PERSPECTIVES: NEUROSCIENCE

Is Art Lawful?

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It must be an eventual hope of scientists who study the brain to address the complexities underlying the aesthetics of art. Perception may seem to some to be a phenomenological experience inaccessible to scientific rigor, but the efforts of generations of perceptual psychologists have shown many aspects of perception to be governed by laws no less tractable than those of quantum physics. In a recent issue of the *Journal of Consciousness Studies*, entirely devoted to addressing how the brain responds to art, Ramachandran and Hirstein present a penetrating neurological theory comprising eight universal laws of aesthetic experience (*1*). Briefly stated, these principles are: enhancement of features that deviate from average (peak shift effect), isolation of key aspects of the composition, grouping of related features, contrasting of segregated features, perceptual problem solving to extract the relevant information, a preference for generic views, the use of visual metaphors and, finally, symmetry. Although these two neurologists are far from the first to respond to the challenge of explaining the human artistic experience, they bring a deeper viewpoint to bear, combining principles from perceptual psychology, evolutionary biology, neurological deficits, and functional brain anatomy. Their treatment is unusual not so much in their development of perceptual rules for art, but in their use of these diverse principles to address the evolutionary meaning of beauty that may be the essence of art.

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Taking their inspiration from the sinuous poses of Indian sculpture (see figure, left panel), Ramachandran and Hirstein propose that one route to the perceptual essence of art is the principle of caricature. This principle proposes that by exaggerating the characteristics of the subject, the artist draws attention to its essential features. For example, the 12th century bronze of the Indian Goddess Parvati (see figure, left panel) with its accentuated hips and bust is a caricature of the female form. The caricature principle is analogous to the "peak shift" phenomenon seen in animal behavior studies. A rat that receives a reward when it learns to discriminate a rectangle from a square will respond even more vigorously to a rectangle with exaggerated dimensions (longer and skinnier). This enhancement of trigger features probably evolved to maximize the behavioral response of animals to critical stimuli (*2*). The authors go beyond the conventional analysis of caricature in cartoons to argue that a similar process of perceptual caricature is one of the key principles of art as a whole. By enhancing the essential in the chosen subject matter, the artist can create an image (graphic or sculptural) that resonates in our memory and stands as a cultural symbol (*3*).

Distilling the essence of art. The 12th-century Indian depiction of the Goddess Parvati **(left)** exemplifies the principle of caricature in exaggeration of the gender-specific features of the female form. *Madonna of the Meadow* by Raphael (1505) is a composition of classic balance and composure within a naturalistic style **(right)**.

The trick is to define which features are essential and which are incidental. Another way to say this is to ask in which direction within the *n*-dimensional space of the compositional features should the features be moved in order to make the desired enhancement. For facial caricatures it is usually assumed that the feature shift for a particular face should enhance the difference between that face and the form of the average face (*4*). Generalizing to the core artistic subject of the human figure, Ramachandran and Hirstein propose that the relevant anchor point should be the form of the average body. The artistic representation of female form, therefore, should be enhanced in a way to exaggerate the features that distinguish the two sexes, accounting for the enhancement of sexual expression in Indian statuary. For each kind of enhancement, this explanation requires that one identify both the form of the anchor point and the appropriate direction away from it, which may not be so easy for landscapes or scenes of particular human activities. Indeed, can one talk of a definitive essence at all when art may be viewed not as an object but as a developing relationship between the artist and the artwork, and subsequently between the artwork and the viewer?

An ultimate problem with this analysis, as the authors make clear, is that art is a vastly diverse enterprise that may not be so readily amenable to a simple treatment. Given a principle such as "the peak shift away from average," one is naturally anxious to try it out on a variety of classic works of art. For example, enhancement of sexual features does not seem to have been a hallmark of Renaissance art in the West. That had to wait for the Baroque and Rococo eras, with their riotous depictions of gods and goddesses, which conform well to the predicted peak shift away from each other—bold muscular gods bending lithe delicate goddesses to their will. It seems that Renaissance art is characterized instead by a deeper principle in which the artist tries to capture the average, or typical, image of the subject matter itself rather than shifting away from it, as in Raphael's *Madonna of the Meadow* (see figure, right panel). This is perhaps exemplified by the early history of art, from the Greek sculptures of the era of the *Venus di Milo* or the *Discobolus* (the classic statue of a discus thrower)—whose appeal seems to be the elegant modesty of their sexual features—to the Renaissance ideal of the *Mona Lisa*, which is almost androgynous. Capturing the typical pose of the subject matter in this way is such a basic principle of art that Ramachandran and Hirstein seem to have missed it, but no

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comprehensive analysis of the issue can afford to exclude it. Much Renaissance art consists of depicting the same pose repeatedly until a canonical form is achieved, as in the *Madonna and Child* or *Christ on the Cross*.

In addition to the peak shift principle, the authors outline seven other principles (drawn from Gestalt psychology and neurology) that they believe constitute the deep structure of the art experience. For example, their second (grouping) principle proposes that multiple features are grouped together by the visual system into unified objects and that this grouping is reinforced by connections between the brain's visual system and limbic system (which controls emotion). Taking examples from the entire history of art, the case for each principle is developed with ingenuity and flair. These two neurologists reveal much more of the brain processes that are likely to be involved in implementing these principles than would most art critics. But it is unlikely that many art critics would regard these eight laws as exhausting the repertoire of principles of art, even accepting the caveat that there is much that is individual in art and that is not amenable to a principled analysis. Notably, Ramachandran and Hirstein say nothing about the widely recognized principle of balance in composition, of the power of the center emphasized by the American art critic R. Arnheim (*5*), or of the dynamic interplay of visual forces emphasized by the father of modern abstract art, W. Kandinsky (*6*).

Of the eight principles delineated, the one that may be of most interest to artists is that of perceptual problem solving (where the subject matter of the artwork can be extracted only with some effort rather than being immediately obvious). Curiously, the section addressing this principle seems to have been lost in the main text, but it is clearly identified in the summary. Had the authors included a section on perceptual problem solving, perhaps it would have explored how this principle accounts for many of the diverse manifestations of 20th-century art. One of the characteristics of modern art is that it encompasses (among other things) a succession of styles of abstraction: fauvism, cubism, dadaism, futurism, abstract impressionism, op art, minimalism, and so on. Even before the 20th century, there existed extremes of representational style such as impressionism, pointillism, expressionism, photo-realism, and so on, that are themselves forms of abstraction. The point is that any degree of abstraction requires the viewer to make a perceptual effort to extract the theme of the painting (compared with the essentially effortless perception of representational art). This effort itself forms an essential component of the artistic experience—by slowing down the perceptual processes of decoding the artwork the viewer becomes aware of their evolution and interplay over time, and then experiences a sense of achievement when the full composition falls into place (or of continued mystery if it does not). Thus, the problem-solving principle, evoked to account for the appeal of hiding the female form under diaphanous garb, could account for much of the development of 20th-century abstract movements (which are difficult to interpret in terms of the other seven principles).

Ramachandran and Hirstein state that their goal is to foster debate on the principles underlying the artistic experience. This they undoubtedly do, as exemplified by the Commentaries and Letters that are to be found in the same issue. But it is clear that the debate will extend far beyond the eight principles that they have enunciated.

References

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PERSPECTIVES: BIOMEDICINE

Lentiviral Vectors—the Promise of Gene Therapy Within Reach?

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The modification of the genetic material of living cells for therapeutic purposes still remains an unrealized promise as a medical intervention in humans. In December 1995, researchers in the gene therapy community received a wake-up call when the National Institutes of Health issued a report that criticized the premature implementation of gene therapy clinical studies and called for a return to the drawing board to optimize gene delivery (vector) systems. Up to that time, scientists had relied mainly on murine retroviruses such as Moloney murine leukemia virus for applications that required stable gene transfer (transduction) into the chromosomes of target cells, and on the high efficiency of adenovirus vectors when genomic integration was not a requirement. However, the use of murine retroviral vectors in human protocols has been associated with poor efficiency of gene transfer, probably because these vectors only integrate into the genome of cells that are actively dividing (*1*). This limitation has prompted a search for efficient vectors that are capable of delivering and expressing genes in nondividing cells.

Considerable progress has been made on this front with the optimization of two important vector systems based on adeno-associated virus and lentiviruses, such as human immunodeficiency virus (HIV). Adeno-associated vectors have been used successfully to treat hemophilia B (a bleeding disorder caused by a deficiency in coagulation factor IX) in dogs by portal vein delivery of the vector to the liver and by its direct injection into muscle (*2*). Plans are under way to test an adeno-associated viral vector carrying the human factor IX gene in hemophiliac patients. Lentiviruses are a type of retrovirus that can infect both dividing and nondividing cells. They have proven extremely efficient at providing long-term gene expression (for up to 6 months) in a variety of nondividing cells (such as, neurons and macrophages) in animal models. Progress is under way to ensure the safe and efficient production of lentiviral vectors for future human use.

Unlike murine retroviruses, HIV and other lentiviruses have a complex genome that, in addition to the essential structural genes (*env*, *gag*, and *pol*), contains regulatory (*tat* and *rev*) and accessory genes (*vpr*, *vif*, *vpu*, and *nef*). HIV has evolved to efficiently infect and express its genes in human cells, and is able to infect nondividing cells such as macrophages because its preintegration complex can traverse the intact membrane of the nucleus in the target cell (see the figure). This complex is composed of the enzyme integrase, the product of the *vpr* gene, and a protein encoded by the *gag* gene called matrix. The matrix protein contains a localization sequence that is recognized by

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