Committee 2
Symmetry In Its Various Aspects:
Search for Order in the Universe

DRAFT--Sept. 12, 1997
For Conference Distribution Only

THE CULTURAL SALIENCE OF SYMMETRY: A PERCEPTUAL PERSPECTIVE

by

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The Twenty-first International Conference on the Unity of the Sciences
Washington, D.C. November 24-30, 1997

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"It is the glory of science that it finds patterns in spite of the noise." (Dennett 1995:358)

Introduction:

In this article I argue that specifically evolved human perceptual capabilities and adaptations can add new perspective and explanatory power to anthropological studies of human behavior. Biologists have for many years linked biological endowments with the nonrandom behavior patterns of animal species. Likewise, increasing knowledge about the many different biological parameters of human activity should enable anthropologists to better understand human behavioral patterns.

Anthropologists have typically studied the patterns of human behavior by describing the *end products*—the different ways people have adapted to life on earth in terms of a series of institutions which regulate kin relationships, economic and political strategies, and beliefs. Anthropology generally has not searched for the *mechanisms* which drive the regularities and universals which underlie human behavior. Instead of focusing on the features that natural selection has honed to give humans their unique cognitive capabilities, anthropologists have described the varieties of cognitive responses, such as differences in kinship systems, economic strategies, or projectile point shapes.

But, anthropologists can do more than simply describe human behavior if they can discover the biomechanisms which enable human behavior—which link the biologically, hard-wired adaptations accrued over the millions of years of primate and hominid evolution to the ways human beings use these highly evolved cognitive capabilities to process, perceive, and experience stimuli and to respond to it in ways we have described as "cultural." It is this linking which will allow anthropologists to more fully explain human cultural behavior, not simply to describe its many manifestations.

Should anthropology attend to the adaptive features which channel and delimit human behavior? This perspective has been best articulated by Tooby and Cosmides in The Adapted Mind (Barkow, Cosmides and Tooby 1992) who argue that anthropology needs to understand the psychological and evolved biological baseline which has enabled *Homo sapiens* to spread all over the globe as generalized exploiters of many different kinds of environments. They cogently target anthropology's superficial attention to the variety of human experiences and argue that anthropology should instead be focused on the "underlying architecture" in each of the behavioral domains. In each domain critical features evolved that enabled humans to efficiently and economically respond to their environment. They argue that a clearer understanding of these biologically endowed capabilities will focus and enhance our understanding of the different kinds of cultural responses to social and environmental stimuli (see also Sperber 1985; Fox 1989; Dissanayake 1988, 1992).

One of the behaviors which anthropologists have explored in depth is the many ways humans communicate with each other. We have extensive understanding about the formalized syntactical and semantic structures of linguistic systems in which humans transfer and store knowledge. The origins, structure, and varieties of these verbal systems and their written alphabetic counterparts enable us to talk about things and events as they occurred in the past or how they might occur in the future as well as to think about them as intangible concepts in ways that other primates cannot. We have also studied, but have not as yet codified as succinctly as we have verbalized language, how we communicate in nonverbal ways, such as in kinesthetically enacted performance such as dance, or in various forms of material culture such as art, religious icons, objects made for daily living, etc.

However, most anthropological studies have not focused on *how* people receive the knowledge which is communicated. Anthropologists have glossed over the mechanisms through which knowledge comes to our awareness. That is, we have studied what the knowledge is, but not how it is received and processed through the different senses. Although we know that humans experience their world through many ports: visual, tactile, auditory, olfactory, and gustatory, very few anthropological studies have explicitly explored the biological underpinnings of these ways of learning about the world and how they enable stimulus detection and interpretation.

Indeed, anthropology in general, has taken for granted the process through which humans acquire most of the information about their world-- the visual intake of perceived stimuli which allows humans to act and react to the world around them. Perhaps we have considered that understanding how and what we perceive is the task of perceptual psychologists, neurologists, and others better equipped to study the mechanics of this process. But unless anthropological studies begin to appreciate how the visual process focuses and delimits what we see, our explanations of the cultural behaviors which are responses to visually perceived stimuli will be impoverished. We will not be able to explain why certain features of objects are selected and acted upon; we will only be able to continue to describe the fact that they are.

In this article I exemplify the validity of this perspective with a detailed study of how some evolved parameters of human vision form the basis of the kinds of art forms that human cultures produce. I discuss how the human perceptual system lies at a critical interface between the physical environment and human notice of it. Of all the human sensory systems, the visual intake of environmental information coupled with the processing of this information in the brain gives human beings extraordinary abilities to explore and respond to environmental events. With knowledge about the *kinds* of information processed by the visual system we can more clearly understand how the visual baseline literally circumscribes and directs what we see and therefore profoundly affects the kinds of "cultural" responses which can be made.

I review how our visual system detects and responds to visually perceived information about object form, focusing on one property of form, symmetry. I review the experimental evidence which reveals how symmetry is a perceptually salient property of form. I advance the notion that the property of symmetry is as fundamentally salient to cultural organization as it has been found to be in the physics, chemistry, and biology of systems in our physical and natural world (Weyl 1952; Wigner 1967; Gardner 1990; Stewart and Golubitsky 1992; Barrow 1995; Stewart 1995; Voloshinov 1996).

Although the symmetries which so pervasively underlie the organization of our universe from the extra galactic to the subatomic may not be understood by the non-scientist, human cultures have produced art that sometimes directly copies nature, as, for example, in Peruvian textile patterns which mimic patterning on marine shells (see Hayes 1995 Fig.5). In addition, I will suggest that many of the basic relationships among human beings and between humans and nature are metaphorically expressed in symmetrical arrangements in nonrepresentational design as well as in representations of cultural things. (cf. house forms in Guss 1989; village layouts in Arnold 1983; geometric pattern in Washburn 1983a).

Specifically, I argue that there exists a "phonetic" complement of form universals for the two and three-dimensional world of objects. Just as we have found that verbal utterances are structured by the systematic combination of phonemes—universal sound patterns that, when uniquely combined, result in the variety of the world's languages--so too are there universal formal features in object form and the representation of that form which structure thought and knowledge and enable its systematic and efficient storage and transfer. The primary point of this article is to detail how symmetry is one of the universal properties of object form which is focused on during visual processing of form and to suggest that, in this "position", symmetry plays an important role in communication in non representational "decorative" pattern.

To date anthropologists have not explicitly connected the underlying components of form (line, edge, angle, brightness contrast, etc.) and properties of form (symmetry, color, orientation, texture, etc.) with their perceptual importance as the building blocks of culturally developed concepts and forms which express those concepts. Perhaps the judgmental, culturally bound concept of aesthetics, that is, a particular culture's "taste" for what is beautiful, has blinded us to the possibility that there are formal universals in representational communication just as there are in verbal communication. Another reason is that students of human behavior generally eschew universal principles and frameworks, arguing that they mask the variety of human expression. Brown (1991) has surveyed the history of anthropology's aversion to this issue and makes a forceful case for the study of the universal similarities underlying human culture. He argues that these studies should be centered in the context of evolutionary psychology as proposed by Tooby and Cosmides (1992:64).

I propose that we build our analytical categories for the analysis of art on the universal features which the human visual system selects as most salient for form perception. This attempt to ground artistic creation in the insights of perceptual studies has been advocated by a number of psychologists (Berlyne 1971, Arnheim (1974, Parker and Deregowski 1990; Solso 1994). This paper is an attempt to build on these insights from an anthropological perspective in order to better understand how human cultures differently utilize these capabilities.

In this paper I will argue that an understanding of form universals is fundamental to a theory of how art communicates and thus why art assumes the styles it does. Although there are many form universals, I focus on one in this paper—symmetry.

<u>The Visual System:</u>

Perception can be defined as the way organisms visually receive, organize, and structure information from the environment (Overviews of the perception process can be found in Dember and Warm 1979; Dodwell and Caelli 1984; Pinker 1984; Granovskkaya et al., 1987; Shepp and Ballesteros 1989; Hendee and Wells 1993). Humans are confronted with a constant barrage of visually received input. But, human vision does not conduct an exhaustive search and processing of all the stimuli present in the visual field. Rather, only those "enduring properties of the environment" (Lockhead and Pomerantz 1991) specifically salient for human action are selected. The rest is disregarded as redundant and irrelevant noise.

Two kinds of models of stimuli receiving and processing have been proposed by experimental psychologists. "Bottom-up" models argue that the eye and brain operate with a series of "feature detectors"—groups of nerves which are activated upon stimulation by particular forms, colors, motions, etc.. The alternative, "top-down" models, argue that stimuli are perceived holistically. Individuals first gain an overall structured impression of the scene; subsequent visual inspection fills in the details.

While consensus on visual processing has not been reached and many factors remain to be investigated, most researchers today believe that vision involves both top-down and bottom-up processing of received stimuli. The brain detects a global impression of the scene as well as searches out the "form primitives"—lines, edges, angles—and combines them into whole forms which the brain then identifies by searching long term memory for similar exemplars. The perception process, then, involves the bottom-up grouping together of form primitives, such as line or edge, in order to *identify* a form (Triesman 1986a,b). At the same time, the brain focuses on more global attributes of form, such as symmetry, in order to *discriminate* one form from other forms and from the background (Rock 1985).

Why should anthropologists be concerned with a process that occurs so rapidly and constantly, or in the terminology of the experimental psychologists, "preattentively", that individuals are not conscious of it? The answer lies in the fact that the brain uses these *kinds* of features not only to build and identify form but to discriminate, compare and categorize form. Perforce, those features the brain uses to analyze and classify form should be equally salient in the way humans use and assign meaning to form. In this article I want to emphasize the importance of both form primitives and global features, with the emphasis on symmetry as a global property of form that gives form structure and thus makes it a particularly important property not only for preattentive human visual assessment of form, but also for cultural uses of that formal property.[2]

I begin by touching upon the most important form primitive—contour—because equivalence in contour is the basis of symmetrical form. We need to understand how contour defines form before we can understand how it is specifically used to produce forms that are regular, that is, that are symmetrical. I will overview the importance of contour in human looking at form; how we know that individuals do, in fact, look at this primitive; and how looking at such features might have been adaptive in the evolutionary past of human beings.

The most essential feature of form is line or the *contour* which distinguishes the figure from the background by defining the edge and thus the outline of the form. In fact, so fundamental is outline that all other kinds of information—color, texture, motion, depth---can be eliminated and yet form can still be detected (Pomerantz, Pristach and Carson 1989). The preeminence of this property was demonstrated by Ryan and Schwartz (1956) who presented subjects with four representations of an object: a black and white photograph, a detailed drawing, an outline drawing, and a cartoon. They found that the photograph, which supplied the greatest amount of detail about the object, took the longest to identify, whereas the cartoon and simple outline drawings were recognized most quickly. That is, cartoons are effective because they are images stripped of embellishing distracters. The eye can focus immediately on the essential characteristics, which Hochberg (1978) called "canonical features", that give the form its specific identity.

In some cases, object recognition is achieved with only a minimal outline, as in Picasso's drawings of faces and bodies. In other cases the outline characteristics essential for recognition may be more distinctive to a specific thing or person. For example, deft cartoonists bring readers to recognize Richard Nixon by focusing on and exaggerating his long nose. Indeed, as Davis argues, it is probable that representation did not occur until humans understood the representational capacity of line (1986). Some of the earliest permanent images from the Upper Paleolithic represent animals by their contour outline (Ratliff 1985). The ubiquity of petroglyphs and pictographs the world over attests to the "readability" of simple outline images.

In fact, so strong is this visual need for outline that the human eye "constructs" a line where none exists. In a classic experimental psychology experiment to show how differences in light intensity can create visual illusions, subjects shown series of juxtaposed bands of successively greater intensities of gray, known as Mach Bands, "see" lines at the points where the light intensities change between the bands of gray even though there are no lines.

From an evolutionary point of view, such superior edge detection would have had distinct survival value for early hominids. Just as laboratory experiments have revealed how subjects are able to isolate the profile of a Dalmatian dog amid a background of similarly irregular dots, the human predilection to search for outline must have aided the detection of prey and predators camouflaged in the dappled light of trees or hidden in the homogeneous, monochromatic grassy plains of the open savanna. Mithen's (1996) speculation about the cognitive capabilities of "Early Humans" in relation to the level of sophistication of their material culture, although not explicitly framed around specific perceptual features, appreciates that early humans would have needed some degree of visual acuity and sophistication in cognitive processing in order to identify and differentiate animal tracks and to select striking platforms and remove flakes from cores to make tools.

But, how do we know that individuals focus on and use form primitives and global features to assess form? Eye movement studies have significantly advanced our knowledge about human "looking" activity. In the first place, clear, distinct human "looking" is very limited in areal scope. Our *foveal* vision sees objects in highest focus only within 1-2 degrees from the center focal point. Beyond this point up to 30 degrees from the center our *parafoveal* vision detects objects, although they are not in focus. From 30 to 90 degrees on either side of our center of vision our *peripheral* vision detects only movement.[3]

Because humans have such narrowly focused foveal vision, they must constantly move their eyes over objects or scenes in order to see all parts of the object in focus. Such eye movements follow a pattern that involves periods of stationary fixation when information is taken in separated by relocation jumps when the eye moves to the next point of fixation. By tracing the scan paths of an individual's eye movements experimental psychologists have been able to clarify how people look at images and objects (Buswell 1935; Loftus 1972; Antes and Penland 1981; Gale 1993; Nodine, Locher, Krupinski 1993; Locher 1996).

It appears that the eye initially scans images globally in short, brief gazes and subsequently focuses in longer gazes on important details (Locher and Nodine 1987). But even with unlimited time for scanning, individuals do not continually search new areas of an image, but return to focus on the most critical and salient parts of the image. These are areas of complexity (Chipman 1977) which have, what experimental psychologists call "high information content", such as where lines change direction at corners, as along an outline of a form, rather than areas of homogeneity, such as along stretches of a straight line (Attneave 1954; Mackworth and Morandi 1967; Baker and Loeb 1973). For example, individuals scanning a face in profile look along the edge of the profile because that edge contains the curvature information that identifies it as a face. In contrast, faces frontally presented are scanned by focusing on the eyes and mouth because these features are the essential cues to information about a person's emotional state (Yarbus 1967).

From an evolutionary point of view the fact that adults direct their looking activity to parts of an image that are most informative while children's gazes are not as disciplined, being diverted easily to aspects of a scene which may not be of primary importance (Mackworth and Bruner 1970), reinforces, from a perceptual perspective, the uniquely human lengthy period of infant and child dependency. In contrast, other animals have visual systems which closely direct their looking activity from birth, obviating lengthy periods of learning about the necessary points of reference in their world.

The above discussion of the importance of contour/outline to form definition, especially in artistic forms of representation, lays the groundwork for our appreciation of the cultural importance of form with a particular kind of contour—that which is symmetrical. I will address the issues of symmetry in object form and how is it visually salient with evidence from perceptual tests in the laboratory and with some examples of how its presence as a property and its use as a concept is played out in the cultural world.

Plane Pattern Symmetries

In this paper we shall be considering symmetrical patterns in the plane that can be described by the transformational rules of Euclidean geometry (see Stevens 1980; Washburn and Crowe 1988; Grunbaum and Shephard 1987 for basic descriptions of these symmetries).[4] All of these patterns are generated by four motions: translation, mirror reflection, glide reflection, and rotation which move identically shaped pattern parts along line and around point axes. Geometers generally describe designs with a single point axis around which elements rotate or through which mirror reflection axes pass as *finite* designs. Familiar examples from the natural world are the four leaf clover; patterns on automobile hubcaps are manmade finite designs. Designs with a single linear axis along which the parts are repeated by the seven different transformations, or combinations of the four motions, are called band designs. Geometers call these designs *one-dimensional infinite* designs because their parts can be repeated indefinitely along the linear axis. Familiar examples are border designs of Greek frets. Designs with linear axes running in two directions are called *two-dimensional infinite* designs because the parts are repeated in two directions along five kinds of lattice frameworks generating 17 different combinations of the four motions. Familiar examples are tiling and wallpapers. A number of different nomenclatures have been developed to describe each symmetry class; the standard crystallographic nomenclature as outlined in Washburn and Crowe (1988) will be used here.

<u>The perception of symmetry</u>

For the anthropological reader, accustomed to developing explanatory models of human behavior from extended participant observation within a specific cultural situation, the acultural laboratory testing of subjects' responses to visual stimuli as practiced by experimental psychologists appears at first inspection to ignore the role of culture in shaping behavior. Yet unless the biological parameters of perception are known, it is difficult to understand why certain things in the visual field are focal points and others are not. We first need to learn the kinds of things individuals see, and then we can explore how different cultures manipulate these features differently for different ends. To this end the following discussion presents an encapsulated overview of the experimental research on symmetry perception.

Recall that vision involves both a bottom-up processing of form primitives in order to identify form and the top-down processing of whole forms in order to discriminate one form from another. The focus in this paper is on symmetry as a property that contributes to holistic processing of form.

The theory that vision involves holistic processing of information was first advanced in the early decades of the 20th century. The Gestalt psychologists argued that the eye focuses on global properties of the configuration among parts of a form. Thus, figures whose elements are clearly distinguished by such principles as spatial separation, closure, good continuation, and symmetry are seen holistically (see Dember and Warm 1979; Palmer 1992 for overviews of the Gestalt approach). While this approach was not initially universally embraced for want of experimental confirmation, recent research using more sophisticated instrumentation has reconfirmed many aspects of holistic processing (Locher and Nodine 1989). Indeed, when Clement and Weiman (1970) attempted to experimentally force subjects to focus on separate elements rather than on the whole pattern configuration, they found that holistic processing always prevailed. Chen (1982) has found, from the perspective of topology, that the Gestalt property of connectivity is, in fact, involved in figural perception. The fact that human vision is holistic is especially significant for evolutionary considerations since Polidora (1966) has observed the reverse in other primates—that rhesus monkeys discriminate patterns by focusing on unique elements, rather than on the pattern as a holistic unit.

The most salient orientation of symmetrical form is along a vertical axis. Subjects shown arrays of lines arranged in various orientations (vertical, horizontal, and diagonal) respond most quickly to those oriented vertically (Rock 1973). In a famous experiment individuals shown two squares—one drawn so that two of its sides are oriented horizontal to the viewer's line of vision and the other oriented so that its sides lie diagonal to the viewer's line of vision---see the first as a square and the second as a diamond, despite the fact that both have precisely the same shape and structure. That is, so deeply imbedded is the viewer's concept of what orientation is properly "up", that things will be seen, known, and differentiated based on their vertical axial arrangement (Palmer 1985). Indeed, of the many different ways stimuli can be varied--by slope, texture, density, etc.--orientation seems to be perceptually the most critical (Olson and Attneave 1970).

Human preference for vertical orientation is probably gravitationally grounded in our upright bipedal stance which gives us a perpendicular orientation to the world. The human perceptual system has evolved to fixate on things in the environment within this particular *perceptual reference frame* (Marr 1982; Palmer 1989). Thus, it is not surprising that bilateral vertical symmetry is the most perceptually salient feature for recognition of form (Rock and Leaman 1963; Julesz 1971; Fox 1975). In fact Shepard and Metzler have demonstrated that subjects actually mentally rotate figures to the vertical before judging their shape identities (1971).

Many subsequent studies have refined our understanding about the relative perceptual saliency of the different *kinds* of symmetry, and how these differences are related to other factors. It has repeatedly been observed that while symmetry across a vertical axis is most readily perceived, the next most salient symmetry is that across an horizontal axis. Symmetry across diagonal axes that diverge greatly from the vertical or horizontal are the most difficult to perceive (Palmer and Hemenway 1978; Royer 1981; Wenderoth 1994). In the absence of mirror lines of symmetry, viewers focus on the centers of rotationally symmetric figures (Bingham and Muchisky 1993).

It appears, thus, that viewing is focused on the center of a form, which is typically along the coordinate axes of symmetry that give the form stability and balance. Eye tracking studies have confirmed that individuals focus on mirror axes (Locher and Nodine 1987) or on centers of rotation (Buswell 1935). In fact, Jenkins (1982) found that any information outside one degree on either side of the axis of symmetry is completely redundant.

In preference tasks, symmetrical forms are always judged more pleasing. That is, the regularity and simplicity of organization in symmetrical figures makes them excellent examples of "good" figures. Experimental results on human perception of symmetric form have repeatedly found that such forms are easier to recognize, remember and reproduce than asymmetric forms (Attneave 1955; Deregowski 1978). Indeed, the more axes of symmetry a figure has, the better the pattern is judged to be (Garner 1970, 1974).

When individuals are asked to create "visually pleasing" designs, most people create symmetric patterns (Szilagyi and Baird 1977). Davis and Johnke (1994) have shown that, given the opportunity to create divisions in form, individuals will consistently subdivide form based on the unity ratio, not on the Golden Section ratio. Locher, Stappers and Overbeeke (ms.) and Washburn and Humphrey (ms.) have found that adults untrained in art consistently create regular, balanced compositions. These experimental findings are at odds with the long held assumption that form characterized by rigid symmetrical equivalences is boring and uninteresting; that it is the slight asymmetry in composition of an image or object which creates tension and thus aesthetic pleasure. It may be that preference for asymmetric form is rooted only in a Western aesthetic grounded in the Golden Section and other proportions which the Greeks explicitly used to construct the Parthenon and human statues. Cross-cultural studies of symmetry preference need to be done in order to determine whether the "appeal of the Golden Section depends on certain deep-seated universal characteristics of the human nervous system and optical apparatus or whether it may be a cultural and therefore learned factor characteristic only of certain social settings" (Berlyne 1971:229).

Symmetry in form reduces complexity so that viewers can more efficiently take in information. Thus, not only are certain symmetries ranked with respect to their ease of recognition, as we saw above, but the *same* ranking is also related to judgments of complexity (Attneave 1957; Arnoult 1960; Day 1968). Chipman (1977) found that viewers judged patterns with vertical reflection to be the least complex, followed by those with horizontal reflection, then, successively, diagonal, rotational and translation patterns. Eisenman and Gellens (1968) found that individuals preferred complex figures only when they were symmetric.

The simplicity of symmetrical form, however, presents us with an interesting paradox. While symmetry in a form enables faster, more accurate recognition, its very presence means that the form carries less information because information is only being carried on one of the symmetric portions; the other parts, being equivalent, carry redundant information (Attneave 1954). But this redundant character of symmetric form has a very adaptive consequence as has been clearly demonstrated in the eye tracking studies of Locher and Nodine (1973) who found that individuals tracked the entire perimeter of nonsense asymmetric shapes but only needed to examine one half of vertically symmetric shapes in order to identify them.

The simplifying and redundant character of symmetric form would have afforded a number of advantages to early hominids. First, the fact that symmetric shapes are recognized and identified faster because only half of each shape has to be analyzed would surely have been an adaptive advantage in the early stages of human evolution as individuals searched the environment for predators and prey. Second, the repetitive and therefore predictable character of symmetric form would enable identification of figures in unfavorable viewing situations, such as figures in partly occluded views (Rappaport 1957). Third, symmetry assists the eye in detecting figures in "noisy" contexts, such as in equivocal figure/ground situations. For example, Wolfe and Friedman-Hill (1992) found that if both the form and the background are symmetric, the background will act as camouflage, masking the form. But if the background is symmetric and the form asymmetric, visual search is facilitated.

It should be recalled that redundancy plays a major role in various other forms of communication--written language, music, and dance--where it functions to emphasize the information communicated in a number of important ways. We can imagine, therefore, that it might play similar roles in art images. First, because symmetric patterns are composed of parts repeated, information embedded in these parts and in the way they are structured is emphasized by its very repetition. As well, by virtue of the way symmetry reduces complexity, it presents a pattern that our visual system preferentially focuses on because the information is presented in a format that is both economical, because it takes less time to scan, and efficient, because the structure omits the complexity and noise which confounds information transfer. Finally, while inherently redundant, symmetric pattern, *in context*, can be highly distinctive and thus highly "viewable." One might imagine this property to be useful in cultural contexts where different ethnic groups are closely juxtaposed, such as when groups periodically come to regional marketplaces. Distinctive symmetric patterns on clothing might serve to enable rapid distinction and identification of group affiliation.

Indeed, so attuned is the visual system to look for symmetry in form that the perceptual system, although slowed by grades and deviations from symmetry (Barlow and Reeves 1979; Locher and Smets 1991), will "see" a figure as symmetric even though it is not perfectly symmetrical (Freyd and Tversky 1984; Shepard 1994). This "seeing" of asymmetric forms as symmetric complements the general thrust of the human visual processing system which imposes order on the visually perceived world through simplification and recalls information in symmetric prototypical form. In fact, recent research on three-dimensional objects specifically suggests that symmetric characteristics of the object are critical factors which the eye and brain use to generate "mental" models of *other* views of the same object that aid in identifying an object seen from an unusual view (Vetter, Poggio and Bulthoff 1994).

Evolutionary Advantages to the Perception of Symmetry:

The observation that symmetry is a salient perceptual feature perforce implies that during the course of human evolution the need to focus on symmetry in form was apparently important enough to have been consistently selected for so that the visual system of modern humans developed to check for and prefer symmetrical form. In the previous section I have speculated on areas where symmetry perception would have been particularly adaptive for early hominid needs. But, is there evidence which might support these suggestions?

Evolutionary biologists have recently advanced the notion that symmetry in body form is adaptive and thus selected for because it functions as a visible indicator of genetic health. The hypothesis is that females seek out the most symmetrical males in order to insure that their offspring will mature into viable, healthy adults. For example, Moller (1992) has found that barn swallow females seek mates whose tails are symmetrical. Thornhill (1992) observed that female Japanese scorpionflies prefer males with symmetrical bodies.

The logical successors to such studies on lower animals are investigations exploring whether humans also use symmetry in body form in the process of mate selection? Do our behavioral responses to kinds of body information perceived today reveal how focus on symmetry in body form may have been adaptive in the past? Hypothesizing from the parasite theory of sexual selection, that is, that sexual selection favors traits that advertise resistance to parasites, Thornhill and Gangestad (1993) and Grammer and Thornhill (1994) proposed that humans should prefer averageness and symmetry in faces, since average features signal high heterozygosity in secondary sex characteristics which would contribute to higher resistance to parasitic disease. In order to test this hypothesis, they queried male and female college students whether real or digitally averaged faces were more attractive and found that males preferred averaged female faces, the first evidence that symmetry is an important factor in judgments related to human sexual selection.

Although from an evolutionary perspective, it seems logical that humans would have exploited the property of symmetry in bodily form in their process of sexual selection of mates, Kowner (1996) has offered the interesting suggestion that the fact that the human visual system "corrects" for imperfect symmetry indicates that visual checking for bodily symmetry was probably salient in early hominid evolution. He then argues that in later periods, when clothing precluded checks for bodily symmetry except in still visible areas such as the face, which Thornhill and others have shown to be the locus of many cues, the biological cue of bodily symmetry was replaced with sociocultural cues which took over the information bearing/communication functions.

Other recent research supports the importance of facial symmetry. Human newborns between three and four months of age are attracted to symmetrical faces (Humphrey et. al., 1986; Humphrey and Humphrey 1989; Muir, Humphrey and Humphrey 1994). At four months of age infants, like adults, process images with bilateral vertical symmetry more efficiently than other kinds of symmetries (Fisher, Ferdinandsen, Bornstein 1981; Bornstein, Ferdinandsen and Gross 1981; Bornstein and Krinsky 1985). The fact that this search pattern occurs so early in the developmental sequence reinforces the idea that it must have been a highly adaptive feature associated with the development of *sapiens* status as an upright, bipedal being. By 12 months old this perceptual mastery of vertical symmetry over horizontal or asymmetric forms is probably correlated with developing motor coordination that enables the child to begin walking upright (Julesz 1971; Corballis and Roldan 1975).

The fact that researchers have found a developmental progression in the ability to recognize and discriminate different kinds of symmetries, again underscores the lengthy period of dependence which human children undergo before they are fully equipped to visually encounter and judge the world. By the kindergarten years children are able to recognize patterns with vertical, horizontal, and diagonal symmetries more accurately than asymmetrical patterns. By second grade children are able to perform pattern matching tasks. They are able to match patterns with vertical symmetry better than patterns with other kinds of symmetries, having particular difficulty with diagonal symmetries until they are six or seven years old. (Chipman and Mendelson 1975; Mendelson and Lee 1981; Bornstein and Stiles-Davis 1984).

All of this evidence regarding the communicative salience of symmetry in body form in animals, including humans, requires us to ask what is it about *human* communication of this information that differs from that in other animals? Many animals have amazing displays of intraspecies communication via vocal calls, coloration, and bodily dance that are highly formalized. Merlin Donald (1991) argues that the difference lies not in the fact that the information is structured, but that only the human species is able to store the information *outside the body* in "external memory devices". It is this cognitive advance in the representation of information that is profoundly unique to the human species. It is not simply the transferring by vocalizing as well as the remembering, but, more importantly, it is the storing and representing information in a permanent external format so that it can be preserved, augmented, changed, and passed along through succeeding generations that separates *Homo sapiens* from other animals. The permanent recording of information in different formats thus supplied human groups with the mechanisms for greatly expanding the capabilities of human groups to communicate and store all kinds of knowledge. In this way, humans replaced dependence on bodily symmetry for communication of information about themselves with symmetry in many other kinds of culturally created objects.

Donald proposed that the first formalization and communication of social concepts probably occurred in what he calls "mimetic" body activities—a miming of information and ideas not immediately at hand. These were followed/accompanied by more formalized verbalized expressions and finally by the important advance to the permanent external recording of actions and ideas in what we call art and writing. We can only speculate that the earliest of formal recordings may have been transitory, similar in form and format to those which some peoples continue to make today. For example, stories may have been "sketched" with fingers in the sand as Munn observed among the Walbiri (1973) or with story knives in the snow and mud as done by Eskimo girls.

I hypothesize that the transition to externally based permanent modes of artistic information storage came in two stages in two forms. The first stage occurred when humans understood the representational capacity of line (Davis 1986) and used contour to create realistic *representations*, such as are found in the Upper Paleolithic cave paintings. These are deliberate depictions of things, not marks or notations, that may have been the Upper Paleolithic counterpart of the pictographic precursors of alphabetic writing in the civilizations of the Near East. I argue that this pictorial stage was followed by the more cognitively sophisticated "re-presentation" of ideas in *nonrepresentational* metaphoric formats. It is this metaphorical rendering which marks a profound advance in human cognition and sets the stage for the development of myth, religion, and all other expressions of conceptual relationships.[6]

Richard Latto, a psychologist from the University of Liverpool (Latto 1995) has argued that works of great artists succeed in communicating ideas because they exploit the properties of stimuli that resonate with the processing of visually received information. That is, great art "works" because if "reflects the properties of the world which the human visual system has specifically evolved to capture and use." I am suggesting that while representational art transmits knowledge via the mechanisms of brightness contrast, linear perspective and other manipulations of line and color, nonrepresentational art imbeds information in the symmetries which structure the pattern. In this structure lies a culture's deepest notice of the relationships of man's place and role in his universe.

<u>Notes:</u>

1. See Dennett 1995 for a discussion of natural selection as it relates to human evolution.
2. There is a large literature on the perception of the other form properties. Each has been uniquely developed in the course of human evolution. So important are each of these properties that recent research has discovered that information about form, color, movement, texture, etc., is perceived and processed separately (Livingstone and Hubel 1988).
3. There is evidence of distinct specialization in the primate brain for different properties of form (Livingstone 1988; Livingstone and Hubel 1988). Visual input enters the brain via two kinds of ganglion cells called the parvocellular and magnocellular. The magno system appear to be the more primitive, sensitive primarily to moving objects. It has been suggested that this ability to detect movement but not specific form may be a remnant from our evolutionary past when survival depended especially on sensitivity to movement in order to detect prey and predators (Solso 1994:23). However, peripheral vision continues to be important for hunters or players of team sports, for example, where perception of movement from all angles contributes to the success of the activity. The more highly developed parvo system is sensitive to object shape, color, and surface properties, and is thus the system sensitive to symmetry and other properties of form.
4. Researchers are currently devising descriptive and quantitative measures for patterns, called "skewed" or "graded", which are not perfectly symmetric (Wagemans, VanGool and

d'Ydewalle 1991, 1992). In fact, Enquist and Arak (1995) have speculated that it might be the human brain's ability to detect *departures* from symmetry that provides the important information for survival.

5. Some researchers have made non-mathematically based distinctions between symmetric and asymmetric stimuli. For example Corballis and Roldan (1974) and Bruce and Morgan (1975) have contrasted forms with vertical axes with forms said to be asymmetric, although the latter stimuli have symmetry when repeated in translation as they were shown to the respondents. By the mathematical definition used here, they were contrasting two kinds of symmetric stimuli, rather than asymmetric versus symmetric stimuli.
6. Parenthetically, it is appropriate to note that human cognitive creativity has continued this process of abstracting the representation of information. Today we are experimenting with information storage in the form of bits and pixels.

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