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Intellectual revolutions in philosophy and art: continua and catastrophes

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As a discipline, Philosophy lies in a field that is beyond science and it is, in this respect, comparable to art. Therefore, the topic of continua and catastrophes is dealt in relation to both of them. We define the term "catastrophe" primary in relation to the catastrophe theory, but, for informal contexts, standard cases of (natural) catastrophes are good examples for the content of this notion. First, we will sketch major trends in the History of Philosophy and especially major linguistic strategies used to treat problems of philosophy (Greek and Renaissance philosophy as well as the modern Analytic philosophy are discussed in some detail). Catastrophe theory can catch aspects of the dynamics in the field of philosophy. In a second part are analyzed, instead, major revolutions, i.e. dramatic changes in the history of art. We will especially deal with Leonardo da Vinci, William Turner, Henry Moore and Salvador Dali. In the case of Dali, we establish a link to René Thom, the founder of catastrophe theory. Dali met Thom in his home and several paintings of Dali treat the topic of catastrophe in the sense of Thom.

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Introduction: Philosophy and Art

Philosophy and art seem to be really different disciplines. Philosophy is traditionally understood as a highly argumentative, very systematic discipline. But Plato's dialogues, Bruno's Italian writings and even the writings of authors like Heidegger or Wittgenstein have a literary, often an artful design. Nevertheless, art is rather a topic of philosophy (under the label of *aesthetics*) than a proper form of philosophy. In the 20th century the Vienna school and later Analytic philosophy, highlighted the scientific character of philosophy. Other authors thought that philosophy should be replaced by general theories, meta-theories, e.g. a theory of science or even become a province of more specific sciences: psychology, cognitive science or other candidates for the throne of general '"wisdom".

Historically, art was first linked to craftsmanship as in pottery, and it became a central part of religious and mythical artifacts such as temples, churches, sculptural or painted decorations. If Plato was skeptical towards art, it

was because it did not always serve truth and the goal of ethical goodness; art-workers eventually became part of a philosophical discourse in the Renaissance period. Thus, Leonardo or Michelangelo are philosophers to an higher degree than many contemporary, religiously confined professors of philosophy. Literature and philosophy, theater and philosophy mixed in the publications of Giordano Bruno (e.g. in his dialogue *Ash-Wednesday Supper* and his comedy *Il Candelaio*)[1].

After Heidegger, who combined traditional (mostly historically minded) arguments with poetic metaphors and idiosyncratic etymologies, many French philosophers from Sartre to Derrida travelled on the frontier-line between literature (style and imagination) and classical philosophy in the Cartesian or Kantian style.

As a general maxim, one cannot treat art and philosophy as strictly separated domains, especially not after the transfer of many topics, which have been classically treated in philosophy to separate disciplines. The standards established in these disciplines did not really penetrate philosophy, which remains not unlike the art-domain a territory of challenges, schools of thought sharing similar premises and tastes, charismatic individuals, politically motivated sub-cultures etc.

The meaning of catastrophes

The analysis of innovation in philosophy and art concerns primarily moments of change: the catastrophe scenarios. We assume that, in these scenarios, the major forces which underlie these intellectual enterprises become visible. Catastrophes, in the non-mathematical sense, are either the outcome of natural forces or the effects of human (bad) decisions or mistakes, dramatically reinforced by natural processes. In a book called *The big catastrophes*[2], nineteen "catastrophes" are described starting from the earthquake in Lisbon (1755) until the inundation by the Mississippi (1927). Eight of them are natural catastrophes; the others combine human mistakes with very strong forces in nature: insufficient constructions which cannot resist the forces of a storm, small mistakes or acts of imprudence which start a huge fire, shipwrecks under difficult weather conditions, collisions of a ship and an iceberg etc. The general feature of them is that there is an underlying continuum of potential dangers which are not clearly visible. In the case of the earthquake and tsunami in Lisbon (1755), the coming catastrophe was only announced by the behavior of animals and some very susceptible humans, but nobody cared about these signs of an imminent danger. The catastrophe tells us that there are small, non-perceptible causes which hide in the world we live in; under certain conditions they suddenly come to the forward and trigger tremendous effects. In chaos

[1] Cf. W. Wildgen, *Das kosmische Gedächtnis. Kosmologie, Semiotik und Gedächtnistheorie im Werke Giordano Brunos* (1548-1600). Frankfurt/Main, 1998 ; Id. *Giordano Bruno. Neun Studien und Dialoge zu einem extremen Denker*, Berlin, 2011: 28-43.
[2] E. Szatmari, *Die großen Katastrophen: nach Berichten von Augenzeugen erzählt*. München 1928.

theory, the picture of the movement of a tiny butterfly whose wing-beat triggers a tornado may describe such a scenario. The epistemological problem lies in the fact that most humans tend to assume a small, well known list of forces and their effects, which can be calculated and thus controlled. The control has the simple logical format: if condition A is given, then effect B occurs; therefore if one wants to avoid the effect B, one must guarantee that condition non-A is preserved. Causal effects follow a kind of syllogistic schema. In reality, forces have continuous values, their impact is governed by probabilistic laws (not only on the quantum-physical level), many forces of different nature may interact, cooperative effects, cyclic enforcements must be taken into account, etc.

A central feature in the context of catastrophes is represented by stability and loss of stability. The logical "metaphor" of cause and effect presupposes a strong stability of all entities, i.e. small forces, which are mostly unknown and uncontrolled, must vanish automatically by convergence. The analysis may therefore neglect their impact. In the case of catastrophes (and a fortiori in the case of chaos), the state of the system diverges strongly, i.e. small forces are not nullified but cumulate; they can even trigger dramatic changes. In situations of instability or near critical points (singularities) even very small and imperceptible forces can trigger the breakdown of a stable state and bring about the transition towards a new state. Basic aspects of such a situation are modeled in catastrophe theory; other aspects are dealt with in the thermodynamic model of systems far from equilibrium by Prigogine. For deterministic systems, generalized catastrophes, now called strange or chaos attractors, complete the small list of elementary catastrophes which René Thom had proposed in 1972[3] as a basis for dynamic models in natural and human sciences.

In the following I shall use the term *catastrophe* in the sense of catastrophe theory, if scientific modeling is the major aim. In more informal contexts, sudden transitions which enforce dramatic changes and show the effect of hidden forces are also called catastrophes, even if nobody is killed and no natural cataclysm is involved. The two major categories of catastrophes alluded to in the report on historical cases remain relevant: unexpected effects of natural forces as in earthquakes, tsunamis or the uncontrolled expansion of fire or flood which override all the precautions taken by Man.

1. Revolutions in Philosophy on a macro-scale

At a first sight, history of Philosophy seems to be rather erratic, depending on religious, political and scientific developments and often on individual personalities (e.g. Socrates, Bruno, Descartes, Kant, Wittgenstein), but as soon as we consider philosophy and its development on a larger scale, where the individual contributions and their differences vanish, we can notice that the directions of change are rather few and that their dynamics are rather

[3] R. Thom, *Stabilité structurelle et morphogenèse*. Paris, 1972; English translation: *Structural Stability and Morphogenesis*, Benjamin, 1975.

simple if not primitive. This encourages the application of very systematic and almost mathematical tools for the analysis of major changes, paradigm clashes, philosophical revolutions and phases of synthesis (stability).

Catastrophe theory belongs to the domain of the dynamic system theory. It basically represents the application of the classification theory of Thom (proved by Mather in 1964). In the period since 1964 the field has further evolved. I will, therefore, include:

- Bifurcation theory[4]
- Theory of strange attractors and chaos theory[5]
- Stochastic dynamical systems as applied in synergetics[6]

In its current state, the field may be organized around two basic topics:

the typology of catastrophes (in deterministic systems) and the fractal character of iterated bifurcations leading to chaos; the stochastic attractors and the slaving effect of basic parameters in synergetics.

These basic dynamical structures explain the emergence of order in general and, therefore, create a framework, into which theoretical intuitions about possible laws or regularities in nature and mind may be integrated.

1.1 The counterpoint of evolutionary change: stability or rigidity (frozen state)

In the animal kingdom some species show stability for long periods (e.g. millions of years). This stability is not due to a lack of changing forces, because the mutation rate in sexual species is independent from ecological changes or other forces, it is a chance factor. Stability is therefore due to the reduction, elimination of stochastic variations. The forces which damp the effect of stochastic changes, e.g. genetic mutation, are related to optimal adaptation to the ecological niche and the stability of the niche itself. Thus the oceans had similar conditions for fishes, dolphins and other inhabitants over long periods. Slow changes could be answered by a relocation of the population. In comparison to dolphins, the human species evolved very quickly and is still changing at a quick rate. Nevertheless, compared to modern rates of change the Paleolithic species of man were bodily stable more than one million years (cf. the proto-species Homo erectus) and so were their cultural (mainly lithic) technologies. We must therefore consider the dynamics of stable states as a background of change.

A very simple model is given by the picture of a sink, a container, a lake, which assembles the ambient water etc. Its formal analogue is a parabola, in one dimension; $f(x)= x^2$, in two dimensions $f(x,y)= x^2 + y^2$ (elliptic paraboloid).

[4] Cfr. H. Guckenheimer - Ph. Holmes, *Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields*, New York 1983.
[5] H.-O. Peitgen, - H. Jürgens - D. Saupe, *Bausteine des Chaos. Fraktale*, Heidelberg/Stuttgart 1992.
[6] H. Haken, *Synergetics. An Introduction* (third revised and augmented edi¬tion), Berlin 1983.

If strong factors enforce a kind of hyperstability, in which even very strong fluctuations cannot trigger a jump to another attractor, one may consider a kind of goblet or narrow vase. In the kingdom of plants, some have the shape of a sink in order to catch insects which they can digest. Some examples of objects and plants with a parabolic design are shown below.

Figure 1 - Examples of design objects with a parabolic shape and an insect-eating plant (the insect cannot evade the natural goblet)

A dynamic analogue of it is represented by the damped pendulum, which returns very quickly to its rest position. A classic example of a two dimensional attractor, i.e. a system which forces every point (object) in its environment into a closed, circular or elliptic orbit, is the movement of the earth around the sun. As long as variations of this movement – due to minor impacts of asteroids colliding with the Earth and effects of other planets and the moon – are damped by constant gravitational forces of the sun, the orbit is stable. If such variations exceed a certain size, e.g. if the Earth collides with a planet of the size of Mars, the earth will leave this orbit and strange things may happen (or if finally the sun changes its shape and dynamics). The baseline of all changes is therefore a situation in which all variations are damped and a seemingly steady state is realized.

In the case of visual art, we can observe long periods of stability and the necessity of strong forces (internal, external, often both together) in order to make paradigmatic changes occur. One strong factor in the stabilization of states is tradition and authority. Thus Greek and Hellenistic philosophy and art was a feature of stability for Roman philosophy and art. After the fall of Rome, many of these traditions were lost in the West, but with the recovery of the major works of Plato and Aristotle, they became almost indestructible authorities in the scholastic philosophy.

1.2 The evolution of philosophy analyzed as the unfolding of a morphodynamic field

The following reflections refer, in their examples, to Western Philosophy; I guess that similar gradients, catastrophes and fractal patterns will show up again if we analyze Indian, Chinese, Japanese philosophies and intellectual frames in non-written traditions (Amero-Indian, Inuit, etc.).

The traditional starting points of philosophy: Plato and Aristotle exhibit already two concurring syntheses, based on the pre-Socratic tradition. In synergetic terms, a synthesis is basically the reorganization of a set of partial systems in a strong interaction, by the choice of very few slaving parameters. For our purpose it is significant that we can distinguish three phases of this process:

1) A differentiated and distributed set of philosophical positions evolves. The interaction is rather low due to geographical heterogeneity (in the ethnically and linguistically subdivided mainland of Greece and in the Greek colonies around the Mediterranean and the Black Sea area).

2) A concentration in Athens due to political and (slightly later) cultural dominance. The slaving force may be located in the intellectual singularity of Socrates and the life-long development of his teaching in the work of Plato. The metastable character of the synthesis is shown by the work of Aristotle and the followers of Plato in the Academy. It is characteristic that the content of the philosophical teaching changed with every successor (at least in the first cycles); nevertheless the stability of the Platonic synthesis was inherited by the Hellenistic Academy, which was only destroyed in the campaign (529 after date) of emperor Justinian (482-565 AD) against pagan religions and philosophies. The Florentine Academy and the academies of the 15th and 16th century have revitalized this tradition.

3) The *disaggregation* of the Greek line of philosophy had many stages (transfer to Alexandria as center, influence on India, Persia and the Arab sciences). In the main line, the rise of Christian and later Islamic nations created a new synthesis based on the Bible and the Koran and, thereby, replaced the anti-mythic Greek philosophy by religious philosophies. Philosophy became an "ancilla theologiae" (the servant of theology). Several new syntheses fostered this role of philosophy:

- The philosophy of Augustinus, which was revived several times (e.g., by the Port-Royal Jansenists).
- The philosophy of Thomas Aquinas (1225-1274), which became the official philosophy of the Roman church.
- A third line, which tried to incorporate structures from the two concurrent monotheistic religions: Judaism and Islam, was opened by Ramon Llull (1232-1315) but remained controversial (at the edge of heresy).

The strongest force in this evolution was surely the philosophy of Thomas Aquinas, which was able to govern philosophical thinking until Leibniz and even later in different forms of Christian Aristotelianism. All these three philosophies had the ultimate aim of fostering Christian faith or even of demonstrating its superiority against the Judaic or Islamic traditions (conversely for the other text-religions).

4) The Renaissance philosophers, like Marsilio Ficino (1433-1499) and later Giordano Bruno (1548-1600) successively broke the link between (Christian) religion and philosophy. Bruno tried to reconstruct some kind of basic Mosaic (Egyptian) religion as the ultimate metaphysical root of philosophy. This return to an independent philosophy was destroyed by Christian reforms (Calvinism, Lutheranism) and by the catholic counter-reform in the 16th and the 17th century. Finally, the philosophy of Enlightenment took up the advances of Renaissance philosophy. From now on the natural sciences and mathematics were taken as stable reference points for truth. This reference point became very strong after the acceptance of Newtonian physics by Condillac and Kant (in the middle and the end of the 18th century).

5) The new creed of Enlightenment, which was motivated by the astonishing successes of modern science and the need for new frames of intellectual orientation (in the context of political and social reorganization), was slowly destroyed by a process that we could call "disciplinary fragmentation". The big theory (Newtonian physics) was broken from within as new paradigms evolved in physics and its role of orientation was overtaken by other disciplines like: biology (Darwinism, molecular genetics), chemistry, psychology, linguistics, etc. In dynamical terms we could call this stage, the fractal stage of modern philosophy.

This very rough picture of three millennia of philosophical evolution[7] fits a dynamical schema, in which specific parameters are able to slave and order the dynamics, that in general have the tendency to diverge individually and thus to lead into chaos or noise. In terms of dynamical systems, stage (1) corresponds to spatially separated modes of a system[8]. Thus, the dominance of philosophical modes, in given geographical or cultural areas, may be explained by a temporally dominance of a philosophical position, that eliminates (via social selection) all other modes. The most miraculous happenings are the big syntheses (stage 2); they ask for very specific conditions. The picture of a singularity in catastrophe theory may illustrate this point. In the elementary catastrophe called "butterfly", we find a singular point leading to three modes. The basic equation is:

[7] Cfr. W. Wildgen, *Dynamische Sprach- und Weltauffassungen* (in ihrer Entwicklung von der An¬tike bis zur Gegenwart), *Schriftenreihe des Zentrums Philosophische Grundlagen der Wis¬-senschaften*, vol. 3. Bremen 1985 (out of print; now accessible in a revised, electronic version: http://www.fb10.uni-bre¬men.de/homepages/wildgen/), for a sketch of the development of dynamic considerations in philosophy and linguistics.

[8] Compare the Belousov-Zhabotinsky-reaction, which shows periodically changing colors (red if the Ce3+ is produced at a high rate, blue if Ce4+ is produced). It eventually creates a stationary distribution with red (above) and blue (below).

$V = x^6/6 + tx^4/4 + ux^3/3 + vx^2/2 + wx$

Partial differentiation (relative to the variable x, called internal variable) gives as the equations (2) and (3).

$V' = \delta V/\delta x = \quad x^5 + tx^3 + ux^2 + vx + w$
$V'' = \delta^2 V/\delta x^2 \quad = \; 5x^4 + 3tx^2 + 2ux + v$

The bifurcation point is defined by the zeroing of the first and the second partial derivative[9].

$dV/dx = d^2 V/dx^2 = 0$. Figure 2 shows the bifurcation lines in the two dimensional space of external parameters (v, w); the other two parameters u and t have fixed values in a specific domain of values.

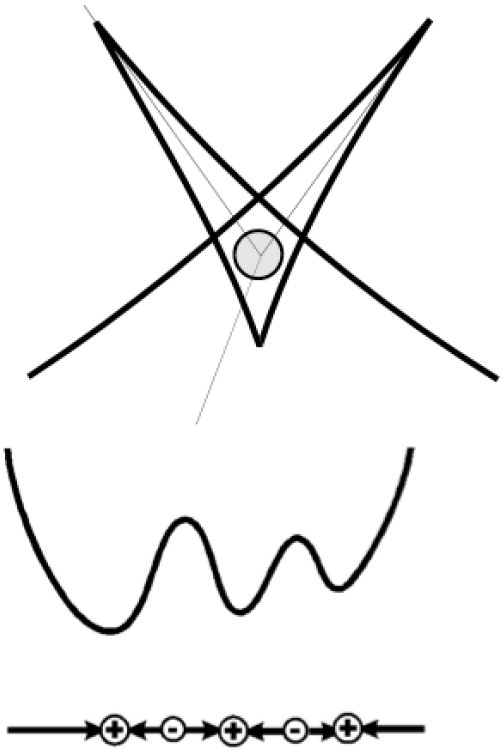


Figure 2 - a) The bifurcation space represented by a picture of (v, w) at specific points of the plane (u, t) and b) the potential function V (on x) and below the Dynkin-diagram of attractors, repellors and vector-flows.

The most complicated and compact picture is the one in the central area of Figure 2 (above). Here we find a singularity that can split-up into a system of two

[9] Cfr. W. Wildgen, *Archetypensemantik. Grundlagen einer dynamischen Semantik auf der Basis der Katastrophentheorie*, Tübingen 1985, p. 170.

or three attractors (minima). Figure 3 shows the splitting in the neighborhood of the singularity.

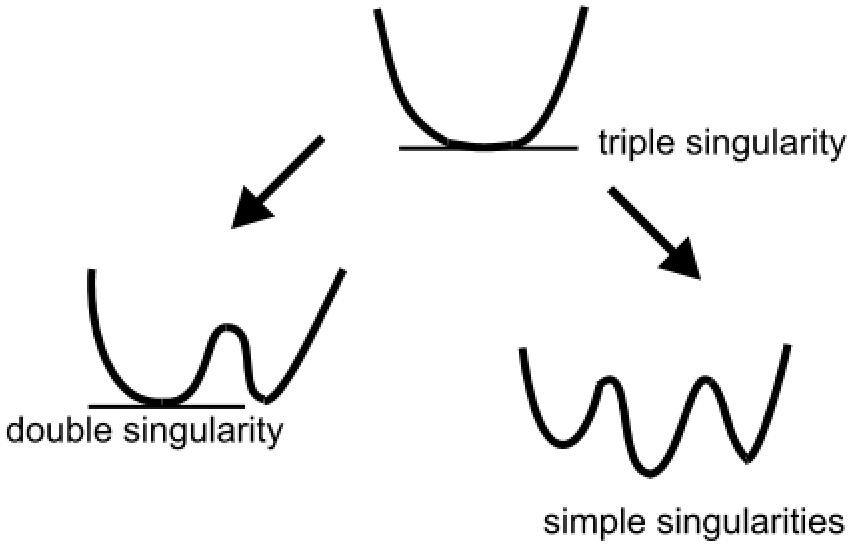


Figure 3: Triple, double singularities and three simple (stable) minima (locally $V = x^2$) as consequences of the unfolding of the germ $V = x^6$.

A big (temporary) philosophical synthesis could abolish the differences between three (in principle n) attractors (= philosophical positions), creating a very complex singularity. The basic prediction is that this synthesis will be unstable. The interesting questions are:

- How long can such a solution persist (under which conditions)?
- What is the gain in the long run of such a synthesis?

I think that very specific historical, social, and intellectual conditions are necessary to give access to a philosophical synthesis (stage 2) and that the extremely low probability of such a singularity makes that its information is very high (if we apply basic intuitions of information theory).

The big points of synthesis – e.g. those of Plato, Aquinas, and Kant – are singular events, linked to singular personalities. In the singularity of a (philosophical) mind a particular balance between rather incoherent modes of philosophical explanation is created. This singularity cannot be explained by general mechanisms, but one can find specific lines that form the organizing center of such a synthesis. In the case of Plato some mix of Pythagorean credo in mathematics and an oriental view of the soul (which is independent of the individual body) may have been such centers of organization. In many cases, the synthesis contains a balance between basically contradictory positions, e.g.,

rationalism and empiricism in Kant's synthesis. We shall come back to bimodality and underlying continua in the last section of this paper.

The chaotic nature of "normal" evolutions in the domain of philosophy may be due to an iterative, self-similar process of mapping. This can occur in the transition from one school to the next one, or in a partial mapping between parallel and concurrent schools. Such a "mapping", by the reformulation of traditional positions, by their citation, comment etc., is always open to deformations (simultaneously on different parameters) and, therefore, open to chaotic dynamics[10] . Dynamically, the self-reference or auto-similarity of a philosophical system is a phenomenon that may be observed in any intellectual system transmitted from generation to generation. It applies a general mechanism of cultural transmission, showing the stability/instability of cultural traditions.

In order to analyze the formal features of such a process we may throw a look at the logistic mapping in dynamical systems theory[11].

$y \rightarrow kx\,(1-x)$ (logistic mapping)

The iteration takes 'y' as the new value of 'x' and thus produces an infinite series of new values of 'y' (in a time 't'):

$$x_{t+1} = kx_t(1-x_t)$$

The parameter k controls the stability of the mapping. If k = 2, we get a steady state after 7 steps of iteration. If k = 3, the steady state is replaced by two alternative states; this constitutes a bifurcation. Between k = 3 and k = 4 chaos appears (and disappears) by period-doubling (chaos breaks down to periodicity and reappears, etc.). Figure 4 shows the Feigenbaum-tree of an iteration of this type.

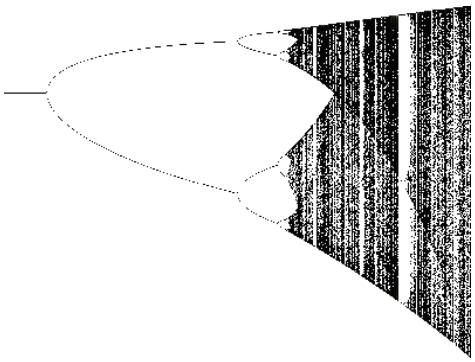


Figure 4 - Bifurcation diagram of the logistic mapping (for different values of k).

[10] Cf. H.-O. Peitgen - H. Jürgens - D. Saupe, *Bausteine des Chaos. Fraktale*, cit, on the copying machine dynamics.

[11] W. Wildgen - P. Plath, *Katastrophen- und Chaostheorie in der linguistischen Modellbildung*, in R. Köhler, G. Altmann and R. G. Pietrowsk (eds), *Quantitative Linguistics/Quantitative Linguistik*. An Internati¬onal Handbook, Berlin 2005, pp. 688-705. Cf. *ibidem* for a more explicit introduction into chaos theory and its application to semiotics and linguistics.

The transfer to my argument on the evolution of Philosophy exploits a structural analogy. The relevance of this analogy is based on the fact that the characteristics of the logistic mapping have been shown to constitute a formal schema applicable in many different domains. In the following we will apply this schema (and not the formula itself).

In the history of Western Philosophy Plato and Aristotle reflect already a late period of self-similar mapping (since ca. 600 BC). The first stages of bifurcation are inaccessible. What may be observed are zones of stability in the domain of chaos, i.e. the small bands of stability (cf. Figure 4) correspond to periods of philosophical synthesis. In many cases they have period 2. Thus, Platonism and Aristotelianism, rationalism and empiricism are subsystems with period 2. As the philosophical evolution is spatially distributed, different branches can occur simultaneously (in different cultural areas or in different persons).

The forces that could control such a synthesis are not part of the schema. They could be of two kinds: First, the forces could be intrinsic to the human mind/brain. Thus, the brain shows effects of convergence and binding involving long-ranging coordination (e.g. in the 40 Hz level) and segregation related to subsystem specialized with a divergent dynamics. These basic mental process-types could explain the rival tendencies of synthesis and diffraction in cultural/intellectual traditions. Secondly, social dynamics may either enhance segregation in intellectual rivalry, in relation to the exploitation of social resources, like public attention and access to pupils and followers or enhance cooperation and convergence via coalitions, that bring together a group of social agents who would, otherwise, be too weak to achieve public acceptance and cultural success. The two levels, the mental and the social, may be linked by a coordination cycle of the type exemplified by Turvey[12] and also assumed in "Social Morphogenesis"[13].

If coordination, synthesis breaks down, a kind of rather general catastrophe occurs. If diffraction goes on without limit, all positions imaginable and their terminological variants are stochastically run through such that no halting point appears and the philosophical enterprise fails totally; it becomes insignificant for the community of philosophers.

In the following paragraph, I shall discuss in detail revolutions (catastrophic transitions) in the visual arts and the mathematical innovations that occurred in parallel or prefigured major changes. In this context, I shall also give examples of new conceptualizations in the aesthetics of visual art based on geometrical, topological and dynamical formal tools, in order to show that these are not only relevant for a kind of meta-theory, dealing with the unfolding of philosophical and esthetic paradigms, but they can complete or in some case replace traditional schemata based on logics or structural methods inspired by formal logics.

[12] M. T. Turvey, *Impredicativity, Dynamics, and the Perception-Action Divide*, in V. K. Jirsa, J. A. Scott Kelso (eds), *Coordination Dynamics. Issues and Trends*, Berlin 2004, pp. 1-20.
[13] D. V. Porpora, *Morphogenesis and Social Change*, in M. S. Archer (ed.), *Social Morphogenesis*, Berlin 2013, pp. 25-37.

2. Revolutions in visual art

In visual semiotics[14] and visual aesthetics, changes in orientation or aesthetic revolutions may depend on contingent factors, such as political and religious revolutions; in this case they should be analyzed in the specific context. There are, however, instances where the general intellectual climate may have been influenced by political changes, but where the major forces are aesthetic ones. In these cases, the sudden and violent changes (catastrophes) are able to demonstrate the underlying dimensions of art-work and aesthetic decisions. This perspective will be selected in the following sections.

I shall summarize some results of my analysis of paintings by Leonardo da Vinci[15] in the following section and then proceed to the analysis of other examples linked to innovations in visual art. The paintings of William Turner were a landmark for impressionists like Claude Monet and the sculptural innovations by Henry Moore paved the way for modern sculpture. The "surrealist revolution" led to an interesting contact of Salvador Dali with René Thom, the founder of catastrophe theory, and became the topic of some surrealist paintings.

2.1 Elements of event, action and sudden change (catastrophe) in Leonardo's paintings

Leonardo's theoretical orientation is documented in the writings transmitted through his manuscripts and in his treatise *Libro di Pittura*. Two major concerns can be emphasized: the geometrical construction of the topics applying the laws of perspective stressed by Brunelleschi (1377-1446) and Leon Battista Alberti (1404-1472), and indirect representation of motion, dynamic constellations as signs of the mental and emotional processes involved (the artist prefers to paint living characters instead of 'wood figures')[16].

The semiotic revolution in Leonardo's painting prefigures the scientific revolution announced in Copernicus' *De revolutionibus orbium* (1543) and brought to the summit in the work of Galileo and Kepler. Together with other intellectual and religious changes they remodel the common knowledge, the world-view of educated people in the sixteenth century and of Western civilization in the centuries which follow. I shall give a short analysis of the thematic composition in Leonardo's paintings of St. Anne.

[14] Cf. W. Wildgen, *Visuelle Semiotik. Die Entfaltung des Sichtbaren. Vom Höhlenbild bis zur modernen Stadt*, Bielefeld 2013.
[15] W. Wildgen, *Geometry and Dynamics in the Art of Leonardo da Vinci*, «Cognitive Semiotics», 5, 2010, pp. 1-30; W. Wildgen, *Visuelle Semiotik*, cit.
[16] «Il bono pittore ha a dipingere due cose principali, cioè l'omo e il concetto della mente sua. Il primo è facile, il secondo difficile, perchè s'ha a figurare con gesti e movimenti della membra», cf. C. Pedretti, (ed.), *Leonardo da Vinci. Libro di Pittura*, Codice Urbinate lat. 1270 nella Biblioteca Apostolica Vaticana (trascrizione critica di Carlo Vecce), Firenze 1995, §180, p. 219.

The painting contains a rich geometric and dynamic structure (weights, bar centers, force-vectors[17], gaze-directions, etc.). A purely static representation would be insufficient for both the pictorial and the narrative aims of the painting. Furthermore, this piece is typical for Leonardo's art which consistently exemplifies the concept of *dynamic valence.*

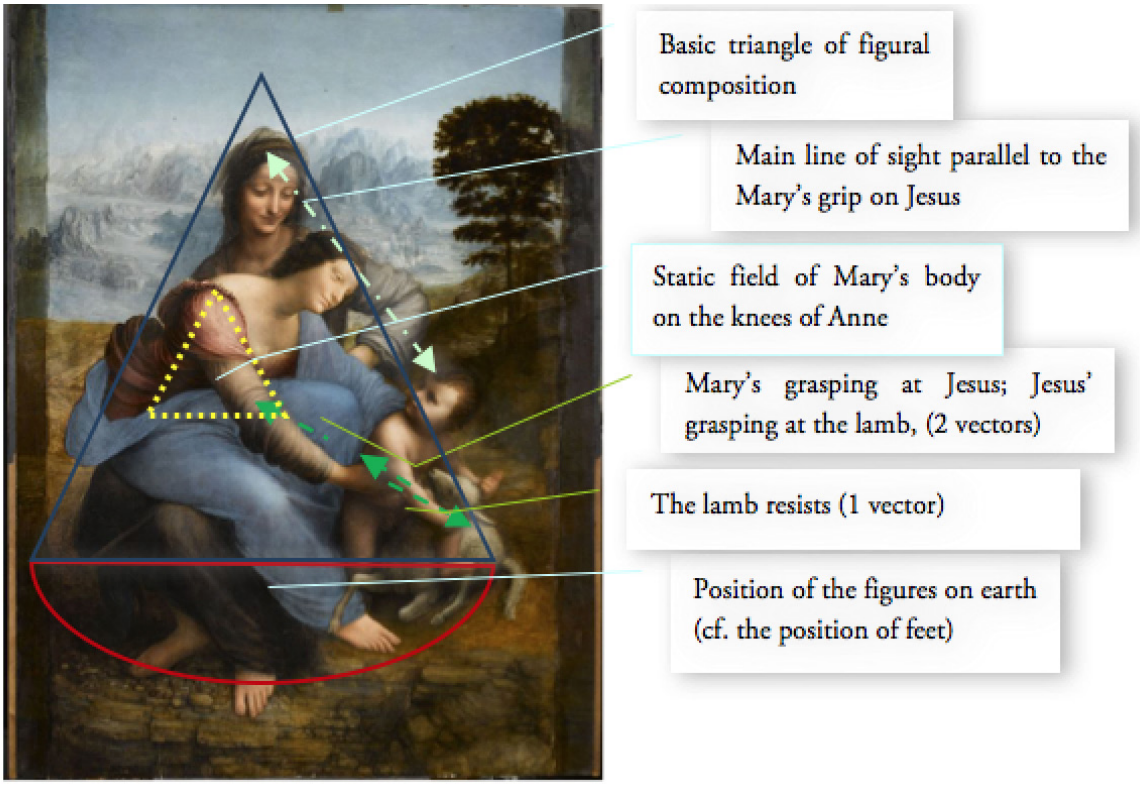


Figure 5 - Leonardo da Vinci, *St. Anne with Mary, Jesus and the lamb* (1509/10; Paris, Louvre)

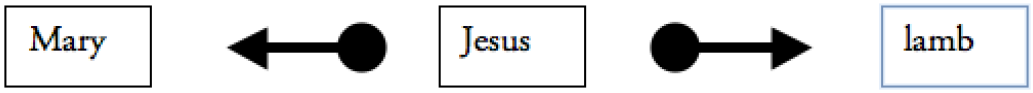
In the case of this painting, we have on the surface a quaternary constellation: Anne — Mary — Jesus — lamb. If one considers the force fields and actions, one notices that a basic interaction links: Mary — Jesus —the lamb.

- Mary *pulls on* Jesus
- Jesus *pulls on* the lamb
- The lamb *resists*
- Jesus *resists* being pulled away from the lamb

There is a conflict between Mary who tries to prevent Jesus from seizing the lamb and Jesus who notices this (he looks back to her), but resists against

[17] A specific consequence of the mathematical conceptualization of dynamics is the calculus of vectors introduced by William Rowan Hamilton (1805-1865). In Fig. 5 three force-vectors and one sight vector are given. In a catastrophe theoretical frame, one would rather consider vector-fields with attractors (minima) and repellors (maxima); cf. Figure 2.

her action. This triad constitutes a force field that dominates the message of the painting. A first schematic representation introduces two vector-fields with attractors:



The constellation of forces between Mary – Christ – the lamb corresponds to the basic archetype of transfer in Figure 6. The archetype is derived by considering a path in the catastrophe set of the butterfly: germ $V = x^6$; cf. section 2.3). In the center of the catastrophe set three attractors (=minima) coexist and the change occurs along a path in this zone[18].

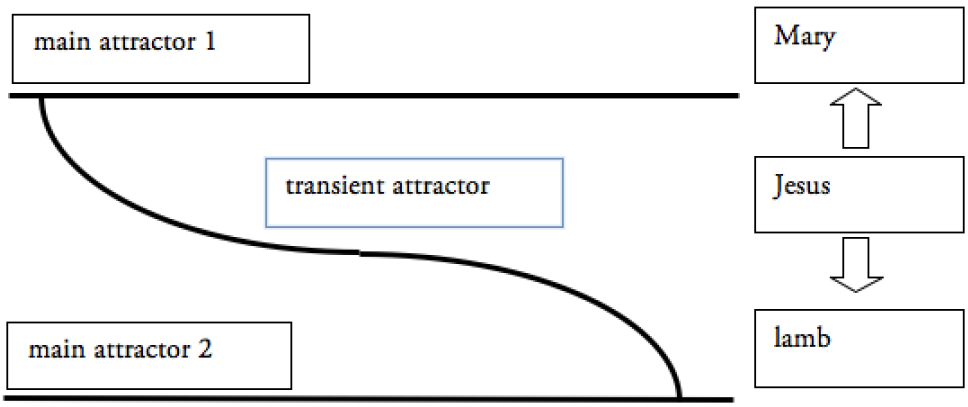


Figure 6 - The dynamical archetype of transfer (giving) and a fiber on it (with attributed contents).

As the archetype does not describe all the interactions in the pictorial composition, one has to add two complications:

- Anne supports/anchors the whole event (physically and genealogically), she is a fourth attractor which sustains the event happening on her knees. This anchoring is visible in the position of the feet and the central triangle of gravitational stability in Figure 5

- The manner of "transfer" is further elaborated in the painting and could be described in a sentence like: *Mary tries to prevent Jesus from seizing the lamb*. This complex sentence goes beyond the elementary schema shown in Figure 6.

[18] For technical details see W. Wildgen, *Catastrophe Theoretic Semantics*, cit.; Id., *Archetypensemantik. Grundlagen einer dynamischen Semantik auf der Basis der Katastrophentheorie*, cit.

The innovation by Leonardo does not break with the tradition of his Renaissance precursors[19], it is rather the climax of this development, which will be imitated in the following centuries. It is followed by the mannerist period and baroque art. Such a climax is a singularity in the sense of catastrophe theory. As such it has a very strong impact on later developments, although it is itself unstable and induces rapid changes which show up already in the late work of Michelangelo, and more radically on that of Tintoretto and Arcimboldo[20].

2.2 The "perceptual catastrophe" in the art of William Turner and Claude Monet

William Turner (1775-1851) is an outstanding figure in British landscape painting mainly because he broke with this tradition and prefigured the revolution of French impressionists, mainly the work of Claude Monet (1840-1926). A painting of the Castle of Chillon at the lake of Geneva from 1809 (British Museum) gives a precise representation with persons in the foreground, buildings, the lakeshore and mountains; it is shown in Figure 7.

Figure 7 - *Castle of Chillon at the lake of Geneva* from 1809 (British Museum)

A watercolor painting from 1841 depicts the same lake of Geneva in a very vague fashion.

[19] Cf. the development of the topic of the *Last Supper* before and after Leonardo in W. Wildgen, Éléments narratifs *et argumentatifs dans l'articulation de l'espace pictural. Transformations de l'Ultime Cène du XIIe au XXe siècle*, in S. Caliandro (ed.), *Espaces perçus, territoires imagés en art*, Paris 2004, pp. 77-97; Id., *Geometry and Dynamics in the Art of Leonardo da Vinci*, cit.; Id., *Visuelle Semiotik*, cit.
[20] Cf. W. Wildgen, *Visuelle Semiotik*, cit., pp. 107-111.

Figure 8 - *Geneva: The mole, the lake and the Savoy Hills*, 1841
(cf. Wilton, 1982: 63, Nr. 89).

In the second painting (cf. above), one can still recognize mountains, the shore of the lake, the water surface (blue), ships, and possibly people, but the symphony of colors, the transitions between surfaces and indirectly the emotional values become dominant. In the perspective of ecological psychology[21], the second picture refers to a different stimulus space. It makes the stimulus recede and therefore gives more weight to sensation and perception. Anyway, the picture is always a 'surrogate' of reality and thus communicates intentional information given by the producer (the painter) to some addressee. In this message, very different values or aspects of the individual result of sensation, perception and cognitive analysis may be selected and transmitted with preference. In his deliberate selection of atmospheric cues and unusual viewing conditions, Turner predated the later developments of "impressionists". Claude Monet, who was an admirer of Turner's work, added the variability of appearances in his series of 25 hay pack paintings, 1890-91. Other series concerned: the *Mornings on the Seine, Poplars, Rouen Cathedral, the Houses of Parliament,* and *the Water Lilies.* The Charring Cross Bridge in London in the fog was the topic of 37 paintings, all taken from the balcony of the Savoy Hotel.

[21] Cfr. J. J. Gibson, *The Concept of Stimulus in Psychology*, in «*American Psychologist*», 15, 1960, pp. 694-703: 344.

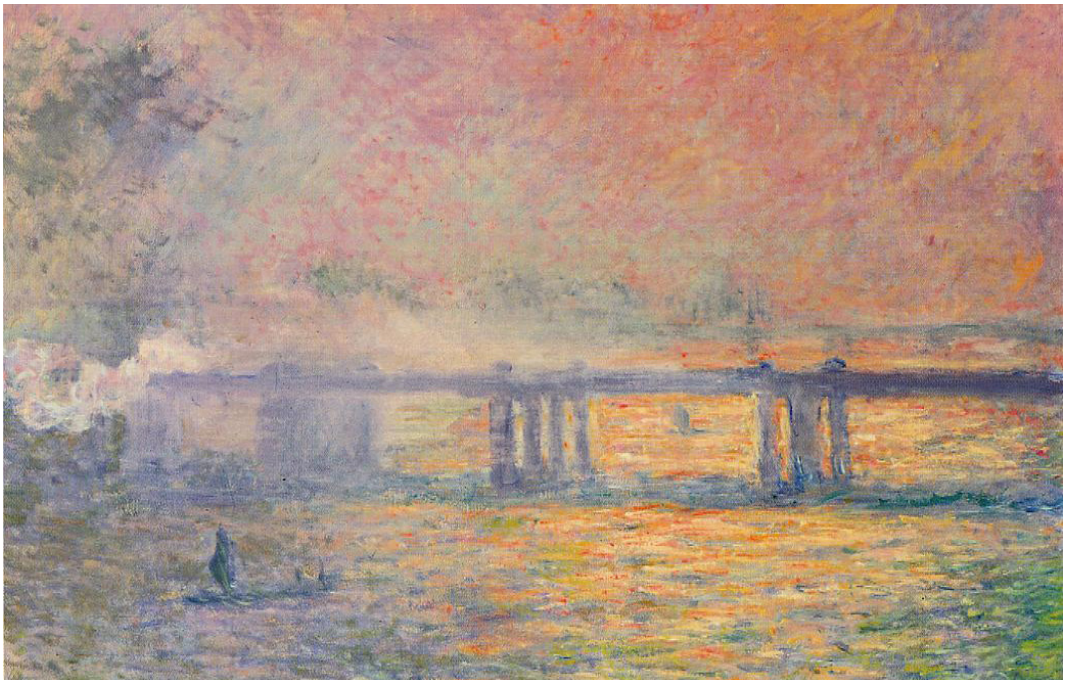


Figure 9 - Claude Monet, *Charing Cross Bridge*, London, 1903
Saint Louis Art Museum.

The catastrophic transition concerns the accepted view (until today encountered in many naïve art 'experts') that a painting has primarily to give a 'true' and moreover a standard picture of the world we live in; a landscape painting must like a postcard or touristic advertisement show its appearance under standard conditions (not in fog, in rain or under very specific conditions). The departure from this quasi-silent convention by Turner was understood as a provocation; some critics called him a lime-painter. In the case of Monet, the series points to the variability of the appearances of one and the same object (haystack, bridge over the Tames etc.). In premodern paintings, the artist first chooses or constructs a frozen 'surrogate' of reality, comparable to a literary description in a novel. The paintings by Turner and Monet abolish the link to an (implicit) text, focusing on the visual message, and acknowledging the visual variability of the object in question. In abstract paintings (after 1913) even the binding by external stimuli and referential links is abandoned. In the sense of Gibson[22] the double nature of visual information in pictures: the information about a depicted reality and the information about the painting as a visual object are separated, only the second "reality" is left and the observer has to concentrate on this aspect and be satisfied by it. In terms of dynamical systems, the classical image is a metastable coordination between two concurring images. In abstract paintings one of them is discarded; in impressionistic paintings the artist stops halfway with a preference for the visual information of the picture as object

[22] Cf. J. J. Gibson, *The Information Available in Pictures*, in «Leonardo», 4, 1971, pp. 27-35; reprinted in E. Reed – R. Jones (eds.), *Reasons for Realism. Selected Essays of James J. Gibson*, London 1982, pp. 269-283: 278f.

in itself. The reduction of the referential illusion eliminates the fundamental ambiguity of pictures[23].

The next section will follow the line of stimulus reduction and abstraction, which became dominant in expressionism and cubism. The work of Picasso could be a good example but I choose the sculptures of Henry Moore.

2.3 Morphological continua and (catastrophic) transitions in Henry Moore's sculptures

Henry Moore (1898-1986) became famous for his large sculptures. Many of them resemble human bodies, but some lack any referential support. In Figure 10 two sculptures by Henry Moore, one with the topic "reclining figure"[24] and one without descriptive content are shown.

The torso of a human body with cut-off extremities (arms or legs?) is completed by a separated piece. alluding to legs and clothing. Henry Moore's sculpture *Oval with Points* shows an oval object with a hole scarcely separated by two points. The reduction may be compared to the transition from geometrical (metrical) to topological spaces, i.e. to the mathematical generalizations triggered by the innovations of Bernhard Riemann (1826-1866), Felix Hausdorff (1868-1942) and their application to physics. What is of special importance is the separation of a spatial domain into two, three or more pieces and holes or handles in such spaces (cf. a torus and a ball with handles in Figure 11). The discontinuities, singularities (points), separations into parts and the cutting or pruning are catastrophe phenomena on a continuum.

Figure 10 - Henry Moore. "Reclining Figure Nr. 5", sited in the grounds of Kenwood House, London, Bronze (1963-64); and "Oval with Points", in Henry Moore Sculpture park Perry Green, Hertfordshire.

[23] W. Wildgen, *Semantic Ambiguity in Relation to Perceptual Multistability*, in M. Stadler – P. Kruse (eds.), *Ambiguity in Mind and Nature.* Berlin 1995, pp. 221-240.
[24] Cf. W. Wildgen, Conceptual Innovation in Art. Three Case Studies on Leonardo da Vinci, William Turner, and Henry Moore, in F. Brisard, M. Meeuwis and B. Vandenabeele (eds.), *Seduction, Community, and Speech: A Festschrift for Herman Parret*, Amsterdam 2004, pp. 183-196: 191-194; Id., *Visuelle Semiotik*, cit., pp. 162-168.

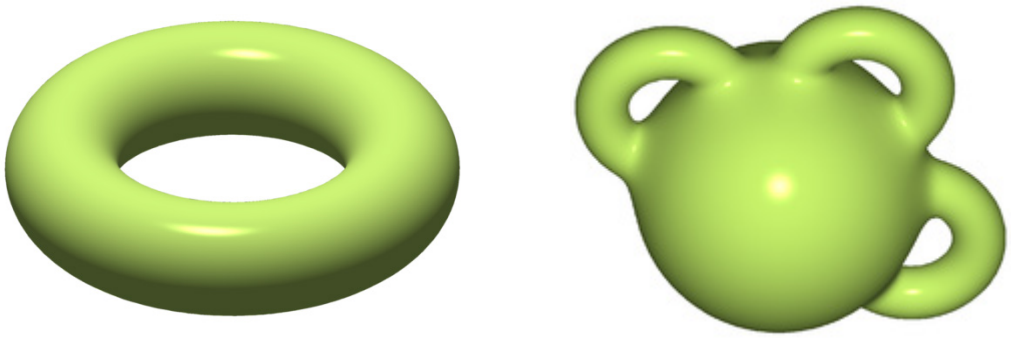


Figure 11 - Torus as the archetype of an object with a hole and a more complicated object (sphere) with handles

The two-piece reclining figure shows a hole in the right part, whereas in the sculpture "Oval with Points" the hole is the central feature; the points are singularities. In general the figures underwent a transformation from perceived bodies and objects to abstract, topologically less detailed but also less coherent constructions. The shape of the cavity or hole is complementary to the shape of the full body and both contribute to the esthetic perception of the object[25].

In terms of morphodynamics, one may imagine a kind of inverse morphogenesis. The highly diversified body shape due to cascades of cell differentiations and specialization of body parts is reduced step by step in the artist's imagination with the aim to return to very simple natural forms, which Henry Moore found in nature as shapes of bones or stones. They were a kind of "objets trouvés", i.e. of r*eady mades* in the sense of Marcel Duchamp (1887-1968). The underlying catastrophe is one of bifurcation and morphogenetic channeling in the sense of Conrad Hal Waddington (1905-1975) and his hypothesis of evolutionary development (EvoDevo).

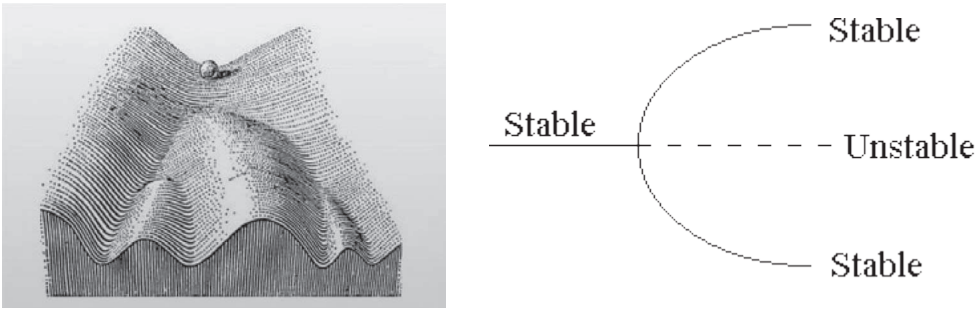


Figure 12 - Epigenetic landscape and bifurcation of a stable state

The transition between a real reclining woman and one of Moore's sculptures is dramatic, quasi a "catastrophe of imagination". Its basis is not

[25] These effects are also exploited by Salvador Dali in his painting: *The triangular hour* (*L'heure triangulaire*, 1933).

knowledge about evolution and morphogenesis[26] but the experience of growth and deformation in our ambient world. Thus the transformation of a newborn child (or even an embryo) into a school child and an adult on one side and deformations due to developmental mistakes and illness (accident) establish a basic space of variation. Under specific visual conditions, camouflage, partial obstruction further deformations may be perceived and remembered. This space of variation is the ground on which the imagination of the artist and that of his clients may meet. Nevertheless, the departure from standard conditions of perception creates a catastrophic impact and a sudden rise of the information value (because such perceptions are rare and have a very low probability). This is the basis of the aesthetic surplus value of the piece of art.

2.4 The surrealist revolution and Dali's encounter with catastrophe theory

André Breton (1896-1966) and his followers considered surrealism as a revolution; cf. the titles of major journals: *La Révolution surréaliste* (1924-1929) and *Le Surréalisme au service de la révolution* (1930-1933)[27]. Surrealism was not only applied to visual art (painting, sculpture, installations, and film) but also to literature and had repercussions in sociology and philosophy. The general tendency of surrealism beyond an exuberant diversity of positions and enterprises is its opposition to dominant and publicly recognized standards and institutions. In Bataille's terms, the heterogeneous, the excluded, the taboo is the major concern of surrealistic enterprises. In mathematical (topological) terms, the pictorial space in surrealism is often a piecemeal of representational subspaces (cf. the technique of collage introduced by Max Ernst, 1891-1976) or astonishing transitions between visual subspaces.

Salvador Dali (1904-1989) considered himself as the incarnation of surrealism.[28] An immediate link to catastrophes is given by the fact that Dali received René Thom in his home in 1978, at the time when catastrophe theory, that had been developed and disseminated by Thom and Zeeman, was at its climax. Dali's turn to mathematics occurred in parallel with his return to Catholicism and sacred art, and his fascination by the topic of atomic, nuclear power after World War II. In Dali's version of the *Last Supper*[29] the rectangular

[26] Morphogenetic principles have been used as a kind of metatheory in sociology. They describe the interaction between agency and culture (social structure). In the arts, individual, creative aspects dominate and trigger the emergence of new cultural values and social relations; cf. Porpora, *Morphogenesis and Social Change*, cit.

[27] The surrealist movement had been prepared by the movement called Dada which started in Zürich 1916, changed to Paris in 1920 and spread over the world (New York, Russia, Japan). Some of the proponents of surrealism (e.g. André Breton, 1896-1966) transferred the surrealist movement on the path to the United States (1941-1946) and influenced younger American artists (e.g. Jackson Pollock). The anarchist tendency of surrealism was later taken up by the Beat generation (beatniks) and Psycadelicart (I thank my son Quirin for this information).

[28] He was excluded from the surrealist movement in a trial in 1934, but considered himself as the true heir of this tradition.

[29] Cf., for the historical evolution of this topic, W. Wildgen, *Geometry and Dynamics in the Art of Leonardo da Vinci*, cit., and Id.,*Visuelle Semiotik*, cit.

table is standing under the "roof" of a platonic solid, the dodecahedron. This spatial archetype, which is the only platonic solid with pentagons as its sides, reappears as major element in the painting *At the search of the fourth dimension* (1979).

Figure 13 - Salvador Dali, *Last Supper* (1955) and *At the search of the fourth dimension* (1979)

The series of ideal (regular) polygons (equilateral triangle, square, pentagon, hexagon etc.) and ideal polyhedrons (only five, the so called platonic solids) has a dynamic and topological equivalent in the elementary catastrophes[30]. Insofar it was only consequential that Dali met René Thom, the famous topologist and Fields medal winner. The regular geometries and stable unfolding are a kind of last residue of stability in a world of constant change, steady transitions and chaos luring anywhere. As Thom had established a link not only to morphogenesis but also to plate tectonic in geology and geography, his and Dali's imagination

[30] P. Slodowy, *Platonic Solids, Kleinian Singularities, Elementary Catastrophes, and Lie Groups*, in J. Petitot-Cocorda (ed.), *Logos et théorie des catastrophes. A partir de l'œuvre de René Thom*, Geneva 1988, pp. 73-98.

came near to one another. In fact, their conversation in Dali's home was fruitful insofar as Dali produced a series of paintings on catastrophes. In one of them, his last painting called "Swallowtail", Dali cites different elements of Thom's theory: a section of the elementary catastrophe called cusp (unfolding of the unstable dynamic system $V= x^4$) and of the swallowtail (unfolding of the unstable dynamic system $V= x^5$).

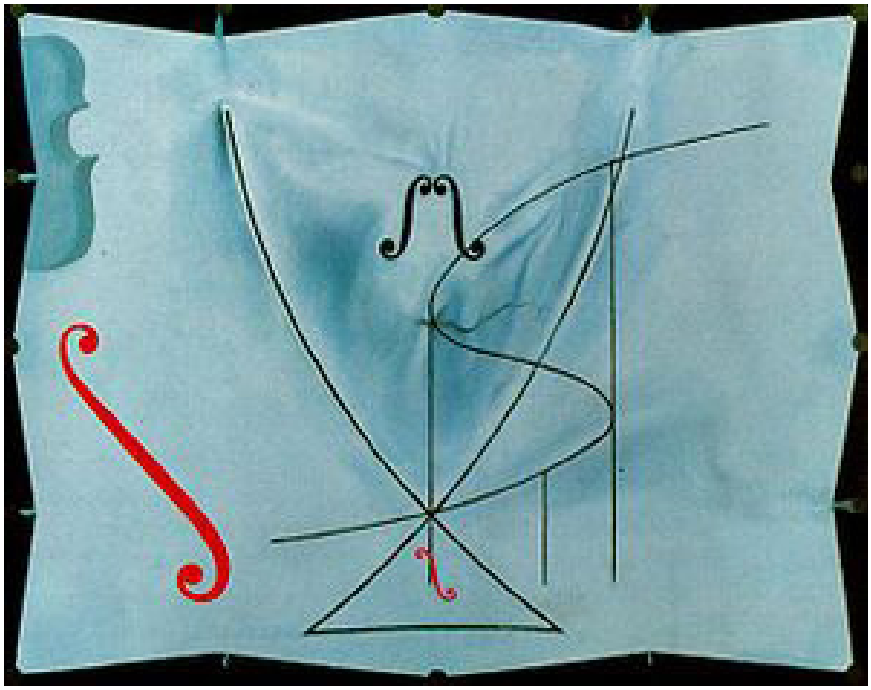


Figure 14 - *The Swallowtail*, 1983

Descharnes and Néret[31] show a photo where the old Dali poses besides this painting. It is an enigma how this painting fits into the life-work of Dali. Is it just a reflection of his admiration for René Thom and for modern science in general, or does it tell us something about Dali's relation to catastrophes, hidden dangers which may suddenly trigger the catastrophe? Great catastrophes have a double nature: first a preparation which is only apprehended by few, very sensitive persons or animals and second the cataclysm which involves many persons and objects. Similarly, it is the symbol of danger and instability, and, during all his life, Dali was very anxious and sensible about imminent dangers.

2.5 Conclusion on revolutions (catastrophes) in art

Innovations in art are more than temporary changes in taste or dominance shifts in the rivalry of schools. They contain at their heart a "problem" and its "solution" by the artist. This has been shown in the case of Leonardo, where the arrangement and the postures in the *Last Supper* contribute to the visualization of the dynamics inherent in the narrative episode represented in the mural.

[31] R. Descharnes – G. Néret, *Salvador Dali, 1904-1989*, Köln 1989, p. 219.

In the series of works dedicated to the triad: Anne, Mary, Jesus, a dynamic configuration with attractors, repellors, forces, weights and counterpoises is visually organized together with a system of sight- and action-vectors. The case studies on Turner and Moore showed the process of symbolic abstraction in landscape painting (Turner) and figural sculpture (Moore) and the directions of their gradual development in the oeuvre of the artists[32]. In the case of surrealism a quasi-political revolution involving programs and establishing leaders and parties of artists can be observed. This shows on one side that its appearance is linked to political events, e.g. the World War I and the destruction of traditional values in its sequel, the strong impact of social struggles, e.g. between fascist and communists movements, anarchistic and Stalinist parties in the Spanish civil war. Nevertheless these political movements were only responsible for a general motivation for change, a search for new values and the negation of traditional value systems including aesthetic values and philosophical positions.

In a last and concluding chapter I would like to ask if a more fundamental parameter is underlying those abrupt changes (catastrophes), i.e. if the logical schemes operating with oppositions (contraries), negation and affirmation are sufficient. This question cannot be resolved by replacing two valued (Aristotelian) logics by three-value logics. We must reconsider the role of continuity underlying all affirmations, negations, oppositions, complementarities etc.

3. Continua underlying intellectual developments, beyond discrete logics

In the mainstream histories of science and art, oppositions and shifts between alternative views and priorities are the dominant patterns of comparison. This may be due to a traditional, logically based dialectics of: true ÷ false in two-valued logics which have been generalized to discursive polarities such as: time ÷ space, wave ÷ particle, energy ÷ matter, realist ÷ idealist, holistic ÷ local, good ÷ bad etc. In this perspective a bipolar shift occurs from position A to B, where A and B are contraries and no intermediate is allowed (cf. the "*tertium non datur*" as basic axiom in two valued logics). Kelso and Engstrøm (2006) argue in favor of "complementary pairs", i.e. the opposition is in many /all cases not exclusive; both of the seemingly alternative choices can be valid. A central topic in their epistemology concerns cooperation. In many systems, the cue is not the opposition between elements or subsystems but the coordination, communication between parts, the emergence of binding phenomena which enable self-organization with

[32] Further semiotic aspects of the art of Leonardo da Vinci have been treated in W. Wildgen, *Visuelle Semiotik der elementaren Kräftefelder der Hände (Gestik) und Augen (Blicke) in einigen Werken von da Vinci und Barocci*, in W. Nöth – A. Hertling (ed.s.), *Körper-Verkörperung-Entkörperung*, Kassel 2005, pp. 149-179, for the directions of gaze and gestures; the iconography of the *Last Supper* was the topic of a chapter in a book on the semiotics of art (in French; Id., Éléments *narratifs et argumentatifs de l'«Ultime Cène» dans la tradition picturale du XIIe au XXe siècle*, cit.). Innovation in art has been analyzed in the context of innovation in language and in science as a chapter of my book on the evolution of human language (Id., *The Evolution of Human Languages. Scenarios, Principles, and Cultural Dynamics*; Amsterdam 2004).

the goal of higher performance and better survival. Basically, coordination is also the key to our understanding of sign use and language. To separate, to distinguish is one intellectual operation valid for specific purposes, but unifying, binding, is an even more important one and in many circumstances even an unavoidable operation. A precondition for such complementarities, or better for the emergence of in-between solutions, transitions and self-organization towards higher performance, is a level of continuity behind the apparent oppositions. The question therefore is: what are the continua behind truth and falseness, realism and idealism, good and bad in esthetic judgments. In the first section I have shown how bipolar or tripolar fields emerge in a continuum with reference to the elementary catastrophes called: *cusp* (germ: $V = x^4$) and butterfly (germ $V = x^6$). But what does the underlying continuum mean? How can we interpret the internal variable x and the quick dynamics which governs the shift, the transition, the catastrophe?

In philosophy, we may start from two infinitely remote, epistemologically untouchable positions. The individual Ego (beyond his/her socialization, beyond gender, beyond learning processes) as the individual genetically prefigured **Self** on one side and objectivity as such (beyond human perception and comprehension) the classical "Ding an sich" (**Object** in itself) discussed by Immanuel Kant. These opposed poles are epistemologically inaccessible, but we find a continuum of positions between them. This continuum may be exemplified by mentioning several sub-fields which show up in epistemological discourse:

- Earliest perceptions of the individual (in the womb, immediately after birth etc.),
- First categorical judgments, precursors of language specific classifications,
- Linguistically mediated judgments,
- Observational data in empirical science,
- Hypotheses and theories in the sciences.
- Unified theories in scientific fields, such as a theory of everything in physics and cosmological models (e.g. the big bang model)
- Metaphysical speculations as those found in religious contexts.

This list is not exhaustive; further positions may exist between any of the terms mentioned. Therefore, if we choose two different positions on the scale, they may appear to be in a kind of dual opposition; in reality they are only different and at a specific distance on the continuous scale and we can always find an intermediate position which diminishes the distance and contains features of both.

In art, the two poles of (aesthetically) *good* and *bad* are also elusive, inaccessible and they depend on the above discussed scale of Self versus Object, insofar as art has always an anchor in individual taste, feeling, subjective reaction and cannot be completely or even in major concerns be objectified. "De gustibus not est disputandum" was the neo-Latin dictum: *Don't discuss on*

taste![33] Nevertheless, humans constantly do so and cannot avoid doing so. The problem is that the points of reference of good and bad in aesthetics are floating dependent on many contingent factors. In a coherent community, where specific aesthetic standards of taste have been fixed, everybody may adhere to a specific judgment with the result that all participants not belonging to this community are rejected as tasteless.

Art is, however, as many specialists of aesthetics would agree, more than just taste and although the values attributed to artwork may change over time and be dependent on geographical and political contexts, there seems to be a stable kernel of "good" art and a separating line to "bad", insufficient, unskilled … artwork. The basic factors of general aesthetics may be the two dimensions proposed by René Thom in his theory of 'prégnance' (biological relevance) and 'saillance' (perceptual salience). The second factor may be accessed via the psychology of art; cf. the work of Arnheim who translated the psychology of Gestalt of his masters (Wertheimer, Koffka) into an aesthetics of visual art[34]. The first factor may in majority be responsible for cultural differences, because in different social, political and economic contexts the biological/social/economic (survival) value or the criteria of success can be very different. One major factor is the place that artwork and artists occupy in a specific society and how much space / freedom is conceded to artists. In critical periods, the whole domain of art (and playful use of human capabilities) may collapse. Such cultural catastrophes are also catastrophes in the usual, non-technical reading. The end of the Roman Empire in Western Europe was such a cultural catastrophe, the arrival of Europeans in the Americas was a cultural catastrophe for the amero-indian populations, and the Nazi-regime was a cultural catastrophe in Germany etc. After the catastrophe, new developments may emerge with some delay, such that the catastrophe, if it is not a total one (e.g. the extinction of a nation or of mankind), allows for a renewal which activates on one side the basic human capacities for culture and esthetics and on the other side puts together the few remains of the former cultural level. Thus the Italian Renaissance and humanism were able to recover many lost elements of the Egyptian, Greek, and Roman culture (via Byzantium and the Arabic traditions present in Spain) and to reconstruct parts of the lost heritage. With these stimulations, new developments based on the drives inherent in European (Italian, Spanish, French, and German etc.) cultures could take place. The classical picture of this after-catastrophe

[33] It is probably derived from neo-scholastic philosophy: „De gustibus et coloribus non est disputandum ». A non-authentic anecdote says that Julius Cesar presented with asparagus in butter instead of olive oil in Milan, spoke the sentence "De gustibus non est disputandum" in order to mediate the Roman disgust of butter in the kitchen, which was considered as barbarian.

[34] Cf. J. Verstegen, *Arnheim, Gestalt and Art. A Psychological Theory*. Wien 2005, and, as a summary, W. Wildgen, *Visuelle Semiotik*, cit, chapter 1.1.4.

scenario is the Phoenix rising from his ashes. It is documented since very early civilizations (Egyptian etc.).

Figure 15 - Miniature of the phoenix in the Aberdeen Bestiary (Library of Aberdeen University, probably 12th century)

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