally about the issues his plays were raising. Brecht was clearly aiming his effects at different parts of the brain than earlier dramatists—intent on tapping the audience's emotions—had done. Yet as subsequent stage directors have found, people generally go to the theater for an emotional experience, and despite the alienation effect (to use Brecht's famous term) that supposedly operates in these plays to prevent the viewer's identification with characters, audiences (and actors as well) have discovered ways to bring the proscribed emotions back.

Although I am unaware of any studies—whether by imaging or self-reporting—on the differences in effect between Modernism and earlier eras of literature, the brain's processing of abstract painting has actively stimulated researchers. Certain forms of non-representational painting—Russian Constructivism, the Dutch De Stijl movement, Op Art, and kinetic art, for example—have proved amenable to examining how the mind processes what the eye sees. As the neurobiologist Semir Zeki puts it, the "emphasis on lines in many of the more modern and abstract works of art . . . [derives] from the experimentation of artists to reduce the complex of forms into their essentials or, to put it in neurological terms, to try and find out what the essence of form as represented in the brain may be" (111). As it turns out, painters such as Malevich and Mondrian have provided a fertile field for brain imaging because of the fact that any particular cell in the visual cortex is sensitive to only a particular orientation—horizontal, say, or vertical or diagonal at a certain angle—of a line. Paintings composed of such lines, as many key works of the past century are, create a series of active brain responses that show up clearly when imaged.[9] Without the distraction of easily identifiable representational content, which might awaken empathy (as in an early Picasso portrait of poor people), or emotions of awe (as in a Turner seascape), the viewer experiences a play of forms that elicits a potentially wide range of responses. Representational painting can evoke many of the

[9] See Zeki's illustrations of different brain responses to particular line orientations (102).

same emotions—pity, fear, disgust, for instance—that literary and narrative texts tap. By contrast, non- and partially representional painting creates pleasures, sometimes of a strongly emotional sort, not necessarily shared by other art forms.

Although neuroscientists cannot (and ordinarily choose not to) explain why a particular abstraction is "great," or even "better" than others, they can show with considerable precision how the visual system creates certain illusions for viewers. For example, Mondrian achieves the illusion of motion in his famous painting *Broadway Boogie Woogie* by juxtaposing colors—a yellow bar containing grey squares against an off-white background—of equal luminance, with the result that he plays on the differences between the two subdivisions of our visual system mentioned earlier in this paper (Livingstone 154-55, 157). Two Op Art painters, Isia Leviant and Bridget Riley, figure prominently in neuroscientists' writings on modern art because some of their paintings achieve an even more pronounced sense of motion than the Mondrian mentioned above (Livingstone 151, 160, 162-63; Zeki 162-63; Marmor, "Illusion and Optical Art" 150-51, 162-65). Zeki, for instance, explains the extraordinary motion we experience in Leviant's *Enigma*, a painting that juxtaposes circles and spokes, on the basis of how different cortical areas become activated (163).

Certain representational movements, above all Pointillism and Fauvism, have also proved fertile sources for commentary on how the brain processes visual art. Like the Op painters, both the Pointillists and the Fauvists had employed radically new techniques to play with their viewers' vision. Standing as they did at the threshold of Modernism, these painters give us recognizable objects from everyday life at the same time that they challenge earlier notions of what it means to represent the real world. A Seurat painting plays on the differing ways we view it from distinct distances—the pointillist dots dominating at close distance, yet disappearing at far distance, while in between these extremes we feel a special vibrancy, a virtual motion. As Livingstone puts it, "You can see simultaneously both the separateness of the dots and a blending together to form a single larger surface" (176). Marmor explains the peculiar power of Pointillist painting from the fact that whereas one subdivision of our visual system "recognizes . . . tiny dots but does not respond to color," the other subdivision "recognizes color [but] cannot discriminate very small lines or objects" ("Eye and Art" 15).[10]

The differences between these two subdivisions are central to our experience of Fauvist paintings as well. A Fauve painting, we remember, gives us deliberately "false" colors that fill the shapes of familiar objects and forms. Yet despite being "misled" by the colors that artists such as Matisse or Derain applied during their Fauvist period, we recognize their representations with relative ease. The reason we do so, as Livingstone explains, is that the wrong colors they give us display the same relative luminance as the right colors would (133-37). Thus, the colorblind system that reads for depth and shape is able to function along with the system that interprets color. Moreover, as Zeki discovered in imaging subjects who viewed different types of art, colors in abstract painting are activated in areas additional to those activated in representational

[10] For a detailed description of Pointillism "as a psychophysiological process," see Lanthony.

painting; and in Fauvist painting the areas that display activation are different both from those in abstract and representational painting (197-204). As a result of his experiments showing the difference in neural activity between a Corot and a Mondrian, on the one hand, and a Corot and a Fauvist painting, on the other, he concludes that "artists are unknowingly exploiting the organization of the brain" (204).

Despite the initial shock effects that Modernism initially created in the visual arts, in the course of the twentieth century viewers gradually assimilated the experiments both in abstraction and in such distortions of representation as the Fauvists and the Cubists created. Not so with the more radical experiments in musical Modernism, above all in non-tonal and chance-organized music. Despite the initial shock-effects created by a number of certain early-twentieth-century works such Stravinsky's *Le Sacre du printemps*, audiences have gradually assimilated these works as long as they remained within the tonal system. By contrast, the non-tonal works of Arnold Schoenberg, whether during his earlier atonal period or after he had developed his serial method, have had to struggle to find an audience, except for hardcore aficionados (of which I happen to count myself one). A possible explanation is that non-tonal works do not resolve their dissonances as tonal works do; Schoenberg himself boasted of his "emancipation of the dissonance" (193). Theodor Adorno, as part of his defense of Schoenberg against Stravinsky, praisingly described the former's musical language as "undisguised, corporeal impulses of the unconscious, shocks, and traumas" (35). A cognitive psychologist, David Huron, agreeing with Adorno's depiction of the disturbing element central to Schoenberg's music, has recently analyzed the composer's way of thwarting the expectations of traditional listeners by means of tone rows that are designed to prevent these listeners from finding comfort in any vestiges of tonality; as a result of this active thwarting, Schoenberg's work, as Huron, puts it, should be called "contratonal" rather than "atonal" (339-44, 352).[11]

A brain-imaging experiment by Isabelle Peretz examined the reactions of subjects to consonant and dissonant pitch combinations in order to determine how and where in the brain dissonance is processed. The subjects included a group of normal persons without musical training plus one subject, I.R., a woman with brain damage whom Peretz has used in a number of studies on music.[12] Passages from various periods of classical music (though not atonal pieces) were played in different versions, each with an increasing degree of dissonance. Whereas the normal subjects declared the dissonances they heard as "unpleasant," I.R. was unable to hear anything unpleasant in these dissonant chords. As a result of the images she recorded in I.R.'s damaged brain, as well as in her control group's brains, Peretz concluded that musical perceptions are first processed bilaterally in the superior temporal

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[11] To demonstrate the centrality of Schoenberg's "contratonality," Huron compares 42 tone rows by Schoenberg with randomly generated sets of rows: the latter display a far greater affinity to traditional tonality (341-43).

[12] See, for instance, Isabelle Peretz *et al.*, "Dissociations," and Isabelle Peretz *et al.*, "Music". The first of these papers shows that I.R.'s brain damage affected only her perception of music, not of language, and thus argues that music and language are autonomous in processing auditory information. The second examines the possibility that emotional and non-emotional judgments are products of different pathways within the brain. The deficiencies observed in I.R. in these and other studies serve, among other things, as a way of defining the differences between normal and brain-damaged subjects.

gyri, after which they are relayed to emotional systems in the paralimbic and frontal areas. Our judgment of the relative pleasantness of consonance and dissonance is thus built into our brains, or, as Peretz puts it, "The brain . . . is pre-wired for processing consonant pitch levels" ("Cortical Deafness" 939). But she also warns that this would still need to be demonstrated across cultures.

Dissonance obviously functions differently in actual musical performance than in this experiment, in which the dissonant chords came not from composed pieces but rather from distortions of classical passages. Still, the fact that the brain judges dissonance to be inherently unpleasant can help explain the difficulty that listeners have experienced assimilating much twentieth-century music. I for one can testify to feeling the chills associated with musical sublimity when I hear certain non-tonal works such as Berg's *Three Pieces for Orchestra* or Schoenberg's *Die Jakobsleiter*. But I also suspect that I do not speak for a large band of listeners.[13]

The difficulties that listeners feel with the Second Viennese school are likely less than those often reported with the music of John Cage, above all the pieces organized by chance operations, a procedure he initiated about 1950. For example, Cage's one foray into opera, *Europeras 1 & 2*, combines actual arias from the standard operatic repertory with orchestral accompaniments that have been scrambled by chance operations governed by means of a computer program. Thus, while hearing familiar arias (with sometimes two going on at once), the audience can often identify

[13] Huron speaks of "experienced listeners" to modernist music who "adapt to this [the composers'] strategy and learn to expect the unexpected" (348).

instrumental phrases that, though drawn from the original scores, have been displaced and assigned to instruments different from those for which they were intended. The result is not simple dissonance but cacophony of the most striking sort—compounded as well with deliberately absurd stage antics. Just as the Menon-Levitin paper ("Rewards") described earlier scrambled familiar musical pieces (with the result that the subjects' brains were not activated as they had been in the unscrambled pieces), Cage's work did not award the musical pleasures ordinarily associated with music—though, according to reviews, it struck many of its audience members at the original Frankfurt production of 1987 as a wildly comic romp.[14]

By contrast, the lithographs that Cage composed by chance operations have, like Modernist art in general, proved much more accessible than his music. These works, done during his last two decades, consist of lines and forms whose size and positioning on the sheet were determined by his chance-oriented computer program. Like the Constructivist art that obviously influenced Cage's print-making style and whose effects on the brain Zeki analyzed (109-42 *passim*), these works, chance-organized though they may be, do not, like his music, affect those parts of the brain that react with feelings of discomfort or indifference.

The varying responses that viewers and audiences have shown to the stylistic ruptures that marked Modernism in the various arts during the preceding century cannot hide the possibility, perhaps even likelihood, that any one

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[14] For a detailed description of *Europeras 1 & 2*, see my chapter, "Regulated Anarchy: John Cage's *Europeras 1 & 2* and the Aesthetics of Opera," in Lindenberger 240-64.

work, whether Modernist or not, will tap the same areas of the brain in most of those experiencing it. This is evident, for example, in Op Art, whose effects can be explained quite precisely by citing matters such as the varying degrees of luminance and the geometrical relations of lines to one another.

An experiment imaging a group of subjects who watched a half-hour segment of a 1966 movie, *The Good, the Bad, and the Ugly*, demonstrated—"unexpectedly," as the authors put it—that "brains of different individuals show a highly significant tendency to act in unison" (Hasson *et al.* 1638). This movie was chosen because its high-action nature allowed subjects to react to a number of emotional peaks. Whatever cultural differences there may have been among these subjects, the same areas of the brain were activated at particular moments: for example, the fusiform gyrus, the area in the ventral occipito-temporal cortex responsible for facial recognition, reacted in face close-ups, while other areas were activated for buildings and inanimate objects. The researchers express surprise about another activated area, the middle postcentral sulcus, for which they could not at first find a correlation with the film images; only at closer inspection did they realize that this region reacted to images of delicate hand movements (1636-37).

Whether or not audiences at musical events act similarly in unison may be put to the test in a concert hall currently being constructed at McGill University, where a segment of the audience will be assigned sensors to monitor heart rate, skin electrical responses, and facial musculature, while another segment will register their reactions on handheld devices (Balter). Does music, one wonders, create the same degree of uniformity as film? Are the ears alone less engaged in a performance than that powerful combination of eyes and ears demanded by cinema? And what if it proved possible to monitor the audience in a large opera house for a performance, say, of a Wagnerian *Gesamtkunstwerk*, in which, at least according to the composer's intentions, all the arts—drama, music, visual design, dance—are supposedly working on the spectator at once?

Whatever uniformity of response neuroscientists may find among viewers and consumers of the arts, certain individuals will ordinarily fail to hear, see, or understand artistic media in a normal way. Take, for example, that phenomenon called amusia, which refers to difficulties in perceiving and processing music. Congenital amusia is not yet known to have a single underlying cause, and it manifests itself in several ways, most commonly in the failure to recognize differences in pitch (Ayotte *et al.*). A study at the University of Newcastle on Tyne compared sensitivity to pitch difference in ten tone-deaf subjects with ten who perceived music normally (Foxton *et al.)*. The former proved unable, for instance, to distinguish between two contiguous notes of different pitch, nor could they tell if a gliding tone was moving upward or downward. But amusical individuals also display varying musical deficiencies: some hear pitch but not rhythm or timbre, others rhythm and timbre and not pitch (Levitin, *This Is Your* Brain 184).

On the other hand, musicality is one of the strong suits of patients afflicted by Williams syndrome, a serious genetic disorder whose developmental basis has only recently become well understood. Williams sufferers, despite some cognitive as well as physical impairment, are quite emotionally responsive to music and can sometimes even perform it well.[15] To cite still another variant in musical perception, patients with autism spectrum disorder, though they may be technically proficient in playing music, show no signs of emotional involvement (Levitin, *This Is Your Brain* 253).

It is clear that even if we can chart our customary responses to works of art, persons with brain impairments, whether congenital or caused by later damage, are unable to perceive many of the crucial signals that writers, composers, and visual artists embed in their works to communicate with their audiences. To take examples from the two recently mentioned disorders, autistic persons are unable to read the emotions of others and, in particular, they lack feelings of empathy. As a result, one could scarcely expect them to identify with the protagonist of a novel or to grant a tragic hero the pity that Aristotle prescribed. Williams sufferers are eminently social and empathetic (Andreas-Lindenberg 386); when cognitively up to the task of following a play, they might well feel moved by a character's plight.

The problems that amusical people encounter processing music find a parallel in the difficulties of the colorblind in viewing paintings. Whereas about four percent of the general population is thought to suffer from some form of amusia (Foxton *et al.* 802), as many as ten percent of American men are afflicted by the most common form of

[15] *Ibid.*, pp. 182-83, 253-54. For a review of research on Williams, see Meyer-Lindenberg. Although Levitin anecdotally cites a good clarinet player among Williams sufferers he has seen (*This Is Your Brain* 183), Andreas-Lindenberg, citing several studies, concludes that those with Williams syndrome, though "highly interested in music, . . . are not musically gifted" (386).

colorblindness, namely, a deficiency in discriminating red and green (Marmor, "Eye and Art" 19). The preponderance of men among the colorblind is due to the fact that the cone photoreceptor pigments for these colors are inherited on the X chromosome, of which women, unlike men, possess two copies. Thus, if a woman's red or green pigments do not function adequately in one chromosome, they are likely to work normally in the other chromosone. Persons who are red/green color-deficient find it difficult to distinguish between red, orange, and yellow. There are also rare individuals who lack the ability to discern color altogether and, as a result, they see paintings (not to speak of the world at large!) in various shades of grey, much as those with normal vision see the world at night.[16]

But painters too have been known to suffer from deficiencies that affect their art. The best-known example of colorblindness among visual artists is the distinguished etcher, Charles Meryon (1821-1868), who, in the course of his art studies, recognized the need to shift to a black-and-white medium. One of his few known works in color, a pastel of a ship in a storm, shows an avoidance of red and green, with a preponderance of yellow and blue.[17] Since color-deficient artists rarely choose to pursue painting, visual defects among painters usually are due to diseases developing in the course of their careers. For example, Marmor has shown the effects that Monet's cataracts and Degas's macular degeneration had on their later paintings: thus, by comparing an earlier and later version of Monet's bridge at Giverny, and earlier and later nude bathers by

[16] For illustrations of what the colorblind "see," see Livingstone 34-35.
[17] For a history of Meryon's career and a reproduction of this pastel, see Ravin and Lanthony.

Degas, he demonstrates how the blurriness of vision and lack of color discrimination emanating from these two diseases made its way into their work ("Opthalmology"). Monet in his old age was even said to have depended on the labels of his tubes of paint to know what color he was using (1767).

For a final example of how a defect can hamper one's experience with art, I turn to a condition known as prosopagnosia, or face blindness. Those afflicted by this show impairment in the fusiform gyrus, the brain site, as mentioned earlier, specializing in the recognition of faces. Since I happen to suffer from a mild version of congenital prosopagnosia,[18] I use this opportunity to indicate the limitations that this condition has imposed on my experience with art forms. The present essay would scarcely be the appropriate venue to discuss the personal difficulties that prosopagnosia has created for me—embarrassments such as facing old friends who, when we meet at professional gatherings, fail to put on their name-tags, or my inability to recognize my college-age children when each had been away for several months. I concentrate instead on my problems recognizing faces in works of art. To be sure, I have never found portrait paintings quite the chore that Zeki suggests they are in the chapter of *Inner Vision* on the effects of prosopagnosia (167-82). At least I never had much trouble in college art-history quizzes asking me to identify famous portraits by, say, Bronzino, Rembrandt, or Ingres: even if the details of faces eluded me, I recognized the pictures by the clothing and the color

[18] For a study of congenital prosopagnosia, see Behrmann and Avidan.

composition, for a defective fusiform gyrus does not affect one's ability to recognize features other than faces.

But films and plays, especially if they have many characters, prove a considerable challenge. To some degree it helps to learn an actor's gait, which, to the extent that one sees whole live bodies moving about the stage, proves easier in plays than in films. Nothing is so difficult for me as films of an earlier time in which male characters are seen wearing similar hats and suits and where only the face is exposed—and where, moreover, there was no color to come to my aid. As a result, I easily confuse heroes and villains as well as major and minor characters. My ability to understand many films remains dependent on the kindness of companions willing to help me identify who is who throughout the picture. Needless to say, I've never been much fun to go to the movies with.

The normative responses to art forms that I have described, together with the various deviations from the norm with which I have concluded, may well arouse suspicions among my colleagues in the humanities about the motives behind this inquiry. Am I trying to divest great art of its inherent mysteries? they may ask. And am I minimizing or even denying the roles that personal taste and cultural difference play in people's understanding and enjoyment of art?

For at least two centuries a certain mystique has ranged around what we dignify with the label art (not crafts, certainly, and not the artifacts of popular culture!). Most of us feel uncomfortable accepting the possibility that our responses to art can be charted by science; even when such charting seems plausible, we prefer to add a *je ne sais quoi* to assert the need to stop before the mystique has totally disappeared. One might remember that the example with which this essay started, Aristotle's theory of catharsis, does not invoke anything mysterious in the experience of drama but, if we take the term *catharsis* literally, seeks a physical basis in this experience much in the spirit displayed by neuroscientists today.

The cognitive psychologists and neurobiologists whose work I have used to think out this paper certainly do not attempt to offer large-scale explanations for art's alleged mysteries. Rather, in accord with traditional scientific procedures, they typically pinpoint a single, narrowly defined phenomenon—the chills that certain musical pieces set off in specific locations within the brain, or the ways that painters create the illusion of movement by juxtaposing equiluminant colors. Unlike many of us in the humanities, they do not reach out for global-size theories.

Yet despite the modesty of reach that characterizes these individual scientific studies, a larger picture seems to be emerging, a picture that suggests we may come to know more about how we perceive, process and enjoy art than we suspected before. I do not suggest that science will rob us of our traditional task of conserving the past and placing art works within an appropriate historical context, or, for that matter, of subjecting them to the interpretation and evaluation that their consumers have long depended upon. But what we learn from science may well affect the methods that we choose to exercise our interpretive and evaluative skills and also, I might add, how we come to look at the various arts in relation to other reward-offering activities.

The studies I have consulted go back little more than two decades, and most date from the past five or six years.

Our exploration of the brain (if I may indulge in the sort of analogy endemic within the humanities) may be no more advanced at this point than was the exploration of the New World around, say, the mid-sixteenth century. And if we are still near the beginning of our knowledge of how the arts and the brain engage with one another, we may yet be in for a few surprises.

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