BRIDGES
Mathematical Connections
in Art, Music, and Science

Visualization: From Biology to Culture

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Abstract

The capacity to comprehend the world through visualization is a product of our evolution in environments where it was the critical difference for the survival of our otherwise vulnerable species, and with exponentially increasing effect as it was invested in the symbolism of language where it could be shared in speech and eventually in writing. Viewed in unbroken continuity with these origins in prehistory, it was to become the sine qua non of science and the visual arts (music also has a visual dimension in its architectonics). The author specifically discusses the affinities between an art based on geometric visualization and model making in the physical sciences, noting that both share a motive force of aesthetic economy, and a reliance on the same suite of natural abilities in a nervous system adapted to function perceptually in three dimensions, acting upon them in particular through prehensile manipulations and technology. To exemplify these suggested "bridges" four recent sculptures are described in relation to their genesis in a visualization process similar to scientific thought in its analytic approach.

Geometric Visualization and Science

In this paper I hope to make four recent works intelligible in terms of the geometric visualizations which underlie them, and in doing so to demonstrate how unifying paradigms emerge in my work to the extent I am able to inventively articulate these visualizations into multi-layered grammars. Visualizing geometry does not require formal mathematical training (I'm a non-mathematician in that sense). It exists as a natural potential of our nervous system's evolution in three dimensions, though choosing it as an aesthetic focus will no doubt have been profoundly influenced by culture (archeologically dating from the appearance of spiral motifs in Paleolithic cave art), often through an osmosis which has been largely unconscious like so much learning.

Another reason an exegesis of the geometric thought in my sculptures may be interesting stems from the extent to which it otherwise tends to be elusive, apart from an immediate impression of their visual coherence, which is why they may sometimes seem familiar and strange at once. Actually if geometrically designed sculpture is successfully complex in its integration of harmonic elements, dissecting them reductively doesn't diminish its aesthetic resonance. The whole objective is a mystique of subtle analytic rigor whose significance as a revelation is simply the logic of the natural world which evolution has made permeable to our animal intelligence.

Imaginatively projecting the possibilities of molecular schematics is an analogous visualization process in science, which, though respecting different rules, has common ground with an approach of visual geometry in sculpture, each creatively searching for what will tenably work in three dimentions. The one reveals patterns present or potential in natural phenomena. The other creates patterns for aesthetic effect which is in turn a phenomenon of perceptual affect experienced by the neo-cortex (perhaps in that of chimpanzees quietly rapt before a sunset as well). Scientists often allude to the aesthetic dimensions of theory successfully distilled to elegant economy, while a paring to the essentials integral to design coherence characterizes geometric sculpture subject to minimalist constraints.

We might view scientists and mathematicians as having their own aesthetic aspirations, or at least as finding aesthetics a useful guide sometimes, which obviously implies a "bridge" of aesthetic concerns between the arts and sciences. And while it isn't infallible, we might surmise that aesthetic appreciation (beginning in a preference for symmetry as a fitness marker in mate selection?) is telling the neo-cortex what has the appearance of being or is at least provisionally right, hinting at the definitive reality beneath the provisionality of conscious experience, and coaxing the mind to a more lucid gestalt of self-recognition as a process of comprehension...such reflections can only have the poetic cast of an artists' perspective, and I voice them with some ambivalence preferring the refuge in concreteness sculpture has always held for me to the problematic uncertainties language holds.

First Sculpture

This sculpture (Figure 1; also see front cover), a ribbon deployed in an asymmetrically enriched trefoil pattern, is the fourth and only knot in a series of ribbons with negative Gaussian curvature along their entire length to the degree their other design features permit. The zero mean culture which I try to approximate as an aesthetic optimum, results in the simplest case when upward curves are negated by downward curves in the double arch formation of the familiar equestrian saddle. This is achieved in these ribbons because in cross section they are a crescent whose concave profile faces away from either the underlying curvature of the spherical surfaces they pass over or from the sharp U-turns in their paths over these surfaces. A twist becomes necessary to accommodate the back-and-forth transition in orientation from the sphere's curvature to the U-turns on its surface. In this particular sculpture the underlying geometry of the ribbon's global circuit consists of three smaller spheres ensconced within a larger sphere at 120-degree angles in relation to its center. The ribbon traverses the interior of the sculpture over the three smaller spheres to accomplish the three crossings of a trefoil, and transits the surface of the larger enclosing sphere when defining the three-lobed exterior of a trefoil. The sculpture's title, "Music of the Spheres," has an obvious descriptive aptness.

The trefoil pattern of the sculpture is asymmetrically enriched by a maneuver deforming the edge patterns of its ribbons front-to-back into a systematic deviation from the perfect symmetry of a classically configured trefoil. This deformation does this with a cogent economy in which the edge patterns of each face continue to have a graceful threefold rotational symmetry. Essentially the curvatures on one face sharpen (see front cover), while those on the other becomes gentler (see Figure 1), a relationship which possibly conserves the total curvature the trefoil would have restored to a classical configuration of perfect front-to-back symmetry. The deformation also displaces the pinch point where the crossing ribbons come closest together from the center of the trefoil to a locus nearer the face whose curvatures are sharper. This intuitive maneuver has a parallel in the topology of systematic grid deformations D'Arcy Thompson found evolutionary changes in morphology following in related species.

Second Sculpture

This untitled sculpture (Figure 2) is a toroidal band one by five inches in rectangular cross section. Its circuit encompasses six adjoining vertices of a cube, a geometry that resolves into a non-planar hexagon whose successive segments zigzag at right angles to each other. (For a more interpretable view of the same underlying geometry see the sculpture in Figure 4 where it is less disguised than in the sculpture under discussion.) At each of the six vertices the band twists 180 degrees like a Mobius strip. Matters, however, do not rest here with an even number of 180 degree twist increments and an apparently orientable surface, but become more subtle because integral to the object's global geometry the ribbon or band must always move across two contiguous sides of the cube in going from vertex to vertex around the

hexagon. This confers an additional twist increment of 90 degrees to the segments between the vertices, and obviously occurs six times for a cumulative 540 additional degrees of twist, or three further 180 degree twist increments, making the total an odd number of nine and the ribbon consequently non-orientable. When the actual sculpture is viewed, the working in concert of these discrete maneuvers forms a seamless holism which dissolves them and becomes the focus of perception.

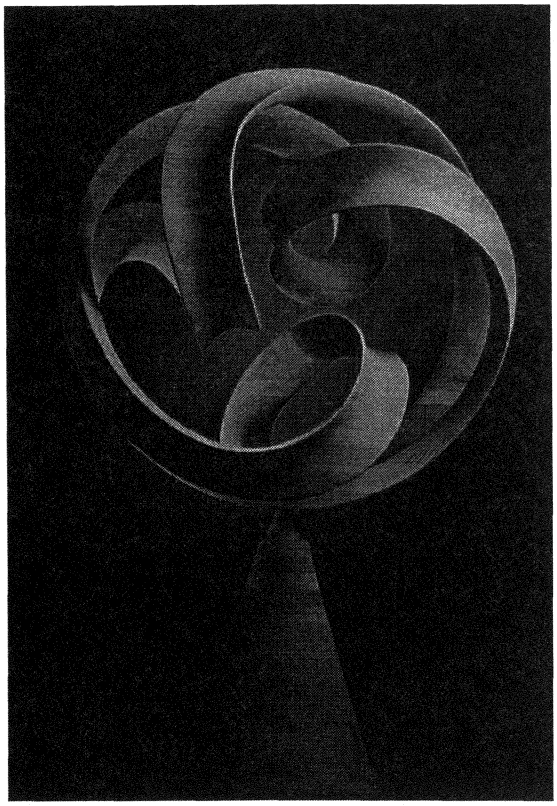

Figure 1: *"Music of the Spheres," laminated wood, 28 x 28 x 20 inches, 1999*

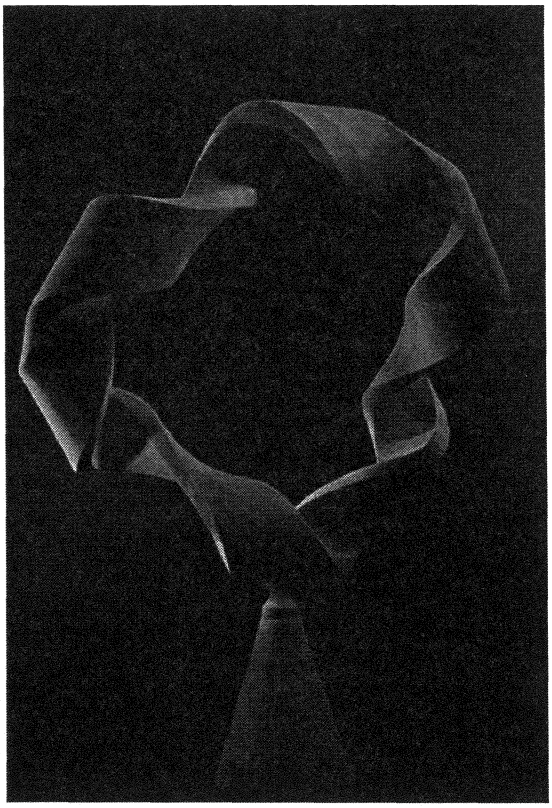

Figure 2: *Untitled, laminated wood, 33 x 33 x 21 inches, 1999*

The ribbon must furthermore twist in three different ways to achieve these maneuvers with a consistently unidirectional cheirality:

A) At each vertice of the hexagon, the ribbon twists 180 degrees over the exterior of the original toroidal column I laminated to carve the sculpture from.

B) In three of the connecting segments between the vertices, the ribbon twists 90 degrees through the interior of the column around its central longitudinal axis.

C) In the other three it also twists through the interior of the column, but with one enge hinged to an axis on the surface of the column.

These three twist patterns succeed each other in tandem as follows: AB AC AB AC AB AC, and in doing so create a convincingly dynamic evocation of natural turbulence, their most precise resonance being perhaps with the stabilized periodic motion of controlled chaos: correlations not entirely foreseen but completely welcome in their aesthetic freshness.

Rotating this object around its vertical axis from one hexagonal face to the other, and then inverting it, will fit it back within itself. Actually I think this is true of all such 180 degree rotations along the radial axes connecting vertices across from each other.

While the object's features are easy to summarize, they nonetheless are in a configuration of significant originality in which symmetry and seeming asymmetry dance in counterpoint. In particular the twist which emerges integrally from the object's global geometry, rather than in the more usual way as localized feature over a given length of ribbon, has a pleasingly unfamiliar subtlety. I wanted to somehow suggest the ultimately enigmatic coherence of the natural world the mind is a part of...an estimable aspiration likely leading to only modest achievement, yet even a hint of non-linear motion can quicken our appreciation of life's unpredictable dynamics: the enormous complexity out of which comprehension, compassion and apparent choice are born.

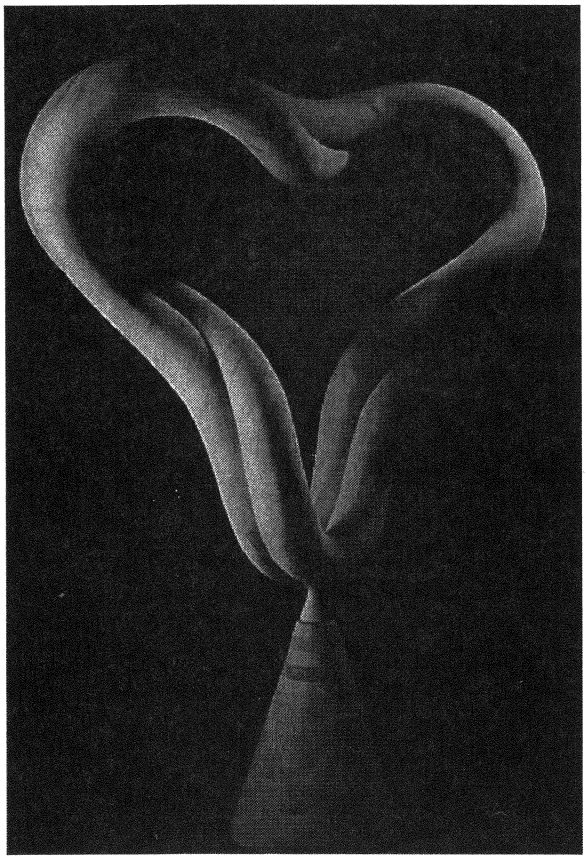

Figure 3: *Untitled, laminated wood 34 x 34 x 17 inches, 1999*

Third Sculpture

To create this sculpture (Figure 3) I initially laminated a triangular toroid. Subtracting from the trunk of this wood lamination, I consecutively produced a series of geometries, each within the enclosure of the preceding. First, a sculptural column, in cross-section a circle six inches in diameter, which spirals clockwise around the longitudinal axis of the original lamination: this linear and planar axis is simply an equilateral triangle with rounded vertices. Continuing to work through removal, I next created a twisting band, in cross section a three by six inch rectangle with rounded corners, within the previous spiraling column: the axis of this band's clockwise twist is the spiraling line which passes through the center of the column. The band twists 180 degrees over each side of the triangular toroid to form a triply twisted Mobius surface at this stage. The final subtractive step was to resolve this band into a single, double-orbiting column intersecting itself, a geometry which can be visualized in cross section as two circles three inches in diameter overlapping so their respective centers are two and three-quarter inches from each other. The continuous cleft of self-intersection which results creates a surprisingly strong resonance

of organic muscularity for such economy of means. This is further enhanced by the curvaceous richness the fused columns have in embodying cumulative spiral and twist patterns.

An interesting topological transition has occurred as well. The single continuous edge of the non-orientable Mobius strip becomes the single continuous cleft of self-intersection between the column's two circuits. Altogether this piece exemplifies how multi-layered grammars can be progressively articulated by unschooled geometric visualization alone.

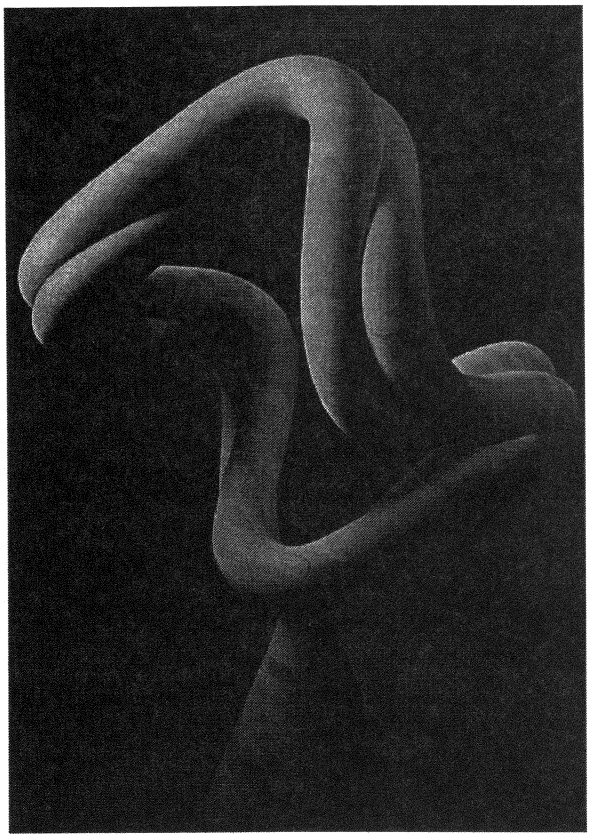

Figure 4: *Untitled, laminated wood, 29 x 29 x 20 inches, 2000*

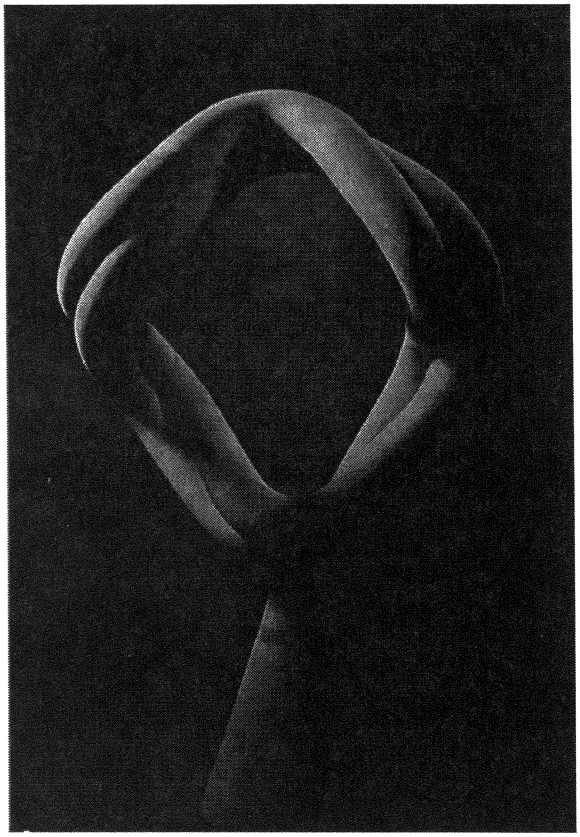

Figure 5: *Untitled, laminated wood, 29 x 29 x 20 inches, 2000*

Fourth Sculpture

This sculpture (Figures 4 and 5) merges design features from the paradigms of the second and third. Like the second it is a toroid following the hexagonal zigzag pattern formed by the segments connecting six adjoining vertices on a cube. And at one stage in its production it was also a band twisting 90 degrees along each segment of the hexagon, as it must by moving across contiguous faces of the cube to keep the same orientation when entering successive vertices. Unlike the second sculpture, however, it does not twist an additional 180 degrees at each vertex Instead it is like the third sculpture in twisting only the 540 degrees (six times 90 degrees) of a triply twisted Mobius strip. It is also like the third in that its band, which intermediately was a three by six inch rectangle with rounded corners in cross section, is further resolved into a single, double-wound self-intersecting column. This again gives a purely geometric conception a surprisingly sensuous resonance of muscular anatomy, while creating the triplet of over-under crossings which define a trefoil knot.

Two views of it are shown to highlight how dramatically its aspect changes from different perspectives. It is highly symmetric, yet as dynamic as serene, and its instantly perceivable coherence nonetheless somehow seems to have a counterintuitive center of gravity, particularly on first encounter...the hope being that taking aesthetic perception to a place of unfamiliar coherence can potentially be an experience of renewal, perhaps the attraction of sanity felt when some new depth is glimpsed.