V.S. Ramachandran

Sharpening Up 'The Science of Art'

An Interview with Anthony Freeman

Introduction

Freeman: The article 'The Science of Art' by William Hirstein and yourself (Ramachandran and Hirstein, 1999) has proved one of the most stimulating ever published in *JCS*. Criticisms of it abound, so to focus your response I will put to you questions that summarize the chief points made by our formal commentators [see *Journal of Consciousness Studies*, **6** (6–7), 1999, and **7** (8–9), 2000] and also pick up other questions that are frequently asked about it. But first I should like to know what motivated you to write the paper — and did you anticipate the reaction it would provoke?

Ramachandran: We mainly did it for fun. Also we hoped the essay would serve to generate a useful dialogue between artists, neuroscientists, perceptual psychologists and art historians — to bridge C.P. Snow's two cultures. The article was intended to be whimsical, provocative and slightly tongue-in-cheek, and to serve as a starting point — it certainly wasn't intended to be a complete theory of art (even assuming there *is* such a thing!). Judging from the enormous number of comments received — both in the journal and at subsequent meetings on the topic — it seems to me that our article has at the very least accomplished our minimum objective: to make some specific experimental predictions and so to stimulate a lively debate.

Freeman: What is your overall reaction to the tone and content of the comments and questions that have been thrown up?

Ramachandran: As one would expect, with such a wide range of commentators, some are favourable and others frown on the whole enterprise — while at the same time disagreeing among themselves or even contradicting each other. My general impression has been that scientists (e.g. psychologists and neurologists) find the essay stimulating whereas some art historians don't. But I was pleasantly

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surprised to find that many practising artists also find the article to be both interesting and provocative. ('It makes what we do seem less "crazy" or *ad hoc* — indeed it legitimizes what we do,' was the way one artist put it while commenting on a lecture I recently gave at the Getty [Ramachandran, 2000b].)

I especially enjoyed reading the clear, cogent, and insightful arguments of Richard Gregory, Colin Martindale, Jaron Lanier, Julia Kindy, Ron Mangun, Jennifer McMahon and Amy Ione and would like to thank them for taking the time to respond.

When reading some of the critical commentaries I was reminded of a story about the great German physicist Hermann Von Helmholtz, the first scientist to propose the First Law of Thermodynamics — that energy can neither be created nor destroyed. Even though the 'law of conservation of energy' was starting to be widely accepted it was violently opposed by many biologists who argued that the law applied only to non-living systems but not to living things. So Helmholtz set up an apparatus to measure the heat output of a living muscle preparation and showed that it did obey the first law just as well as an 'ideal' or perfect machine should. Amazingly, when he set up a demonstration of this at a scientific meeting in Germany, even many contemporary physicists (including Joule and Carnot) refused to believe the evidence before their eyes. Helmholtz wrote home to a friend: 'Despite the evidence staring at them, not a single member believed a word of what I said. From the vehemence of their denials and denunciations I now *know* I must be right.' The vigorous opposition to Helmholtz was mainly the result of the then prevailing strong anti-reductionist stance in biology — especially the superstitious belief that living things were imbued with a mysterious 'vital essence' that rendered any application of scientific laws — such as the first law — inapplicable to them. One discerns a touch of the same endearing naivete in the responses of many social scientists to our essay on the science of art, for example in the comments of Ruth Wallen (who describes herself as a 'practising Buddhist') who seems worried that a scientific analysis of art might detract from its spiritual dimension! (See further on p. 22 below.)

Incidentally, I am amazed at the willingness of Dr Goguen to allow 'Donnya Wheelwell' to publish her piece under a pseudonym — a practice that is unheard of in respectable academic circles (and despite his telling me over the phone that a pseudonym would not be used). If Ms Wheelwell really had something interesting to say, why hide behind a psudonym?[1]

Freeman: You have said that you mainly wrote the article 'for fun', but I don't entirely believe that. I sense that you have a passionate and deeply serious underlying commitment to the project you have begun.

Ramachandran: In publishing 'The Science of Art' we had one main goal in mind, namely to stimulate an interdisciplinary discussion and debate between neuroscientists, social 'scientists', artists and art historians on the meaning of art and the quest for artistic universals.

[1] See pages 3–6 above for a discussion of editorial policy on unsigned contributions — *Editor*.

Freeman: Doesn't the attempt to discover 'artistic universals' negate the very essence of art, which is after all a celebration of individuality, not about what's common across people and cultures?

Ramachandran: My spelling out universal 'laws' of aesthetics does not negate the originality of the artist. I am merely asking what rules of thumb the artist consciously or unconsciously deploys. But which laws a given artist chooses to emphasize and how effectively she does it is entirely up to her skill and originality. Monet was a master of introducing peak shifts in colour space whereas Henry Moore was probably tapping into and exploiting form primitives — analogous to the stick with three stripes. By way of analogy consider two 'universal laws' in poetry — metaphor and rhyme. Spelling out these laws does not detract from the fact that Shakespeare was better at deploying them than any other human being. (The only difference is that for universals in poetry, such as rhyme, it is hard to find the evolutionary rationale or neural underpinnings in the manner I have tried to do for the universal laws of visual art.) An even better analogy is with Chomsky's discovery that there is a 'universal grammar' underlying all human languages despite their surface diversity. His ideas have enormously enriched our knowledge of language, but no one would argue that the existence of such universals detracts from Shakespeare's originality.

Freeman: How did you — a neuroscientist — first become interested in the question of artistic universals? And didn't you feel the need for a formal training in art history or the philosophy of aesthetics before embarking on such a venture? As things are, you surely run the risk of making simple mistakes that give your opponents an excuse to brush aside your more incisive remarks.

Ramachandran: My current work is in behavioural neurology but most of my earlier work in the last two decades was on human visual perception — especially its biological basis. I also enjoy and study Indian art as a hobby. So it was quite natural for me to become interested in artistic universals and the underlying neural substrate. I became especially intrigued by the word *rasa* that appears in ancient Indian (Sanskrit) art manuals. The word is hard to translate but roughly means 'Capturing the very essence of something in order to evoke a specific emotion or mood in the viewer's brain'. I realized that to understand the neural basis of art one needs to understand *rasa*.

My lack of expertise in art history is both a disadvantage and an advantage. A disadvantage, perhaps, because it may lead me to ignore stylistic historical trends and the important cultural dimensions of art. An advantage, because it is only by deliberately ignoring the *variations* imposed by culture that one can begin to approach the question of whether or not there are universals and it's easier to ignore something if you don't know anything about it!

My point is not that culture is not important but that it's what most people study — it's called art history. On the other hand almost no real progress has been made in understanding universal principles that *cut across* cultures and that's what interests me as a scientist. Even if only 10% of art turns out to be lawful it's that

10% that interests me, not the unlawful 90% that interests sociologists and historians. After all there are thousands of stodgy, boring inaccessible tomes on art history, styles, fads, etc., gathering dust on bookshelves, but very little that is intelligible and interesting about the universals.[2] So while I plead guilty to ignoring the complexities imposed by culture, I would point out that my decision to do so was deliberate. And I would argue that my ignorance of art history (especially Western art) is an advantage since it has perhaps allowed me to approach the problem with fresh unprejudiced eyes.

Freeman: But why is this debate so important to you?

Ramachandran: The history of science may be seen as a long succession of attempts to banish vitalism from our understanding of Nature. People said that living things could never be understood in terms of chemistry because there was a mysterious *élan vitale*, 'entelechy' or vital spirit, but the discovery of DNA's structure changed all this. Likewise it was widely believed that even though we may someday understand all the functions of the brain, we can never explain the 'soul' or consciousness. This challenge too has been taken up (e.g. Crick and Koch, 1998) and few educated people now believe in a nonmaterial soul. Now with regard to art, the easy way out is to say, 'Well, it will always remain ineffable and mysterious' — as some of the commentaries on our essay imply. On the other hand it requires guts to say, 'Well, maybe that's true and eventually we will come up against an epistemological barrier, but *even if that is so*, I would prefer to forge ahead in my quest for laws until I do confront that barrier.' This is why I regard Zeki's efforts to understand art as so important, even though he doesn't have all the answers. Saying 'it will always remain mysterious' is the easy way out.

Prediction and Experimental Testability

Freeman: You lay great emphasis on the claim that your ideas entail predictions that are experimentally testable. Can you elaborate on this with concrete examples?

Ramachandran: Yes, at least some of the ideas in our essay make very specific counterintuitive predictions — and that's what sets these apart from the vague ideas of philosophers and even vaguer ideas of art historians.

Let me take up a challenge that would, at first sight, seem almost unapproachable by science: cubism. It has long been known that cubism liberates the viewer from the tyranny of a single viewpoint by presenting two or more 'views' of an object or face squished into a single plane — so as to be seen from a single vantage point. So a Picasso portrait might show a profile face and a frontal view simultaneously in a single image (see, e.g., Zeki, 1999). However what no art scholar or scientist has asked is *why* such a simultaneous depiction of two views should be actually *more pleasing* to the observer than any single view, even though it looks 'unrealistic'. One option would be to suggest that cubism is not all that pleasing and that it's the result of propaganda and culture — indeed Zeki

[2] See below for some notable exceptions, e.g. work by Gregory, Arnheim, Gombrich, Humphrey, Zeki.

speaks of it as a 'failure'. But following my line of reasoning about the 'super beaks' that gull chicks respond to, I can make a specific physiological prediction concerning cubism (Ramachandran, 2000a,b).

First I would emphasize that the 'super beak' idea is not the same as 'caricature' or hyperbole. The key difference is that in the latter it is obvious what dimension is being exaggerated ('peak shift') whereas in the former the super-stimulus bears *no* obvious relationship to the original stimulus to which the organism has evolved (or learnt) to respond. That is to say, from looking at a real beak you couldn't have predicted that a long stick with three stripes is the optimal configuration for driving the neurons. And I suggest that this idiosyncratic response is a sort of spandrel — it has something to do with neurons using certain primitive rules or 'shortcuts' to detect beaks quickly and adequately with high probability and without too many false positives. The system is adequate but not optimal (and certainly not infallible). Indeed all that's required is that the neurons have a high enough 'hit rate' in detecting beaks that they leave behind enough genes for the next generation of gulls. (We need a new name for this so lets call it 'hypernormal stimuli'.)

Freeman: Is the response to the beak learnt or present at birth in the chick's brain?

Ramachandran: It is present at birth. But my notion of 'hyper-stimuli' would apply even to learnt visual patterns — e.g. specific faces. For instance, a large proportion of cells in a certain part of the fusiform gyrus (inferotemporal cortex) of the monkey respond to faces in a highly selective manner and not to other things (e.g. pigs, chairs or bananas). Each cell will respond only to one view of a particular face, e.g. 'boss' or 'infant' or 'Monkey A' or 'Monkey B', with different cells responding to different faces. In addition there are many different cells responding to a given face — with each cell responding to *different* view of that same face, e.g. frontal view, semiprofile or full profile (Rolls, 1999). But at the subsequent stage in processing, in the next visual area in the hierarchy, a new type of cell is seen that will respond to *any* view of a given face — e.g. mother or monkey A or B (and different cells respond to different faces). These 'master face cells' (as I call them) are of course what the monkey ultimately needs — for it needs to detect the mother's presence no matter what direction she is looking. Now how do you 'construct' or wire up one of these master face cells? In all likelihood you pool the outputs of several regular face cells each of which responds to a different view of the same face. So you take the output of all the regular single-view face cells corresponding to a given face and have these output axons converge on to a single master face neuron for that face. The net result of such a convergence would be that the master cell in question responds equally well to *any* view of that face — which is what you want.

Freeman: But what has all this to do with cubism and Picasso?

Ramachandran: In order to see that, first consider this fact. When a convergence of axons from several 'regular' face cells occurs on a single master cell, nature (or evolution) is not going to go through all the trouble of ensuring that the

convergence results in a perfect 'OR-gate'. On the contrary it may well be that if both views are simultaneously presented to the master cell then the converging inputs from the two corresponding regular 'single view' cells may simply add linearly — until saturation. This means you would be *hyperactivating* the master neuron in a manner that could never occur in nature (Ramachandran, 2000a,b). So this master face neuron may scream out loud (so to speak) 'WOW — what a face!' and excite the limbic system correspondingly. Now the advantage with this explanation is that it can be tested experimentally.

Neuroscientists at Oxford and Princeton are currently recording from both types of cells in these very areas. My prediction is that if you find a regular face cell, it should get excited by regular faces but not any more so by a Picasso face (since only one of the views will excite the cell). But if you go to the *master* cell, where convergence of many views occurs, then that cell will not only respond to *any* individual view but even better to two views presented simultaneously as in a cubist portrait! I am especially fond of this example because often when I give talks a social 'scientist' will raise his (or her) hand and say, 'You scientists are reductionists. You may explain atoms and molecules using string theory, you may explain heredity using DNA — maybe even aspects of the mind, such as memory in sea slugs — but you can never explain a Picasso!' Well what I have proposed above is nothing less than a specific testable theory of Picasso, in neural terms.

Freeman: But it may turn out that your explanation is wrong.

Ramachandran: Yes — and that is the beauty of it! In that case it's *at least* wrong: one can show for sure that it is wrong! And you can't say that for 99% of the philosophical theories of aesthetics and art. To my knowledge this is the first clear cut experimental prediction on cubism that has been ever proposed.

Freeman: Your enthusiam is contagious, but if your ideas about Picasso are correct, then why doesn't everyone like Picasso?

Ramachandran: This is an important question. The surprising answer might be that everyone does 'like' Picasso but not everyone knows it! The key to understanding this is to realize that the brain has many quasi-independent 'modules' that can at times signal inconsistent information. It may well be that *all* of us have the basic neural circuits in the fusiform (and especially at the next stage) i.e. the 'master face neurons' that would show a heightened response to Picasso, but perhaps in many of us other 'higher' cognitive systems (e.g. the interpreter in the left hemisphere) might kick in and censor or veto the output of the face neurons by saying, in effect, 'There is something wrong with this face — two eyes cannot possibly occur on a profile — so ignore that signal from the master face cells even though it is very strong'. In short I am saying all of us *do* like Picasso but many of us are 'in denial 'about it, and as I have argued elsewhere 'denial' is much more widespread than people realize. For instance polls show that roughly 95% of people think their intelligence is 'above average' — a mathematical impossibility. The finding implies that almost half of mankind is in denial about its stupidity! Likewise I would argue that even people who claim not to like Picasso are closet

Picasso enthusiasts and this could in principle be tested with brain imaging and GSR — it's not an untestable assertion.

Let me make a second prediction and that concerns the exaggerated 'feminine pose' or sense of movement rhythm and dance seen in certain Indian sculptures (see my article for examples) as well as Western sculptures, e.g. Degas. I suggest these are hyper-normal stimuli for a system of cells called 'mirror neurons' in the frontal lobes of primates. Certain cells in the monkey's ventral premotor area respond when the monkey performs actions such as 'pulling', 'reaching for a peanut', etc., i.e. they are motor 'command' neurons for initiating and orchestrating complex sequences of movement. Now Rizzolati has shown that a subset of these — called 'mirror neurons' — will be activated even if the monkey doesn't move his hand but watches another 'model' monkey perform that very same action, i.e. it's a 'monkey see monkey do' neuron. Similarly, there may be neurons that respond optimally to the adoption of certain postures by the other monkey. It was as though the neuron was doing an internal VR simulation in order to 'read' the model monkey's 'intention'. To create a work of art that takes advantage of these principles, I suggest that one exploit two laws — 'isolation' and 'peak shift' — in order to hyperstimulate E, the mirror neuron system in humans. To do this one could create point light displays mounted on the 'model' human's joints as she performs complex movements (e.g. dance) or adopts certain poses ('isolation') analogous to displays used by Johannson (1975) and then introduce postural peak shifts or exaggeration in these displays. This would serve as a hyper-optimal stimulus for the mirror neurons and I predict it would be aesthetically more pleasing than watching a real woman adopt corresponding poses or movements.

Lastly I would emphasize that the idea that art involves exaggeration or hyperbole is hardly new. What is novel here is the idea that the more effective stimulus that hyperactivates the visual cells need not bear *any* obvious resemblance to the thing being depicted (e.g. stick with three stripes = beak) and may, instead, reflect the manner in which that cell is 'wired up' to take certain short-cuts in processing visual images. Indeed certain fish will respond most vigorously to a blue dot painted on a fish of the opposite sex even though there is nothing resembling that blue dot on the original! Perhaps abstract art taps into such form and colour primitives in human vision (and the idea can be tested by experiments of the kind outlined above for Picasso).

Also, as we argue in our essay, both the idea of 'peak shift' and the idea of 'hypernormal stimuli' (like the stick with three stripes) can be extended to domains other than 'form' — e.g. colour (Monet and Van Gogh) or movements (in dance) — i.e. to domains to which the idea may initially seem inapplicable. Indeed it is likely that there are visual areas (or neurons) in the brains of primates that extract other visual primitives that are even less obvious, such as light and shade, highlights, skin texture, etc., and one often sees renaissance paintings that deliberately exaggerate or produce 'hypernormal' versions of these very characteristics — e.g. an old man with anatomically impossible wrinkles, absurdly accentuated highlights on a shiny face or eyes, rippling, grossly hypertrophied muscles, or a pink flush that is almost too healthy (Boucher). Deeply accentuated

(and physically impossible) shading is also often used to artificially heighten the sense of 3-D form and depth. Without these extra touches you just have realism — not art. (And conversely if these laws are deployed inappropriately you get kitsch art and tacky art.) Some people have argued that what is kitsch and what is sophisticated is a matter of convention and culture but I disagree. The evidence against this is that one can mature from initially liking kitsch to liking more sophisticated art but one cannot usually slide backwards to kitsch (which implies that there is something genuinely 'better' about the former). Other aspects of aesthetics, besides art, may also exploit 'peak shifts'. E.g. lip stick and rouge emphasize that a potential mate is not anemic and is therefore fertile. Belladonna enlarges pupils and glitter sprinkled on the skin looks like sweat — simulating sexual arousal.

Freeman: As an aside, your speaking of sea gulls and impressing chicks raises the question, Do animals have art?

Ramachandran: I wouldn't rule it out. Male bower birds in New Guinea and Australia build elaborate and very ornate bowers decorated with brightly coloured berries, shiny bits of metal (Ramachandran and Hirstein, 1999), lustrous feathers and pebbles, etc. Even a cursory examination reveals many of my laws at work, e.g. grouping (similar coloured pebbles or berries are grouped close together) and clusters of shiny metallic bits may be hyperactivating certain neurons just like a Picasso face does for us (signalling the presence of water or dew perhaps?). I don't see all that big a difference between the creations of these birds and much of what passes for contemporary art in Madison Avenue or Santa Fe (although, in saying this, I do feel a bit like the little boy who said the emperor has no clothes!).

Originality

Freeman: I have also played the role of that little boy in my own discipline of theology, and one of the defences put up against me by the 'establishment' was to claim my ideas were actually nothing new, and therefore could be ignored. You seem to be vulnerable to a similar accusation. For instance, you open your essay by saying that the goal of art is not realism, that is to say it's not to copy something. Surely this is not an original observation.

Ramachandran: Of course it's not original — we were not even trying to be original — this was just a rhetorical opening line, nothing more. But you would be amazed at how widespread this misconception of art was, and indeed still is. As we say in our essay, Victorian Englishmen often criticized Indian sculptures because of lack of anatomical realism ('multi-armed monstrosities' to quote one eminent bard). For example, they thought that Chola bronzes and 'mediaeval' stone sculptures of women were too voluptuous — with enormous breasts and hips — for their delicate Victorian sensibilities. How ironic, then, that it was at just this time that corsets were introduced in England. Women even had their lower ribs removed surgically to accentuate their bust and hips to impress those

very men who were criticizing statues of Indian goddesses for having precisely the same attribute — too narrow a waist!

Freeman: Does that mean you are not claiming any of your ideas are original?

Ramachandran: I am tempted to quote Gerald Edelman, who once said, 'If I have seen further, it is by standing on the heads of pygmies.' On a more serious note, our article of course builds on the earlier work of many eminent scholars, especially Rudolf Arnheim, Ernst Gombrich, Richard Gregory and Roland Penrose, all of whom have written extensively and eloquently about art. I was especially intrigued by the ingenious recent speculations on art by the physiologist Semir Zeki — particularly his insight that neurons in the visual pathways often seem to do exactly what the artist himself is trying to do, e.g. the extraction of contrast. (Although I part company with him on certain specifics. For instance, he says cubism was a failure whereas I present I very specific explanation of why cubism is a success and offer a precise mechanism in terms on neural circuitry.) But one also needs to address the question of *why* the artist's 'mimicking' what the neurons are doing should be *pleasing* to the organism. For this one needs to borrow ideas from computational vision and evolutionary biology. A proper answer to *why* requires teleology.

Freeman: We all owe a general debt to earlier research, but haven't some of your quite specific ideas been proposed before? For example, one of your laws is 'grouping'. Wasn't this well known to the Gestaltists?

Ramachandran: Yes, indeed we owe a major dept to the Gestaltists and much of this has been expounded to modern audiences by Arnheim and Gombrich. Many of the 'laws' I have described have indeed been foreshadowed by others and I cite all those that I am aware of. One must be careful, however, not to read too much (by hindsight) into these early glimmerings. For example one could argue that the so-called Pythagoras theorem is already implied in the first axioms of Euclid, but we still give Pythagoras the credit for making it explicit. (Incidentally, this theorem was already known to Indian mathematicians a millennium earlier, but we call it 'Pythagoras theorem' because the Indians did not have a proof — only Pythagoras did.) Likewise the atomic theory was known to Jains in India several hundred years before Christ, but we usually credit Dalton (who himself drew on the ancient Greek Epicureans) because he was the first to marshall all the evidence in its favour into a comprehensive scientifically testable scheme.

Secondly, we believe that *some* of the laws we propose (and certainly the specific experimental tests) are in fact completely new, to the best of our knowledge.

Thirdly, our goal is not so much to propose an entirely new theory of art as to bring together strands of evidence from seemingly unrelated disciplines such as single unit neurophysiology, ethology, perceptual psychology and evolutionary biology. And judging from the volume of responses received, it seems to have served as a forum for debate between scholars from all these diverse disciplines. More specifically, I argue that in order to understand any complex mental attribute in humans — be it humour, art, dance, or sex, one needs to have in place *three*

cornerstones: First, the underlying *functional logic* (e.g. what I call 'laws'). Second, the *evolutionary rationale*, i.e., speaking teleologically, why do the laws have the 'form' that they do? (e.g. evolution has wired into your brain the 'rule' that grouping is pleasing and attention grabbing). Third, an understanding of what is the *neural hardware* in the brain that mediates the law in question. As a specific example of these three 'corners' of an argument consider the following.

In the 'law of grouping', the functional logic is to link scattered fragments into a whole. It's evolutionary rationale is to help defeat camouflage and find objects in noisy environments: vision evolved in our primate ancestors mainly to *find objects quickly and efficiently but not infallibly*. And third, we suggest that as soon as the fragments are bound, there is a synchronization of neuronal spikes of those neurons (Singer and Grey, 1995) that fire for different parts of an object and it is this synchrony that causes an 'AHA' reward signal to be sent to the limbic system (Ramachandran and Hirstein, 1999). So while most artists, fashion designers and art historians may be aware of the grouping law they may not be aware of the evolutionary rationale nor of the neural mechanism (synchrony of spikes causing a reward signal to be sent to the limbic system). And we attempt to do this not just for grouping but for all eight of our laws.

Finally, as Richard Gregory points out in his commentary, we make novel predictions and propose specific experimental tests (e.g. our physiological experiment on Picasso). Without such empirical tests, 'theories' of art are merely intellectual exercises of the kind philosophers engage in.

Freeman: Aren't some of your principles well known to practising artists? For example, what you call 'isolation' or minimalism is surely very familiar.

Ramachandran: I don't deny that some of my laws have been foreshadowed by others and some have even been explicitly stated. But what I have tried to do is to spell out each law in considerable detail, point out its logical consequences, explore the evolutionary rationale of the law and (when possible) propose physiological mechanisms and experimental predictions. Each of these approaches on its own is insufficient. Let me illustrate what I mean using three of my laws, isolation, symmetry, and 'peekaboo' (or perceptual problem solving), all of which are well known to artists. We also need to avoid internal contradictions among the 'laws' — e.g. isn't the principle of isolation or minimalism ('less is more') the very antithesis my other law of 'peak shift' or hyperbole or exaggeration? No it isn't, and I will explain why.

Artists have long known that an outline sketch can be very beautiful. Even prehistoric cave artists knew this. Now the standard 'explanation' for this provided by perceptual psychologists (see, e.g., Cavanagh, 1998) and physiologists is the cells in the visual parts of the brain respond to change — not to uniform surfaces — e.g. cells in area 17 and 18 respond optimally to sharp edges or boundaries but not to homogeneous edge-free surfaces. So an outline drawing has most of the essential information concerning the objects face and will 'drive' or activate the cells just powerfully as the cells would be driven by a half tone photo, But surely this explanation begs the question. It only explains why an outline drawing

should be adequate or as effective as a half tone grey scale picture, it doesn't explain why the outline is actually *more* evocative. That's where my isolation principle comes in. Analogously, just because you find cells in the fusiform that respond adequately to (say) a Rembrandt portrait it doesn't follow you have explained the neural basis of portraiture or Rembrandt. To do so you would have to find cells that respond better to Rembrandt than to a real face and also explain why the cell does this (in terms of both its circuitry and its evolution).

To understand the principle of isolation we need to consider the critical role of attention, i.e. the fact that even though the brain is a massively parallel computer with 100 billion cells, it has limited attentional resources — an attentional 'bottleneck' that allows only one stable neural representation to occupy centre stage at a given instant. Since the critical information about (say) a nude or a face is in its outlines, everything else on it, e.g. skin tone, hair, shading, etc., is irrelevant to its being that particular face or nude shape and actually distracts your attentional resources from where it is critically needed. Therefore, if the artist has introduced 'peak shifts' in the *form* domain, then he needs to throw away everything else so that the viewer can allocate all his attention to this single domain that the artist has exploited — and ignore the others. On the other hand if the artist is mainly introducing 'peak shifts' in colour space (e.g. Monet or Van Gogh) then it might be a good idea to deliberately smudge the outline or form so that attention is spontaneously allocated to colour alone (and indeed that's what Monet and Van Gogh *do*!).

Three experimental predictions can be made. First, people who can spontaneously allocate their attention to single (or a small subset of) dimensions should be actually better at art! Thus Van Gogh's epileptic seizures in his temporal lobes may have actually strengthened neural connections between his visual object and face area and the amygdala, nucleus accumbens and other brain regions involved in gauging the emotional significance of what's being viewed. Such a heightened attention and emotional response to visual images may have made him a more accomplished artist — his seizures enabling him to 'attend' to certain critical dimensions more than you or I. Indeed it's not inconceivable that there was a selective enhancement of connections from V4 (the colour area) and the limbic structures which would explain his preoccupation with the *rasa* of colour.

Freeman: Are you using *rasa* here to mean the same as 'peak shift'?

Ramachandran: *Rasa* is at least partly that, but probably more. Newton showed that all the colours we see can be produced by optically mixing just three 'primaries' (red, green and blue) because we have three cone pigments in the eye that respond optimally (but not exclusively) to these primaries. Any other colour excites the cones in certain ratios unique for that colour. By artificially bleaching out two of the cone pigments (e.g. green and blue) and presenting white light (composed of all wavelengths) you can hyper-stimulate red in a manner that you could never do in nature and the result is an abnormally heightened supersaturated red. (One that may well signal danger and evoke a bigger GSR than any red in the real world could.) We have no idea how 'form' is encoded but it's not inconceivable that there is a finite set of form primitives or 'primaries'. So the

Chola bronze of Parvati is not merely a peak-shifted version of a woman but somehow evokes the percept of an idealized 'quintessential' female. (The appeal of the universal 'Golden ratio' may also be based on some such elementary coding principles — as yet unknown.) One wonders if something like this could also explain the erotic appeal of a Henry Moore statue or O'Keefe painting.

Freeman: Does the peak shift principle apply to subjects other than art?

Ramachandran: Sometimes you find yourself attracted to a woman (or man) inexplicably — even though she may not be quite as pretty (by consensus) as others. I think this may be because you carry 'templates' of your mother and perhaps other women from your teenage years, and the new woman has a face that is a 'hyperstimulus' for those neurons — even though she may not resemble your mother or other early sexual partners in any externally obvious manner. (Just as it isn't obvious why the stick with three stripes hyper-activates 'beak neurons'.)

Of course there is a danger of circular reasoning here. Since we do not know what the coding parameters of 'form' are for human vision, if you find something inexplicably attractive you could at once invoke my principle — saying that the pattern is 'like the stick with three stripes'. In response to this I would say that my theory may be difficult to test in *practice* (making it vulnerable to the charge that it is circular) but not in *principle*. So once the coding parameters for human perception are understood, one can begin to explain clearly why certain patterns are pleasing to the eye (e.g. my suggestion about cubism).

Freeman: I interrupted your discussion of the enhanced artistic skills of people who can spontaneously allocate their attention to a single dimension.

Ramachandran: Yes. Another piece of evidence for this comes from patients in whom most or many brain areas (e.g. frontal and temporal lobes) other than those concerned with artistic proportion (e.g. the right parietal) are functioning suboptimally so that attention is then spontaneously allocated to the right parietal alone. Examples include retarded autistic savants as well as adult onset fronto — temporal dementia — a degenerative brain disease in which the frontal and temporal lobes are affected but the parietal is spared. Some of these patients show a sudden efflorescence of artistic talent — a change that I would attribute to the principle of isolation or minimalism.

Third, one might predict that if you record from master 'face cells' in monkeys they might actually respond better to outline drawings than to half tone photos even though the latter have 'more information' (assuming that the masking by irrelevant attributes occurs earlier than the neuron's response). The extra information is not part of the defining attribute of the face — only the outline is. Lastly if you obtain GSR (galvanic skin response) from humans or do non-invasive brain imaging you should see a bigger signal (either on the palm or in the fusiform brain area) for outline drawings of faces than would be the case with half tone photos — and an even bigger response if the drawing is also subjected to peak shift, caricature or exaggeration.

So we started with a deceptively 'simple' law — isolation — and explored its rationale and many of its logical consequences. I will now apply a similar approach to two others laws, symmetry and 'peekaboo'.

Symmetry is attractive, whether one is talking about a child playing with a kaleidoscope or Shah Jahan's immortal monument to Love — the Taj Mahal. (In fact I would regard it as my 'eighth law' in addition to visual repetition or rhythm which is the ninth law.) But *why* does symmetry grab our attention? There are two possibilities. First, the goal of vision is often to discover and orient to (and identify and respond to) a camouflaged object in a cluttered visual scene. Now in allocating attentional priorities the detection of *biological* objects is especially important since such an object is usually a prey, predator, or mate — eliciting the so-called 'Four "F"s' of behaviour — feeding, fighting, fleeing or f∗∗∗ing. And most biological objects (animals, not plants) are symmetrical, so we have an early warning system hard wired into our brains — based perhaps on direct responses by neurons in the early visual areas to symmetry. I suggest these neurons are directly wired up to the limbic/reticular structures in such a way as to cause you to 'orient' and pay attention to the symmetrical object, i.e. your visual pathways are hardwired to the limbic system is such a way as to make symmetry pleasing in order to provide the incentive to direct your eyes and attention towards it. Second, we shun asymmetrical mates because in nature asymmetry is often a sign of early parasitic infestation and and you don't want to mate with an anemic parasite infested partner. For this reason, too, there may be an aesthetic preference for symmetry. Little did Prince Shah Jahan realize that the reason he built the Taj is the *same* reason he fell in love with the symmetrical, parasite-free face of his beloved Mumtaz!

Third, consider the 'peekaboo' principle, a device well known to artists: a face or a nude seen behind a shower curtain or a diaphanous veil is much more evocative than a fully visible one. Many authors (e.g. Gombrich) have noted its use but the question is *why* is it beautiful and/or attention grabbing? Again, I suggest this has to do with our ancestors having to detect prey, predator or mate in camouflaged, noisy backgrounds often in dim light. So when the visual system is confronted with a perceptual jigsaw to link together scattered fragments to find 'hidden' objects — you have to wire up the visual pathways in such way as to ensure that the visual 'hunt' itself is rewarding, lest the visual system 'gives up' too easily. I suggest that just as problem solving is rewarding to the cognitive system (which explains things like 'curiosity') so also visual 'puzzle solving' has evolved to be rewarding. Without this neural wiring in place your ancestors wouldn't have pursued a mate or game in fog! To understand this more clearly we need to abandon the 'standard' model of vision as proposed by Marr (1981), i.e. the notion that it is a sequential, hierarchical 'bucket brigade'. (Visual images are first decomposed into elementary features, then the features are grouped into clusters based on Gestalt laws, the cluster is segregated from background clutter and finally the object is recognized and an 'AHA': rewards is sent to limbic structures.) Instead of this we suggest that at each stage in the processing hierarchy an 'AHA' signal is sent to limbic structures which then feeds back to the early stages

and encourages further binding of features. And through such progressive bootstrapping the object finally emerges (Ramachandran and Hirstein, 1999; Ramachandran *et al.*, 1998). *It is these multiple 'AHA' signals that the artist titillates in order to excite your visual-limbic structures more optimally than she could using real images* — and I believe this to be a novel conception of art. (One prediction from this is that patients with Capgras syndrome resulting from a visual–limbic disconnection should no longer be able to enjoy art — even though they might still be able to appreciate it intellectually like an art critic or art historian might.)

Reductionism

Freeman: One of the consistent criticisms I hear is that what you are giving is a highly reductionistic theory of art. I suspect that you welcome that assessment, but how do you answer the allied charge that by doing this you belittle art?

Ramachandran: I have three responses to this. First, reductionism is the most powerful strategy known to science. Second, although I provide reductionist explanations (e.g. neurons responding to Picasso), I also repeatedly emphasize the need for two other 'levels' forming the other two apices of the triangle — i.e. the level of *functional* or computational logic (as advocated by Marr, Pinker, Tooby and Cosmides, Wilson, and others) and the level of *evolution*. Where I part company with functionalists like Marr and with evolutionary psychology is in my insistence on reductionist neurophysiology as being equally important (see my critique of functionalism, pp. 25–6 below, and the analogy with digestion). Third, a reductionist explanation of a complex phenomenon does not eliminate the phenomenon — it only explains it. For example, if I explain the 'wetness' of water in terms of the physical properties of its constituent molecules, would that mean 'wetness' no longer exists? Of course not. Likewise, a reductionist view of what happens in your brain when you look at art, will not eliminate your enjoyment of art (any more than an account of the neural mechanisms of sex would eliminate your ability to experience orgasms).

Freeman: But what about the spiritual dimension of art? Ruth Wallen was especially concerned with that in her commentary.

Ramachandran: Exactly the same answer applies. Despite a common misconception among social scientists to the contrary, explaining a phenomenon in terms of the behaviour of its constituent components ('reductionism') doesn't explain it *away*. As someone who collects Indian art I am well aware of the capacity for the highest art forms to evoke transcendental or spiritual experiences. But often this involves the clever use of hyperbole of expression and posture and certain visual metaphors (e.g. the dance of the Chola bronze Shiva, Nataraja, in a circle of fire evokes a profound sense of grandeur and awe and a strong sense of the cyclical nature of the creation and destruction of the cosmos — his dance symbolizing the dance of the cosmos itself). I would refer Ms Wallen to the works of the art

historian Heinrich Zimmer who has written eloquently about the imagery and metaphor of Indian and Buddhist art.

Freeman: Even so, can something as ineffable as art really be reduced to the skin's resistance (GSR)?

Ramachandran: Of course not — I never said that something as complex and multidimensional as art can be measured entirely by GSR. My point was that it provides a starting point and Berlyne (1971) has made the same point. By way of analogy consider IQ tests as a measure of the heritable component (little g) of general intelligence. I myself have argued that this measure provides only a very crude partial measure of the richness of a human beings intellect Yet no one would deny that the test does measure *something* — and in fact is quite useful if you want to get a quick and approximate measure of intellect. A person with IQ 70 is unlikely to excel intellectually whereas a person with 130 is. Or an even better analogy is pulse and temperature as measures of one's 'general health'. These two indeces go all the way back to Ayurvedic and Greek Medicine but even in this day and age, when we have 25 tests of liver function alone, they continue to provide a quick and ready 'index' of the person's health as he/she is wheeled into the emergency room. They are crude and incomplete tests but are useful nonetheless. And I would argue that the same holds for GSR in response to art and beauty.

Freeman: A related question — doesn't GSR merely measure 'arousal' as opposed to aesthetic response?

Ramachandran: Obviously the GSR measures only emotional arousal — it can't discriminate positive and negative arousal. But even negative arousal has a place in art — as witness all the bruhaha surrounding the 'disgusting' art in Manhattan recently. My point was only that the GSR provides a starting point for measuring responses to art, not that it's a complete measure. It's also a more direct measure than asking someone for a verbal description because such descriptions are often not an accurate measure of what the person truly believes — it is 'tainted' and filtered through many layers of subsequent processing (e.g. your visual centres may signal a strong positive signal from seeing a Picasso, but the signal may be vetoed or censored by subsequent high level thought processes on the logical grounds that 'A woman can't have two eyes on a profile'). Also, the use of GSR allows us to make certain testable counterintuitive predictions, e.g. response to a caricature of a familiar face should be greater than response to a regular undistorted drawing. One can readily distinguish this from the effects of mere arousal due to surprise (or horror) by comparing the increase seen with the caricature with the increase seen with a random distortion (which would be equally surprising to look at). So, contrary to Ms Wheelwell's 'common sense' expectation, our ideas predict that a simple outline doodle of a nude by a brilliant artist — cleverly exploiting peak shifts, isolation, etc. — will, paradoxically elicit a *bigger GSR* (or response in single neurons encoding such stimuli) than a half tone photo, e.g. a playboy pinup. Deliberately simplifying a problem as a starting point is an immensely successful strategy in science, but social 'scientists' like

Ms Wheelwell simply don't understand this. (I am reminded of Jim Watson's derisive but brilliant and pithy quip, 'There are only molecules — everything else is sociology'.)

Also, words such as arousal *vs* aesthetic response are used very loosely by psychologists when, in fact, no one has the foggiest idea of how distinct and separable they really are. Indeed I would argue that arousal is an important part of aesthetics — although not the only part. And surely no one but a prude or feminist like Wheelwell would deny that aesthetic appeal and sexual arousal might be inextricably linked when viewing beautiful renderings of the human nude, whether female or male. (And, more generally, who can deny the link between art, Eros and creativity?) I suggest Ms Wheelwell also look at a Henry Moore sculpture or a Georgia O'Keefe painting.

Finally, to get around the arousal problem altogether, one could, if necessary, stay away from nudes and stick to faces. It is well known that everyone shows a bigger GSR to (say) his or her mother's photo than to a stranger. Now using a computer it is possible to produce a caricature of the mother (by exaggerating the difference between her and the average female face), an 'anti-caricature' that takes the difference and reduces it, a skilled artist's portrait and lastly, a random (but anatomically plausible) distortion equal in magnitude to the caricature. If the GSR was only being caused by a distortion-induced 'arousal' then all four should produce the same GSR (since the level of distortion is the same). But if I am right then the caricature and portrait should yield a bigger GSR (because the arousal component of GSR would be the same for all four but the 'hyper stimulation by recognition' component should be higher for caricature and portrait and the net result might be an even higher overall response).

Freeman: It has been suggested that your ideas smack of 'sociobiology' and 'evolutionary psychology' of the kind popularized by Edward Wilson. How do you feel about being linked to these notions, which have been the subject of sharp — you might say vicious — criticism?

Ramachandran: If you regard art as a product of the human brain and the brain as (at least partly) the product of evolution then there is no escaping the importance of natural selection. I would be the first to admit that untestable arm-chair teleology and evolutionary psychology can easily lead one astray, and I myself have criticized evolutionary psychology for these reasons. Indeed, I once wrote a satirical essay, 'Why do Gentlemen prefer blondes?', which was so convincing that many in evolutionary psychology took it as a serious candidate theory rather than a spoof! (see Ramachandran and Blakeslee, 1998). But there is no way you can get around the question of why grouping evolved, or why it is aesthetically pleasing, without bringing evolution into the picture. This is where the Gestaltists failed. They attributed grouping to mysterious autonomous 'fields' in the brain instead of thinking about the neural and evolutionary basis.

Freeman: Speaking of evolutionary psychology, I recently heard a theory that the reason why humans (especially women) like art is because it serves as a

marker or 'index' of the potential mate's superior eye–hand coordination skills, whether to wield a paint brush or a sword. Have you come across this?

Ramachandran: Yes, this is an interesting idea. It's been dubbed the 'Come and see my etchings' theory of art. It's as if the guy is telling the gal, 'See how good my eye–hand coordination is — I have good genes, come mate with me.' In my mind this theory beautifully illustrates the pitfalls of the claims of evolutionary psychology — namely that either they are obvious and banal (e.g. the fact that faeces smell disgusting because they have pathogens and its bad to eat them) or they are untestable. If the main selection pressure came from the need to 'display' eye–hand coordination, then men should have evolved to be excellent at knitting (and not many women, not even feminists like Ms Wheelwell, are likely to find knitting attractive in a man). I guess what I am trying to say is that this theory doesn't explain why the 'index' or marker for eye–hand coordination should take this *particular form*, namely art. Why not use more direct indeces like archery or javelin throwing (which, to be sure, *are* attractive)? Let me add, though, that even though I disagree with this particular idea, the author does introduce many other ideas in his book that I do find convincing. I think the real reason we engage in art is because detecting and recognizing objects is pleasurable to the organism and the visual system is wired up to embody this rule. And the artist enhances his images to more optimally titillate these rules than he could with a mere snap-shot.

A second reason might be that humans have to generate internal simulations (what we call mental images) in order to do a sort of VR simulation of forthcoming future actions, such as rehearsing a bison hunt. Now nature (or evolution) has seen to it that such internal simulations are not *perfect*. They cannot actually substitute for the real thing, because if they could an organism would soon starve to death (by imagining banquets) or fail to reproduce (by imagining orgasms). As Shakespeare says, you cannot cloy the hungry edge of appetite with bare imagination of a feast! But if this were true how did our ancestors rehearse forthcoming hunts or instruct their young ones about it? I suggest this is how cave art originated. The caricature-like renderings served as a less dangerous and less energy consuming substitute for the real thing — whether for rehearsal or for instruction.[3]

A third reason for the emergence of art might be status and the assertion of individuality, as eloquently argued by Pinker (1999).

Freeman: This will probably sound like heresy to a neuroscientist, but part of me wants to ask, What does it matter what the neurons are doing? Can't we simply follow the functional and evolutionary logic of art — or any phenomenon — and wouldn't that constitute a complete and intellectually satisfying account?

Ramachandran: This stance, as you know, is called 'functionalism' and although it sounds logical it doesn't work in practice. To see why this is, instead of the visual system consider another biological system such as digestion. If in the last two hundred years we had only looked at the 'output' of the digestive system, i.e.

[3] This idea emerged from a conversation with to Diane Rogers, whom I thank.

faeces, and its 'evolutionary logic', how much progress would we have made? Hasn't our understanding been tremendously enhanced by our knowledge of the anatomy, i.e. the liver, pancreas, salivary glands, intestinal mucosa, etc.? I would argue that, analogously, our understanding of visual perception and art will be enormously enriched by understanding the detailed neural circuitry that mediates it (just as our understanding of heredity was enhanced a hunderedfold when the structure of DNA was unravelled).

As a specific example consider our evidence about gull chicks' responses to a long stick with three red stripes. You cannot predict or understand this in terms of functional logic or evolutiuonary rationale. It works because evolution often takes 'short cuts', i.e. the goal is not to produce a neuron that optimally responds only to a beak (in which case you couldn't fool it with anything) but to wire up the system with minimum computational cost so that it is adequate (rather than optimal) for the job on hand i.e. detecting beaks — as quickly as possible. Now all of this (and my argument concerning its relevance to abstract art and cubism) was discovered, not by arm chair evolutionary psychology or functionalism but by ethological experts. And a more detailed understanding will require additional physiological expertese, e.g. recordings from the chick's tectum, rotundum or hyperstraiatum may reveal aspects of the neural circuitry that causes the neurons receptive field to prefer a stick with three stripes to a real beaks, e.g. the receptive field may be wired up to embody the rule 'The more red contour the better, etc.'. As a result the neuron isn't very 'fussy' in its requirements and can be easily fooled by the experimenter (just as we are 'fooled' by Picasso or Henry Moore) but in nature the neuron works perfectly adequately since its never likely to encounter a mutant seagull with a beak with three stripes or indeed a malicious ethologist waving a stick with three stripes! The point is that one cannot predict the efficacy of this peculiar stimulus configuration — long thin stick with three red stripes — simply based on the organism's *functional* requirements. The third cornerstone of our triangle (neural circuitry) needs to be taken into account.

Comprehensiveness

Freeman: A number of critics have argued that your focus is very limited. For instance, isn't your theory largely restricted to artistic representations of the human form, and in particular Indian art?

Ramachandran: No it isn't. I use the human form as a convenient starting point, mainly as a rhetorical device because the 'laws' are easiest to demonstrate along this dimension. But throughout the essay I refer to (and try to explain) many other types of art. It's valid for all — or at least for most — of them (although perhaps not so much for Dada, surrealism, 'conceptual art', etc.). I chose Indian art to illustrate my ideas only because I am most familiar with it, and also to dispel misconceptions about Indian art, widely prevalent in the West. (Many artists and connoisseurs have pointed out to me that after reading my essay they now enjoy Indian art much more than before.) But I also discuss Picasso, Rodin, Henry Moore, Van Gogh and Monet.

It is worth noting, though, that despite its initially unfamiliar appearance, Indian art has much more in common with Western art than people realize. If you look at the history of Western art it went through three stages of 'evolution' — with lots of overlap. Initially there was emphasis on realism — e.g. every muscle, sinew and tendon was 'copied' perfectly, as in Gray's text book of anatomy (e.g. renaissance sculptures or ancient Greek sculpture). Later, the emphasis shifted away from realism to semi-abstract (e.g. Rodin, Klimt, Picasso) and lastly, in this century, to completely abstract forms (e.g. Kandinsky or Pollack). Few people realize, though, that Indian art went through the same three stages of maturation — Terracotta busts in the Indus valley (2000BC) are superbly realistic renderings of the human male figure. Later in 'mediaeval' times (800–1100AD) artists said 'to hell with realism' and resorted to pleasing and whimsical exaggeration and 'peak shifts' (as in the erotic temple sculptures of Kajuraho and in Chola bronzes of the south). And finally there emerged a movement called 'Tantric art' that used just jumbles of abstract shapes to 'align fields and forces' in the brain to connect you to God, words reminiscent of those used by Kandinsky. So Indian art went through the same stages — realism, semi-abstract and completely abstract — as Western art did, but a millennium earlier.

Unfortunately the 'feminist' Ms Wheelwell (whose intellectual cowardice forbids her from revealing her true name) conveniently ignores this fact and she purports to 'criticize' our theory on the grounds that the paper has too many pictures of naked Indian Godesses! (I wonder if she also regards Raphael, Rubens, Gaugin, Boucher and Rodin as pornography, or whether she views only *Indian* art as pornography — if so she could be accused of ethnocentricity.)

Freeman: Why do you make a partial exception in the case of surrealism?

Ramachandran: I think there are two types of surrealism. First there is the Magritt type that involves deliberate and whimsical violation of the rules of perception (such as my law of avoiding 'suspicious coincidences'), e.g. the rules of occlusion, opacity. etc., as an attention grabbing 'arousal' device. To borrow a linguistic analogy, the artist is playing with the syntax — rather than semantics — of visual images. The second type is the Dali kind, which involves violation of high level visual semantics or meaning rather than early syntactic rules. The objects he creates are not literally impossible physically (e.g. melting clocks) but are highly improbable and dream-like. My theory has very little to say about all this except to point the way, since its really a form of conceptual art — one is really talking about violation of high-level concepts rather than low-level, purely visual rules. (And the same argument holds for conceptual art whose goal is to visually intrigue or even shock the viewer.)

Freeman: A related criticism is that your theory is mainly about aesthetics rather than art. How do you answer that?

Ramachandran: I have two responses to this. First, even if this were true, it wouldn't bother me, because a biological theory of aesthetics would be just as valuable as (indeed more general than!) a theory of art. Second, the boundary

between art and aesthetics is not very clearly defined — I bet there is a lot of overlap between the two concepts — so understanding one will enhance our understanding of the other. (The same holds for the distinction that sets 'design' in opposition to 'high' art.)

Freeman: At the start of this interview you said your proposals were never intended to be 'a complete theory of art'. So just how comprehensive is your paper?

Ramachandran: We have barely scratched the surface of the problem — it's really only a beginning. But I do believe that it points the way to the general *form* that a future more mature theory should have. (In much the same way that Crick and Koch's ideas do for the study of consciousness and qualia.) More importantly our goal was to get the wheels turning in people's minds and to initiate a dialogue between ethologists, artists, neuroscientists and perceptual psychologists. In this regard, I would especially emphasize the need for the 'three cornerstones' — functional logic, evolution and neurophysiology. If in addition, our ideas lead to new testable empirical claims (e.g. in cubism, GSR, etc.) then we would be amply rewarded. But we do have a long way to go.

Consider a simple question such as what makes a female (or male) face beautiful? Galton showed that an average of many female faces tends to be prettier than any one exemplar since it tends to average or iron out any imperfections. But we would predict that according to our scheme a beautiful female face will result if you subtract an average female face from an average male and amplify the difference. It makes evolutionary sense that blemishes are unattractive and would be smeared out by the averaging process (as in Galton's pictures). But if so, why are *some* blemishes — such as beauty spots — attractive? I recently found that if Cindy Crawford's famous mole (near her left upper lip) is moved to the central midline, e.g. on the forehead or tip of the nose, it looks hideous. It needs to be asymmetrically placed. It's also prettier if placed near a sharp facial feature e.g. the angle of a lip or near the angle of the eye, but not so much if its far from a feature — e.g. middle of the cheek. And lastly if *two* moles are symmetrically placed on either side of her nose just above her upper lip, it again looks bad.

I am saying all this only to emphasize that the aesthetic response to the precise positioning of the beauty spot is quite lawful yet we have no inkling why such a lawful response function exists. Or consider an even simpler question: why is it so unpleasant to look at a picture frame on the wall that is even slightly tilted? Why is such a tiny departure from rectilinearity so disproportionately disturbing? If we cannot answer even such simple questions we are surely a long way from understanding the 'Science of Art'. But however long it takes us, 'the journey is sure to be gorgeous' (Kindy, 1999).[4]

[4] I thank Diane Rogers, Francis Crick, Patricia Churchland and Julia Fuller Kindy for stimulating discussions on the many fascinating topics that straddle the huge divide between art and science. I thank All Souls College, Oxford, for a fellowship that enabled me to devote time to some of these questions.

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knife sharpening , myths busted , secrets revealed , Super Steel. Carbides in Maxamet. by scienceofsharp â€¢ November 3, 2019 â€¢ 29 Comments. Page 1 of 33. 1 2 3 â€¦ 33 Â». Recent Comments. awestib on Simple Straight Razor Honâ€¦ Mike Shults on The Pasted Strop â€“ partâ€¦ glock27 on What does stropping do? scienceofsharp on Diamond Plate break-in partâ€¦Â Customize. Follow. Sign up. Log in. Report this content. I went to the American Academy of Art, in Chicago, where I quickly learned the art of sharpening a pencil, charcoal, china marker, and any other writing instrument that can be sharpened to a pointâ€¦Â The methods taught to me at the American Academy of Art were passed down from the previous generation of professors, most notably William H. Mosby, the academyâ€™s master artist professor and graduate of the Belgian Royal Academy, and the great Andrew Loomis, who also taught at the school during the 30â€™s and 40â€™s. Some of Mosbyâ€™s notable students include artists Gil Elvgren, Bill Parks, Ted Smuskiewcz, Howard Terpning, and Richard Schmid, who credits Mosby as his most influential art professor. share. Sharpening Up One's Image. See allHide authors and affiliations. Science 22 Apr 2005: Vol. 308, Issue 5721, pp. 464 DOI: 10.1126/science.308.5721.464e. Article. Info & Metrics.Â AAAS login provides access to Science for AAAS members, and access to other journals in the Science family to users who have purchased individual subscriptions. Become an AAAS Member. Activate your Account. Purchase Access to Other Journals in the Science Family. Account Help. Log in through your institution.