

# The Artful Brain

V. S. Ramachandran

**W**HAT IS ART? When Picasso said, “Art is the lie that reveals the truth,” what exactly did he mean?

Neuroscientists have made remarkable headway in understanding the neural basis of psychological phenomena such as body image or visual perception. But can the same be said of art—given that art obviously originates in the brain?

In particular, we can ask whether there are such things as artistic universals. There is obviously an enormous number of artistic styles across the world: Tibetan art, Classical Greek art, Renaissance art, Cubism, Expressionism, Indian art, pre-Columbian art, Dada . . . the list is endless. But despite this staggering diversity, can we come up with some universal laws or principles that transcend these cultural boundaries and styles?

The question may seem meaningless to many social scientists; after all, science deals with *universal* principles, whereas art is the ultimate celebration of human individuality and originality—the ultimate antidote to the homogenizing effects of science. There is some truth to this, of course, but even so I’d like to argue that such universals do exist.

First, a note of caution. When I speak of “artistic universals” I am not denying the enormous role played by culture. Obviously, without culture there would be no different artistic styles—but neither does it follow that art is completely idiosyncratic and arbitrary, or that there are no universal laws.

To put it somewhat differently, let us assume that 90 percent of the variance seen in art is driven by cultural diversity or—more cynically—by just the auctioneer’s hammer, and only 10 percent by universal laws that are common to all brains. The culturally driven 90 percent is what most people already study—it’s called art history. As a scientist, what I am interested in is the 10 percent that is universal—not in the endless variations imposed by cultures. The advantage that scientists have today is that unlike philosophers we can now test our conjectures by directly studying the brain empirically. There’s even a new name for this discipline. My colleague Semir Zeki calls it neuroaesthetics—just to annoy the philosophers.

I recently started reading about the history of ideas on art—especially Victorian reactions to Indian art—and it’s a fascinating story. For example, let’s go to southern India and look at the famous Chola bronze of the goddess



Figure 1. Parvathi, consort of Lord Shiva, twelfth-century Chola dynasty (replica).

Parvathi dating back to the twelfth century. (See Figure 1.) To Indian eyes, she is supposed to represent the very epitome of feminine sensuality, grace, poise, dignity, elegance: everything that's good about being a woman. And she's of course also very voluptuous.

But the Victorian Englishmen who first encountered these sculptures were appalled. Partly because they were prudish, but partly also because of just plain ignorance. They complained that the breasts were far too big, the hips were too wide, and the waist was too narrow. It didn't look anything like a real woman—it wasn't realistic—it was primitive art. And they said the same thing about the voluptuous nymphs of Kajuraho—even about Rajastani and Mogul miniature paintings. They said the paintings lacked perspective, that they were distorted.

The Victorians were unconsciously judging Indian art using the standards of Western art—especially classical Greek and Renaissance art, where realism is strongly emphasized. But obviously this is a fallacy. Anyone will tell you that art has nothing to do with realism. It is not about creating a replica of what's out there in the world. I can take a realistic photograph of my pet cat and no one would give me a penny for it. In fact, art is not about realism at all—it's the exact opposite. It involves deliberate hyperbole, exaggeration, even distortion, in order to create pleasing effects in the brain.

Obviously that can't be the whole story. You can't just take an image and randomly distort it and call it art. (Although in California, where I come from, many do!) The distortion has to

be “lawful.” The question then becomes, what kinds of distortion are effective? What are the laws?

I was sitting in a temple in India and in a whimsical frame of mind when I just jotted down what I think of as the universal laws of art, the 10 laws of art that cut across cultural boundaries (see the sidebar).<sup>1</sup> The choice of 10 is arbitrary . . . but it’s a place to start.

The first law I call peak shift. To illustrate this, I’ll use a hypothetical example from animal behavior, from rat psychology.

Imagine you’re training a rat to discriminate a square from a rectangle by giving it a piece of cheese every time it sees a particular rectangle. When it sees a square, it receives nothing. Very soon it learns that the rectangle means food; it starts liking the rectangle—although a behaviorist wouldn’t put it that way. Let’s just say it starts going toward the rectangle because it prefers the rectangle to the square.

But if you take a longer, thinner rectangle and show it to the rat, it actually prefers the second rectangle to the first. This is because the rat is learning a rule—rectangularity. Longer and thinner equals more rectangular and, so far as the rat is concerned, the more rectangular, the better.

And what has that to do with art?

Think about caricature. To produce a caricature of, say, Richard Nixon, an artist must first ask, What’s special about his face? What makes him different from other people? The artist will take the mathematical average, so to speak, of all male faces and subtract it from Nixon’s face, leaving a bulbous nose and shaggy eyebrows. These are then amplified to pro-

### Universal Laws of Art

1. Peak shift
  2. Grouping
  3. Contrast
  4. Isolation
  5. Perceptual problem solving
  6. Symmetry
  7. Abhorrence of coincidence/generic viewpoint
  8. Repetition, rhythm, and orderliness
  9. Balance
  10. Metaphor
- 

duce an image that looks even more like Nixon than Nixon himself. Skilled artists work this way to produce great portraiture;<sup>2</sup> take it a step further and you get caricature. It looks comical, but it still looks even more like Nixon than the original Nixon. So you're behaving exactly like that rat.

What has all this to do with the rest of art? Let's go back to the Chola bronze of Parvathi, where the same principle applies. How does the artist convey the very epitome of feminine sensuality? He simply takes the average female form and subtracts the average male form—leaving big breasts, big hips, and a narrow waist. And then amplifies the difference. The result is one anatomically incorrect but very sexy goddess.

But that's not all there is to it—what about dignity, poise, grace?

Here the Chola bronze artist has done something quite clever. There are some postures that are impossible for a male owing to the constraints imposed by pelvic anatomy, curvature of the lumbar spine, and angle between the neck and shaft of the femur. I can't stand like that even if I want to. But a woman can do it effortlessly. So the artist visits an abstract space I call "posture space," subtracts the average male posture from the average female posture, and then exaggerates it. Doing this produces the elegant triple flexion—or tribhanga—pose, where the head is tilted one way, the body is tilted exactly the opposite way, and the hips again the other way. And again the viewer's reaction is not that the figure is anatomically inappropriate because nobody can stand like that. What the viewer sees is a gorgeous, beautiful, celestial goddess. This extremely evocative image is an example of the peak shift principle in Indian art.

So much for faces and caricatures and bodies and Chola bronzes. But what about the rest of art? What about abstract art, semi-abstract art, Impressionism, Cubism? What about Picasso, Van Gogh, Monet, Henry Moore? How can many ideas even begin to explain the appeal of some of those artistic styles?

To answer this question, we need to look at evidence from ethology, especially the work of Niko Tinbergen at Oxford more than fifty years ago, who was doing some very elegant experiments on herring-gull chicks.

As soon as the herring-gull chick hatches, it sees its mother's long yellow beak with a red spot on it. It starts pecking at the red spot on the beak, begging for food. The mother then regur-

gitates half-digested food into the chick's gaping mouth, the chick swallows the food and is happy. Tinbergen asked himself, "How does the chick recognize its mother? Why doesn't it beg for food from a person who is passing by or from a pig?"

And he found that you don't need a mother. A hatchling would react in exactly the same way to a disembodied beak with no mother attached.

Why does a chick think a scientist waving a beak is a mother seagull? Well, the goal of vision is to do as little processing or computation as is necessary for the job on hand, in this case for recognizing mother. And through millions of years of evolution, the chick has acquired the wisdom that this long thing with a red spot always has a mother attached to it, rather than a mutant pig or a malicious ethologist. So it can take advantage of the statistical redundancy in nature and assume "Long yellow thing with a red spot equals mother," thereby simplifying the processing and saving a lot of computational labor.

That seems fair enough. But what Tinbergen found next is that he didn't even need a beak. He took a long yellow stick with three red stripes, which looked nothing like a beak—and that's important—and the chicks pecked at the stick even more than they would have pecked at a real beak. They preferred it to a real beak, even though it didn't resemble a beak. Tinbergen had stumbled on a superbeak—an ultrabeak. So the chick's brain goes, "Wow, what a sexy beak!"

Why does this happen? We don't know exactly, but obviously there are neural circuits in the visual pathways of the chick's brain that are specialized to detect a beak as soon as the chick

hatches. They fire upon seeing the beak. Perhaps because of the way they are wired up, they may actually respond more powerfully to the stick with the three stripes than to a real beak. Maybe the neurons' receptive field embodies a rule such as "the more red contour the better." And so even though the stick doesn't look like a beak—maybe not even to the chick—this strange object is actually more effective in driving beak detectors than a real beak. And a message from this beak-detecting neuron goes to the emotional limbic centers in the chick's brain, giving it a big jolt and the message "Here is a super-beak." The chick is absolutely mesmerized.

All of which brings me to my punch line about art. If herring gulls had an art gallery, they would hang a long stick with three red stripes on the wall; they would worship it, pay millions of dollars for it, call it a Picasso, but not understand why—why they are mesmerized by this thing even though it doesn't resemble anything. That's all any art lover is doing when buying contemporary art: behaving exactly like those gull chicks.

In other words, human artists through trial and error, through intuition, through genius, have discovered the figural primitives of our perceptual grammar. They are tapping into these and creating for the human brain the equivalent of the long stick with three stripes. And what emerges is a Henry Moore or a Picasso.

The advantage with these ideas is that they can be tested experimentally. It is possible to record from cells in the fusiform gyrus of the brain that respond powerfully to individual faces. Some of them will fire only to a particular view of a face, but

higher up are found neurons each of which will respond to *any* view (profile versus full frontal) of a given face. And I predict that if you present a monkey with a Cubist portrait of a monkey's face—two different views of a monkey's face superimposed in the same location in the visual field—then that cell in the monkey's brain will be hyperactivated just as a long stick with three red stripes hyperactivates the beak-detecting neurons in the chick's brain. So what we have here is a neural explanation for Picasso—for Cubism.<sup>3</sup>

I've discussed one of my universal laws of art so far—peak shift and the idea of ultra-normal stimuli—and have borrowed insights from ethology, neurophysiology, and rat psychology to account for why people like non-realistic art.<sup>4,5</sup>

The second law is more familiar. It's called grouping.

Most of us are familiar with puzzle pictures, such as Richard Gregory's Dalmatian dog. At first sight you see nothing but a bunch of splotches, but you can sense your visual brain trying to solve a perceptual problem, trying to make sense of this chaos. And then after 30 or 40 seconds suddenly everything clicks in place and you group all the correct fragments together to see a Dalmatian dog. (See Figure 2.)

You can almost sense your brain groping for a solution to the perceptual riddle. As soon



Figure 2. Gregory's Dalmatian Dog (photo by Ron James).

as you successfully group the correct fragments together to see the object, what I suggest is that a message is sent from the visual centers of the brain to the limbic-emotional centers of the brain, giving it a jolt and saying, “A-ha, there is an object—a dog,” or “A-ha, there is a face.”

The Dalmatian example is very important because it reminds us that vision is an extraordinarily complex and sophisticated process. Even looking at a simple scene involves a complex hierarchy, a stage-by-stage processing. At each stage in the hierarchy of processing, when a partial solution is achieved—when a part of the dog is identified—there is a reward signal “a-ha,” a partial “a-ha,” and a small bias is sent back to earlier stages to facilitate the further binding of the features of the dog. And through such progressive bootstrapping the final dog clicks in place to create the final big “A-HA!” Vision has much more in common with problem solving—like a twenty-questions game—than we usually realize.

The grouping principle is widely used in both Indian and in Western art—and even in fashion design. For example, you go shopping and pick out a scarf with red splotches on it. Then you look for a skirt which has also got some red splotches on it. Why? Is it just hype, just marketing, or is it telling you something very deeply about how the brain is organized? I believe it is telling you something very deep, something to do with the way the brain evolved.

Vision evolved mainly to discover objects and to defeat camouflage. You don’t realize this when you look around you and you see clearly defined objects, but imagine your primate an-

cestors scurrying up in the treetops trying to detect a lion seen behind fluttering green foliage. What you get inside the eyeball on the retina is just a mass of yellow lion fragments obscured by all the leaves. But the visual system of the brain “knows” that the likelihood that all these different yellow fragments being exactly the same yellow simply by chance is zero. They must all belong to one object. It links them together, decides it’s a lion (based on the overall shape), and sends a big “a-ha” signal to the limbic system telling you to run.

Arousal and attention culminate in titillating the limbic system. Such “a-has” are created, I maintain, at every stage in the visual hierarchy as partial object-like entities are discovered that draw our interest and attention. What an artist tries to do is to generate as many of these “a-ha” signals in as many visual areas as possible by more optimally exciting these areas with painting or sculpture than could be achieved with natural visual scenes or realistic images. Not a bad definition of art, if you think about it.

That brings me to my third law—the law of perceptual problem solving or visual peek-a-boo.

As anyone knows, a nude seen behind a diaphanous veil is much more alluring and tantalizing than a full-color *Playboy* photo or a Chippendale pin-up. Why? (This question was first raised by the Indian philosopher Abhinavagupta in the tenth century.) After all, the pin-up is much richer in information and should excite many more neurons.

As I have said, our brains evolved in highly camouflaged environments. Imagine you’re chasing your mate through dense

fog. Then you want every stage in the process—every partial glimpse of her—to be pleasing enough to prompt further visual search—so you don't give up the search prematurely in frustration. In other words, the wiring of your visual centers ensures that the very act of searching for the solution is pleasing, just as struggling with a jigsaw puzzle is pleasing long before the final "a-ha." Once again it's about generating as many "a-has" in your brain as possible.<sup>6</sup> Art may be thought of as a form of visual foreplay before the climax.

We have discussed three laws so far: peak shift, grouping, and perceptual problem solving. Before I go any further I'd like to emphasize that looking for universal laws of aesthetics does not negate the enormous role of culture, nor the genius and originality of an individual artist. Even if the laws are universal, which particular law (or combination of them) an artist chooses to deploy depends entirely on his or her genius and intuition. Thus while Rodin and Henry Moore were mainly tapping into "form," Van Gogh and Monet were mainly introducing peak shifts in an abstract "color space"—brain maps in which adjacent points are mapped in color rather than Cartesian space. Hence the effectiveness of artificially heightened "nonrealistic" colors of their sunflowers or water lilies. These two artists also deliberately blurred the outlines to avoid distracting attention from the colors where it was needed most. Other artists may choose to emphasize even more abstract attributes such as shading or illumination (Vermeer).

And that brings us to my fourth law—the law of isolation or understatement.

A simple outline doodle of a nude by Picasso, Rodin, or Klimt can be much more evocative than a full-color pin-up photo. Similarly, the cartoon-like outline drawings of bulls in the Lascaux Caves are much more powerful and evocative of the animal than a *National Geographic* photograph of a bull. Hence the famous aphorism “Less is more.”

But why should this be so? Isn't it the exact opposite of the first law, the idea of hyperbole, of trying to excite as many “a-ha-s” as possible? A pin-up or a Page Three photo has, after all, much more information. It's going to excite many more areas in the brain, many more neurons, so why isn't it more beautiful?<sup>7</sup>

The answer to this paradox lies in another visual phenomenon: “attention.” It is well known that there cannot be two overlapping patterns of neural activity simultaneously. Even though the human brain contains a hundred billion nerve cells, no two patterns may overlap. In other words, there is a bottleneck of attention. Attentional resources may be allocated to only one entity at a time.

The main information about the sinuous, soft contours of a Page Three girl is conveyed by her outline. Her skin tone, hair color, etc. are irrelevant to her beauty as a nude. All this irrelevant information clutters the picture and distracts attention from where it needs critically to be directed—to her contours and outlines. By omitting such irrelevant information from a doodle or sketch, the artist is saving your brain a lot of trouble. And this is especially true if the artist has also added some peak shifts to the outline to create an “ultra nude” or “super nude.”

This theory can be tested by doing brain imaging experiments comparing neural responses to outline sketches and caricatures versus full-color photos. But there is also some striking neurological evidence from children with autism. Some of these children have what is known as the savant syndrome. Even though they are retarded in many respects, they have one preserved island of extraordinary talent.

For example, a seven-year-old autistic child, Nadia, had exceptional artistic skills. She was quite retarded mentally, could barely talk, yet she could produce the most amazing drawings of horses and roosters and other animals. A horse drawn by Nadia would almost leap out at you from the canvas. Contrast this with the lifeless, two-dimensional, tadpole-like sketches drawn by most normal eight- and nine-year olds—or even a very good one by Leonardo da Vinci. (See Figure 3.)

So we have another paradox. How can this retarded child produce a drawing that is so incredibly beautiful? The answer, I maintain, is the principle of isolation.

In Nadia, perhaps many or even most of her brain modules are damaged because of her autism, but there is a spared island of cortical tissue in the right parietal. So her brain spontaneously allocates all her attentional resources to the one module that's still functioning, her right parietal. The right parietal is the part of the brain concerned with our sense of artistic proportion. We know this because when it's damaged in an adult, artistic sense is lost. Stroke patients with right parietal damage produce drawings that are often excessively detailed but lack the vital essence of the picture they are trying to de-

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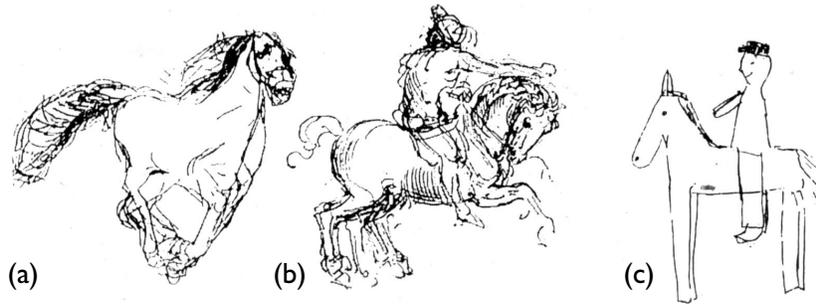


Figure 3. (a) A drawing of a horse by Nadia, the autistic savant, when she was five years old. (b) A horse drawn by Leonardo da Vinci. (c) A horse drawn by a normal eight-year-old. Notice Nadia's drawing is vastly superior to that of the normal eight-year-old and almost as good as (or perhaps better than!) Leonardo's horse. (a) and (c) reprinted from *Nadia*, by Lorna Selfe, with permission from Academic Press (New York).

pict. They have lost their sense of artistic proportion. Nadia, since everything else is damaged in her brain, spontaneously allocates all her attention to the right parietal—so she has a hyperfunctioning art module in her brain which is responsible for her beautiful renderings of horses and roosters. What most of us “normals” have to learn to do through years of training—ignoring irrelevant variables—she does effortlessly. Consistent with this idea, Nadia lost her artistic sense once she grew up and improved her language skills.

Another example is equally striking. Steve Miller, of the University of California, has studied patients who start developing rapidly progressing dementia in middle age, a form of dementia

called fronto-temporal dementia. This affects the frontal and temporal lobes but spares the parietal lobe. Some of these patients suddenly start producing the most amazingly beautiful paintings and drawings, even though they had no artistic talent before the onset of their dementia. Again, the isolation principle is at work. With all other modules in the brain not working, the patient develops a hyperfunctioning right parietal. There are even reports from Alan Snyder in Australia that it is possible to unleash such hidden talents by temporarily paralyzing parts of the brain in normal volunteers. If his findings are confirmed, it will truly be a brave new world.

That brings me to another question: why do humans even bother creating and viewing art?<sup>8</sup> I've already hinted at some possible answers, but let me spell them out more explicitly. There are at least four possibilities—none mutually exclusive.

First, it is possible that once laws of aesthetics have evolved (for reasons such as discovering, attending to, and identifying objects), then they may be artificially hyperstimulated even though such titillation serves no direct adaptive purpose, just as saccharin tastes “hypersweet” even though it provides zero energy and zero nutrition.

Second, as suggested by Miller, artistic skill may be an index of skillful eye-hand coordination and, therefore, an advertisement of good genes for attracting potential mates (the “come and see my etchings” theory). This is a clever idea that I don't find convincing. It doesn't explain why the so-called “index” takes the particular form that it does: art. After all, few women—not even feminists!—find the ability to knit or em-

broider attractive in a man, even though these demand excellent eye-hand coordination. My point is, why not use a much more straightforward “index” such as proficiency in archery or javelin throwing (which, to be sure, *are* attractive in a man)?

Third, there is Steve Pinker’s idea that people acquire art as a status symbol to advertise their wealth: the “I own a Picasso, so help me spread our genes together” theory. Anyone who has been to a cocktail reception at an art gallery knows there’s some truth to this.

Fourth—the idea I favor—art may have evolved as a form of virtual reality simulation. When you imagine something—as when rehearsing a forthcoming bison hunt or amorous encounter—many of the same brain circuits are activated as when you really do something. This allows you to practice scenarios in an internal simulation without incurring the energy cost or risk of a real rehearsal.

But there are obvious limits. Evolution has seen to it that our imagery—internal simulation—isn’t perfect. A hominid with mutations that enabled it to perfectly imagine a feast instead of having one, or imagine orgasms instead of pursuing mates, is unlikely to spread its genes. This limitation in our ability to create internal simulations may have been even more apparent in our ancestors. For this reason they may have created real images (“art”) as “props” to rehearse real bison hunts or to instruct their children. If so, we could regard art as Nature’s own “virtual reality” (just as my mirror box allows patients to actually see their phantom arm and move it—whereas they couldn’t do so just using imagination).

Limitations of space prevent the discussion of all my other laws in detail, but I will mention the last on my list. In many ways it is the most important, yet the most elusive: visual metaphor. A metaphor in literature juxtaposes two seemingly unrelated things to highlight certain important aspects of one of them (as when the Indian poet Rabindranath Tagore referred to the Taj Mahal as “A teardrop on the cheek of time”). The same thing is possible in visual art. For example, the multiple arms on the Chola bronze of the dancing Shiva or Nataraja (Figure 4) are not meant to be taken literally, as they were by the Victorian art critic Sir George Birdwood, who called it a multi-armed monstrosity. (Funnily enough, he didn’t think that angels sprouting wings were monstrosities—although I can tell you as a medical man that to possess multiple arms is anatomically possible, but wings on scapulae are not!)

The multiple arms are meant to symbolize multiple divine attributes of God, and the ring of fire that Nataraja dances in—indeed his dance itself—is a metaphor of the dance of the cosmos and of the cyclical nature of creation and destruction, an idea championed by the late Fred Hoyle. Most great works of art—be they Western or Indian—are pregnant with metaphor and have many layers of meaning.<sup>9</sup>

Everyone knows that metaphors are important, yet we have no idea why. Why not just say “Juliet is radiant and warm” instead of saying “Juliet is the sun”? What is the neural basis for metaphor? We don’t know.

Many social scientists feel rather deflated when informed that beauty, charity, piety, and love are the result of the activity

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Figure 4. Nataraja, or dancing Shiva.  
Chola dynasty, copper alloy, thirteenth century.

of neurons in the brain, but their disappointment is based on the false assumption that to explain a complex phenomenon in terms of its component parts (“reductionism”) is to explain it away. To understand why this is a fallacy, imagine it’s the twenty-second century and I am a neuroscientist watching you and your partner (Esmeralda) making love. I scan Esmeralda’s brain and tell you everything that’s going on in it when she is in love with you and making love to you. I tell you about activity in her septum, in her hypothalamic nuclei, and how certain peptides are released along with the affiliation hormone prolactin, etc. You might then turn to her and say, “You mean that’s all there is to it? Your love isn’t real? It’s all just chemicals?” To which Esmeralda should respond, “On the contrary, all this brain activity provides hard evidence that I *do* love you, that I’m not just faking it. It should increase your confidence in the reality of my love.” And the same argument holds for art or piety or wit.

#### THE INTERNET AND THE UNIVERSITY

Do these laws of neuro-aesthetics encompass everything there is to know about art? Of course not; I have barely scratched the surface. But I hope that these laws have provided some hints about the general form of a future theory of art and about how a neuroscientist might try to approach the problem.

The solution to the problem of aesthetics, I believe, lies in a more thorough understanding of the connections between the 30 visual centers in the brain and the emotional limbic structures (and of the internal logic and evolutionary rationale that drives them). Once we have achieved a clear understanding of these connections, the insights they offer into the human brain will have a profound impact not just on the sciences but also on the humanities. Indeed, they may help us bridge the huge gulf that separates C. P. Snow's two cultures—science on the one hand and arts, philosophy, and humanities on the other.

We could be at the dawning of a new age where specialization becomes old-fashioned and a twenty-first-century version of the Renaissance man is born.

#### ACKNOWLEDGMENT

This chapter is excerpted from my book, *A Brief Tour of Human Consciousness* (New York: Pi Press, 2004).

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### NOTES

1. My book *The Artful Brain* is due to be published in 2005. Also see the Web site of Bruce Gooch (University of Utah) on the laws of art: <http://www.cs.utah.edu/~bgooch/>.

2. Experiments dating back to Francis Galton show that averaging several faces together often produces a face that is quite attractive. Does this contradict my peak shift law? Not necessarily. Averaging probably works by eliminating minor blemishes and distortions such as warts, disproportionate face parts, asymmetries, etc., which makes evolutionary sense. Yet the peak shift principle would predict that the most attractive female face is not necessarily the “average” but usually one with the right kind of exaggeration. For example, if you subtract the average female face from the male and amplify the difference you would end up with an even more gorgeous face—a “superfemale” with neotonous features (or a male stud-muffin with exaggerated jawline and eyebrows).

3. Just for fun, let’s see how far we can take this argument. Cubism involves taking the usually invisible other side of an object or face and moving it forward to the same plane as the side that is visible: two eyes and two ears visible on the profile view of a face, for example. This has the effect of liberating the observer from the tyranny of a single viewpoint: you don’t have to walk around the object to see its other side. Every art student knows this is the gist of Cubism, but few have raised the question of why it is appealing. Is it just shock value, or is there something else?

Let us consider the response of single neurons in the monkey brain. In the fusiform gyrus, individual neurons often respond optimally to a particular face, e.g., one cell might respond to the monkey’s

mother, one to the big alpha male, and one to a particular side-kick monkey—a “Phanka waala cell,” you might say. Of course, the one cell doesn’t “contain” all the properties of the face; it is part of a network that responds selectively to that face, but its activity is a reasonably good way of monitoring the activation of the network as a whole. All this was shown by Charlie Gross, Ed Rolls, and Dave Perrett.

Interestingly, a given neuron (say an “alpha male face neuron”) will respond only to *one* view of that particular face—e.g., its profile. Another one nearby might respond to a semi-profile and a third one to a full frontal of that face. Clearly, none of these neurons can by itself be signaling the concept “alpha male” because it can respond only to one view of him. If the alpha male turns slightly, the neuron will stop firing.

But at the next stage in the visual processing hierarchy you encounter a new class of neurons that I’ll call “master face cells” or “Picasso neurons.” A given neuron will respond only to a particular face, e.g., “alpha male” or “mother,” but unlike the neurons in the fusiform the neuron will fire in response to *any* view of that particular face (but not to any other face). And that, of course, is what you need for signaling: “Hey—it’s the alpha male: watch out.”

How do you construct a master face cell? We don’t know, but one possibility is to take the outgoing wires—axons—of all the “single viewpoint” cells in the fusiform that correspond to a single master face cell—in this case the alpha male cell. As a result of this pooling of information you can present any view of the alpha male and it will make at least one of the individual view cells in the fusiform fire, and that signal will in turn activate the master cell. So the master cell will respond to any view of that face.

But now what would happen if you were simultaneously to present two ordinary incompatible views of the face in a single part of the

visual field in a single plane? You would activate two individual face cells in parallel in the fusiform, and hence the master cell downstream will get a double dose of activation. If the cell simply adds these two inputs (at least until the cell's response is saturated), the master cell will generate a huge jolt, as if it were seeing a "super face." The net result is a heightened aesthetic appeal to a Cubist representation of a face—to a Picasso!

Now the advantage of this idea—however far-fetched—is that it can be tested directly by recording from face cells at different stages in the monkey brain and confronting them with Picasso-like faces. I may be proved wrong, but that is its strength—it can at least be *proved* wrong. As Darwin said, when you close one path to ignorance, you often simultaneously open a new one toward the truth. This cannot be said for most philosophical theories of aesthetics.

4. If these arguments about "aesthetic universals" are correct, then an obvious question arises: why doesn't everyone like a Picasso? The surprising answer to this question is that everyone *does*, but most people are in denial about it. Learning to appreciate Picasso may consist largely in overcoming denial! (Just as the Victorians initially denied the beauty of Chola bronzes until they overcame their prudishness.) Now I know this sounds a bit frivolous, so let me explain. We have known for some time now that the mind isn't one "thing"—it involves the parallel activity of many quasi-independent modules. Even our visual response to an object isn't a simple one-step process—it involves multiple stages or levels of processing. And this is especially true when we talk about something as complex as aesthetic response . . . it is sure to involve many stages of processing and many layers of belief. In the case of Picasso I would argue that the "gut level" reaction—the "a-ha" jolt—may indeed exist in everyone's brain, caused, perhaps, by early limbic activation. But then in

most of us higher brain centers kick in, telling us, in effect, “Oops! That thing looks so distorted and anatomically incorrect that I had better not admit to liking it.” Likewise, a combination of prudery and ignorance might have vetoed the Victorian art critics’ reaction to voluptuous bronzes—even though neurons at an earlier stage are firing away, signaling peak shifts. Only when these subsequent layers of denial are peeled off can we begin to enjoy a Picasso or a Chola. Ironically, Picasso himself derived much of his inspiration from “primitive” African art.

5. In my book *Phantoms in the Brain* I suggested that many of these laws of aesthetics—especially peak shift—may have powerfully influenced the actual course of evolution in animals, an idea that I call the “perceptual theory of evolution.” A species needs to be able to identify its own species in order to mate and reproduce, and to do so it uses certain conspicuous perceptual “signatures”—not unlike the gull chick pecking the stick with three stripes. But because of the peak shift effect (and ultranormal stimuli), a mate might be preferred that doesn’t “resemble” the original. In this view the giraffe’s neck grew longer not merely to reach tall acacia trees but because giraffes’ brains are wired to automatically show greater propensity to mate with more “giraffe-like” mates, i.e., mates with the giraffe trait of longer necks. This would lead to a progressive caricaturization of descendants in phylogeny. It also predicts less variation in the externally visible morphology and colors in creatures which don’t have well-developed sensory systems. (e.g., cave dwellers) and less florid variations of internal organs which cannot be seen.

This notion is similar to Darwin’s idea of sexual selection—i.e., peahens preferring peacocks with larger and larger tails. But it is different in three respects. My argument, unlike Darwin’s, doesn’t apply only to secondary *sexual* characteristics. It argues that many mor-

phological features and labels identifying species (rather than sexual) differences might propel evolutionary trends in certain directions. Although Darwin invokes “liking larger tails” as a principle in sexual selection, he doesn’t explain *why* this happens. I suggest that it results from the deployment of an even more basic psychological law wired into our brains that initially evolved for other reasons, such as facilitating discrimination learning.

Given our seagull chick principle, i.e., the notion that the optimally attractive stimulus need not bear any obvious surface resemblance to the original (because of idiosyncratic aspects of neural codes for perception), it is possible that new trends in morphology will start that have no immediate functional significance and may seem quite bizarre. This is different from the currently popular view that the sexual selection of absurdly large tails occurs because they are a “marker” for the absence of parasites. For example, certain fish are attracted to a bright blue spot applied by the experimenter on a potential mate, even though there is nothing remotely resembling it on the fish. I predict the future emergence of a race of blue-spotted fish even though the blue spot is not a marker of sex or of species or an advertisement for good genes that promote survival. Or perhaps a race of seagulls with striped beaks!

Note that this principle sets up a positive feedback between the observer and the observed. Once a “species label” is wired into the brain’s visual circuits, then offspring who accidentally have more salient labels will survive and reproduce more, causing an amplification of the trait. That in turn will make the trait an even more reliable species label, thereby enhancing the survival of those whose brains are wired up to detect the label more efficiently. This sets up a progressive gain amplification.

6. Another way to test these ideas would be to obtain a skin con-

ductance response (SCR), which measures your gut-level emotional reaction to something by measuring increases in skin conductance by sweating. We know that familiar faces usually evoke a bigger response than unfamiliar ones because of the emotional jolt of recognition. The counterintuitive prediction would be that an even bigger response would be shown to a caricature or Rembrandt-like rendering of a familiar face than to a realistic photo of the same face. (One could control for the effects of novelty caused by the exaggeration by comparing this response to that elicited by a randomly distorted familiar face or an “anticaricature” that reduced rather than amplified the difference.)

I am not suggesting that an SCR is a complete measure of a person’s aesthetic response to art. What it really measures is “arousal,” and arousal doesn’t always correlate with beauty—it only implies “disturbing.” Yet few would deny that “disturbing” is also part of the aesthetic response: just think of a Dali or Damien Hirst’s pickled cows. This is no more surprising than the fact that we seem to, paradoxically, “enjoy” horror movies or white-knuckle rides. Such activity may represent a playful rehearsal of brain circuits for future genuine threats, and the same could be said of visual aesthetic responses to disturbing, attention-grabbing, visual images. It’s as if anything salient and attention-grabbing—almost by its very nature—encourages you to look at it more to process it further, thereby fulfilling at least the first requirement of art. But the “attention-grabbing” component would be the same for the randomly distorted face and the caricature, whereas only the latter will have an additional component added by the peak shift. These different “components” of the aesthetic response will eventually be dissected more as we develop a clearer understanding of the connections between the visual areas and limbic structures and of the logic that drives them (the “laws” we

have been discussing). So a randomly distorted nude might excite only the amygdala (“interest + pleasure”).

An analogy with IQ tests might be illuminating. Most people would agree that it is ludicrous to measure something as multidimensional and complex as human intelligence using a single scale such as IQ. Yet it’s better than nothing if you are in a hurry: trying to recruit sailors, for example. An individual with an IQ of 70 is unlikely to be bright by any standard, and one of IQ 130 is unlikely to be stupid.

In a similar vein I would suggest that even though the SCRs can provide only a very crude measure of aesthetic response, better a crude measure than none. And it can be especially useful if combined with other measures such as brain imaging and single neuron responses. For example, a caricature or a Rembrandt might activate face cells in the fusiform more effectively than a realistic photo.

It may be helpful, also, to make a further distinction between “aesthetic universals” versus “art”—which is in some ways a more loaded term. Aesthetic universals would include so-called design, but wouldn’t include pickled cows.

7. It isn’t clear what “kitsch” is, but unless we tackle this we cannot really claim to have completely understood art. After all, kitsch art also sometimes deploys the same “laws” I am talking about—e.g., grouping or peak shifts. So one way of finding out what neural connections are involved in “mature aesthetic appreciation” would be to do brain imaging experiments in which you subtract the subject’s reaction to kitsch from her reaction to high art.

One possibility is that the difference is entirely arbitrary and idiosyncratic, so one man’s high art might be another’s kitsch. This seems unlikely, since we all know that you can evolve from appreciating kitsch to appreciating the genuine thing, but you can’t slide backwards. I would suggest instead that kitsch involves merely *going*

*through the motions* of applying the laws we have talked about, without a genuine understanding of them. The result is “pseudo art” of the kind found in hotel lobbies in North America.

As an analogy we can compare kitsch to junk food. A strong solution of sugar elicits a gustatory jolt, as every child knows, and powerfully activates certain taste neurons. This makes sense from an evolutionary standpoint: our ancestors (as Steve Pinker points out) often had to go on carbohydrate binges in preparation for enduring frequent famines. But such junk food cannot begin to compete with gourmet food in producing a complex multidimensional titillation of the palate (partly because of reasons divorced from the original evolutionary functions, e.g., peak shift and contrast, etc., applied to taste responses and partly to provide a more balanced meal that’s more nutritious in the long run). Kitsch, in this view, is visual junk food.

8. Do animals have art? Some of these universal laws of aesthetics (e.g., symmetry, grouping, peak shift) not only may hold across different human cultures but may even cross the species barrier. The male bower bird is quite a drab fellow but an accomplished architect and artist, often building enormous colorful bowers—the avian equivalent of a bachelor pad; a sort of Freudian compensation for his personal appearance, you might say. He makes elaborate entryways, groups berries and pebbles according to color similarity and contrast, and even collects shiny bits of cigarette-foil “jewelry.” Any of these bowers could probably fetch a handsome price if displayed in a Fifth Avenue gallery in Manhattan and falsely advertised as a work of contemporary art.

The existence of aesthetic universals is also suggested by the fact that we humans find flowers beautiful, even though they evolved to be beautiful to bees and butterflies, which diverged from our ances-

tors in Cambrian times. Also, principles such as symmetry, grouping, contrast, and peak shift used by birds (e.g., birds of paradise) evolved to attract other birds, but we are similarly moved by them.

Richard Gregory and Aaron Scholman have pointed out to me that if universal laws exist, it might be possible to program at least some of them into a computer and thereby generate visually appealing pictures. Something along these lines was in fact attempted by Harold Cohen many years ago at UCSD, and his algorithms do indeed produce attractive pictures that fetch handsome prices.

9. Not all Western art critics were as obtuse as Sir George. Listen to the French scholar René Grousset describing the Shiva Nataraja (see Figure 4):

Whether he be surrounded or not by the flaming aureole of the Tiruvasi—the circle of the world, which he both fills and oversteps—the king of the dance is all rhythm and exultation. The tambourine, which he holds with one of his right hands, calls all creatures into this rhythmic motion, and they dance in his company. The conventionalized locks of flying hair and the blown scarf tell of the speed of this universal movement, which crystallizes matter and reduces it to powder in turn. One of his left hands holds the fire which animates and devours the world in this cosmic whirl. One of the god's feet is crushing a titan, for “this dance is upon the bodies of the dead,” yet one of the right hands is making the gesture of reassurance (*abhaya-mudra*), so true it is that, seen from the cosmic point of view . . . , the very cruelty of this universal determinism is kindly, and the generative principle of the future. And, in more than one of our bronzes, the king of the dance wears a broad smile. He smiles at death and life, at pain and at joy alike, or rather, if we may be allowed so to express it, his smile is both death and life, both joy and pain . . . From this lofty point of view, in fact, all things fall into their place, finding

their explanation and logical compulsion. . . . The very multiplicity of arms, puzzling as it may seem at first sight, is subject in turn to an inward law, each pair remaining a model of elegance in itself, so that the whole being of the Nataraja thrills with a magnificent harmony in his terrible joy. And as though to stress the point that the dance of the divine actor is indeed a force (*lila*)—the force of life and death, the force of creation and destruction, at once infinite and purposeless—the first of the left hands hangs limply from the arm in a careless gesture of the *gajahasta* (hand as the elephant trunk). And lastly as we look at the back view of the statue, are not the steadiness of these shoulders that support the world, and the majesty of the Jove-like torso, as it were a symbol of the stability and immutability of substance, while the gyration of the legs in their dizzy speed would seem to symbolize the vortex of phenomena.

**V. S. Ramachandran** is director of the Center for Brain and Cognition and professor of neurosciences and psychology at the University of California, San Diego, and an adjunct professor of biology at the Salk Institute.