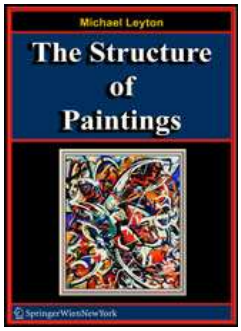
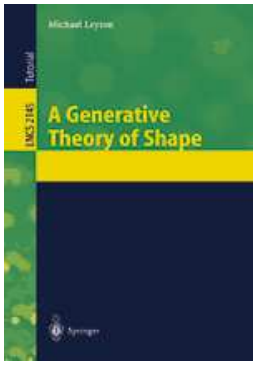
The structure of paintings *Michael Leyton*, Springer Verlag, Wien-New York, 2006 (207 p.), Soft cover, ISBN 3-211-35739-4, 40.00 €.



Michael Leyton is professor at the faculty of psychology and at the DIMACS center for Discrete Mathematics and Theoretical Computer Science. His work is as diverse as his affiliation. He publishes in psychology journals, but also in journals about complexity, geometry, computer science, and he is an artist. One may find images of his sculptures, and paintings, on the web and he published musical compositions.

Most of his ideas are the result of an unconventional view of shape and geometry. This idea he has applied or has been applied by others to all kinds of arts, science and technology. His original paper dates back to 1987 [4] in which he explains his Duality-symmetry theorem, and the whole theory is more elaborated in his subsequent book *Causality, symmetry, mind* [1]. More recently he wrote several books where he is extending and applying his theory to several application fields. In his *A generative theory of shape* [2], he exposes the "full mathematical foundations" and he applies the theory mainly to CAD/CAM, in *Shape as Memory* [3] it is applied to architecture and in the present book to the analysis of paintings.



So, what is this geometrical theory that is so universally applicable? This book, as well as several of his other papers or books give an introduction to his views. No mathematics are needed to understand what he means.

First of all he wants to throw away geometry as it existed for the last 3000 years up to and including Einsteins additions. What this traditional geometry is studying are properties that stay invariant under congruence (Klein) or under change of reference frame (Einstein). Leyton's new foundations of geometry are based on a dynamic concept that to each shape one may associate a history. This history can be recovered backward in "time" by removing step by step all asymmetry of the shape which will ultimately result in total symmetry represented by a circle (which refers to the egg, origin of everything). In this respect there is some relation to the work of Golubitsky and Stewart [5-6]. Hence it is the asymmetry, not the symmetry that is important because it is the memory that contains the history of the shape, and that is, according to Leyton, exactly what aesthetics are. Thus $\boxed{geometry = memory = aesthetics}$, and the memory is in the asymmetries. Artworks are maximal memory stores.

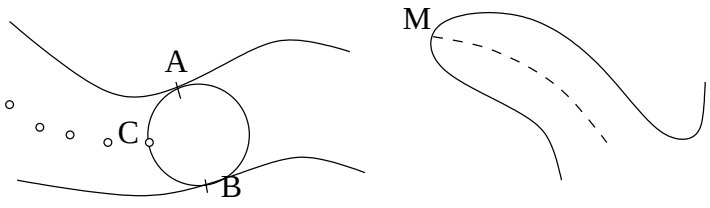


Fig. 1: *Symmetry-curvature duality theorem: Any section of smooth curve with exactly one curvature extreme has exactly one symmetry axis which terminates at the extreme.*

Thus a first step is to define asymmetries. If the curvature is not equal everywhere (like on a circle) then there are extremes in curvature and to each extreme, one may associate a symmetry axis as the collection of points C that are halfway the circular arc between the two tangent points A and B of a circle that touches the curve on either side of the extreme. See figure 1. The process resulting in this asymmetry has evolved along this symmetry axis from a more symmetric situation of the curvature to the present extreme. An ellipse is a deformed circle which is obtained by an internal force pushing it outward along its longest axis or an external force pushing it inward along its short axis.

Thus it is also important to know what in inside (foreground, solid, positive) and what is outside (background, thin, negative). This gives emotional expression to a curve. As one may see on Figure 2, the processes at extrema M^+ and m^- are penetrating the recipient space, sharpening the extreme, tightening the surrounding space, and facilitate arching. At the other two extrema, the processes are

compressing the recipient space, flattening the extreme, broadening the surrounding space and oppose arching. The $m^{\pm}$ are both inward while the $M^{\pm}$ are outward.

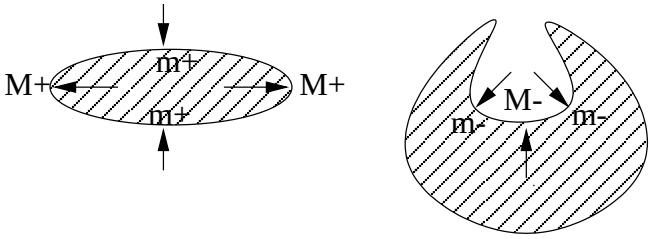


Fig. 2: *Four process types: M^+ protrusion, m^- indentation, m^+ squashing, M^- resistance*

A duality operator switches inside and outside and has the effect that $M^+ \leftrightarrow m^-$ and $m^+ \leftrightarrow M^-$ are both dual pairs.

What happens if the dynamics continue at the extrema? For M^+ and m^- nothing really happens. They continue to be as they are. For m^+ and M^- things will eventually change: a squashing continues till it indents ($m^+ \to m^-$) and a resistance continues till it protrudes ($M^- \to M^+$).

More interesting are bifurcations. If there is too much resistance against the continuation, bifurcation may be the result. As is shown in Fig. 3 for the bifurcation at M^+. On the right of Fig. 2, one may see this situation $m^-M^-m^-$ as a bifurcation of what was originally an indentation m^-. Similarly, a bifurcation can occur at the other two types of extrema.

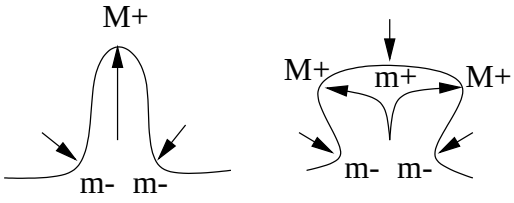


Fig. 3: *Bifurcation at an M^+: Note that $M^+ \to M^+m^+M^+$.*

The properties seen so far allow Leyton to do a lot of analysis on a number of paintings. Curves can be given emotional value and some curves are repeated at different stages of the dynamical process in the same painting which reveals the emotional values and character of the persons represented by the painting.

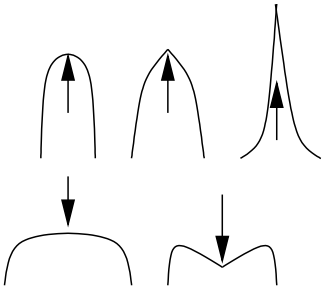


Fig. 4: *Two histories leading to a cusp.*

In a last chapter, Layton introduces smoothness-breaking. That is when the smoothness symmetry is broken by a corner or a cusp in the curve. An extreme at a protrusion can evolve into a point "with infinite curvature" which is a corner, and when pushing the process further, it may become a cusp. Another possible history may be an indentation that evolves into such a cusp. See Fig. 4.

Again, these new insights are applied to a full analysis of a number of paintings by Picasso, Raphael, Cézanne, Holbein, Modigliani, Balthus, Ingres, Memling, Gauguin, and an abstract by de Kooning.

The present book is intended to be the first volume of a series because curvature, which is the central theme here, is only one way of memory storage. Subsequent volumes in the series intend to analyse other sources of asymmetry in paintings.

References

[1] M. Leyton, Symmetry, Causality, Mind, MIT Press, 1992.

[2] M. Leyton, A generative theory of shape, Lecture Notes in Computer Science, Springer, Berlin, 2001.

[3] M. Leyton, Shape as Memory: A Geometric Theory of Architecture. Birkhäuser, Basel, 2006.

[4] M. Leyton, Symmetry-Curvature Duality. *Computer vision, graphics, and image processing*, **38**, 327-341, 1987.

[5] M. Golubitsky, I. Stewart, The symmetry perspective. Progress in Mathematics, vol. 200, Birkhäuser, Basel, 2002.

[6] M. Golubitsky, I. Stewart, Fearful symmetry, is God a geometer?. Penguin, 1993.

Adhemar Bultheel