Catastrophe Theoretic Semantics

An elaboration and application of René Thom's theory

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An Elaboration and Application of René Thom's Theory

by

Wolfgang Wildgen
University of Bremen, West-Germany

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TO MY SON IVO LUDWIG

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INTRODUCTION*

The proposals made by René Thom for a radically new model of semantics based, not on logical schemata, but on deep dynamic principles, entered the field of scientific discussion in the late sixties, but until now they have neither been refuted nor been applied within a strictly linguistic framework. The present essay is an attempt to fill this gap by giving a short critical appraisal of Thom's position and by developing it systematically in order to place it within a modern semiotic and linguistic framework. As there already exists a number of introductory and general books on catastrophe theory (Poston and Stewart 1978; Woodcock and Davis 1978; Gilmore 1980; Saunders 1980) we shall rather be concentrating here on the specific construction of a model of semantics, in order to enable the reader to follow and evaluate the concrete working of this model. It is hoped that the clarification and concretization of Thom's model will help other linguists to gain access to this rather difficult domain of research.

Our extended version of Thom's topological and dynamic semantics is more exhaustive than the original, as it covers more phenomena; in addition it reveals a hierarchy of higher archetypes, thus proposing a natural basis for dynamic operations on elementary propositions. Many of the derivations by Thom which were unclear in his writings can be shown to be correct or may be derived starting from slightly different assumptions. The topological model gives us a rich typology of basic (archetypal) processes. In opposition to Thom, we do not think that catastrophe theory can serve directly as a complete semantics of natural languages. It describes, and to a certain extent explains, the most fundamental and therefore irreducible inventory of cognitive scenarios for dynamic phenomena. These abstract schemata are an underlying repertoire, which can be uncovered in considering the structure of specific languages. They constitute a kind of preconventional basis for linguistic systems, thus controlling the social shaping of linguistic conventions (cf. section 5.2.) and guaranteeing at the same time human interlanguage communication (compare Wildgen 1978a,b). The structures found in a particular language can elaborate the archetypal basis in several ways:

(a) If on pragmatic grounds a subset of archetypes is not realized, it exists as a latent possibility which is actualized as soon as language use calls for it.

In this sense the set of archetypal patterns can be compared to basic schemata of colour perception (cf. section 4.2. for the dynamics of the colour lexicon).

(b) The archetypal structure can be realized in different ways. It can appear as an implicit structuring of the lexicon (on the level of dynamic lexical fields), it can be grammaticalized in the form of cases, prepositions, markers of aspect or be represented as a basic level in the organisation of utterances. It would be an interesting undertaking to compare languages under this perspective and to group them typologically. We cannot hope that the whole set of archetypal processes is realized at one level, in one language. We shall rather assume that the archetypal system is only partially represented in each particular language and that its representation is in no way unitary, i.e. we can find traces of these archetypes in different domains. In chapters 4 and 5 we sketch the realization of semantic archetypes at some of the important levels of a theory of language: phonology, word semantics, syntax, textual organisation and conversation.

(c) Semantic archetypes are holistic entities: linguistic gestalts. This feature can be mathematically derived from catastrophe theory. Nevertheless we can define the concept of dynamic inference (cf. section 4.1.) which interrelates the different archetypes. Basically the existence of such gestalts is in opposition to the Fregean principle of compositionality, which in our perspective is valid only for the superficial aspect of language transmission as it adapts the "inner" form of language to the acoustic channel. Language is basically multidimensionally organized. The results of verbal planning are projected into a low dimensional space of realization. The archetypal reduction of the multidimensional cerebral field to very few and highly structured configurations is a precondition for the later transmission by an acoustic channel (the reduction at the archetypal level is immense if we compare the number of 10 billions of possible individual activities in the brain (cf. Zeeman 1962) to maximally eight, normally less than five external parameters in the catastrophe theoretic model). Compare Wildgen (1979: 468-494) and Wildgen (1980). Moreover linguistic gestalts can be detected beneath *and* above the level of those entities whose surface form is not composite:

(i) Linguistic forms can be simple on the surface level and yet be composite semantically. The archetypal level is therefore found after semantic decomposition has taken place. Compare Wildgen (1981c) and section 4.2..

(ii) Linguistic forms can be complex and yet represent one gestalt. Such gestalts can even appear at the higher levels of text and dialogues. Our holistic model is therefore not specialized to one single level of linguistic organisation. It can be applied as a summarizing and organizing schema at different levels. Our applications will mainly consider this level of realization (in chapter three together with the derivation of the set of semantic archetypes and directly in chapter four and five).

1. APPLIED CATASTROPHE THEORY: A SHORT INTRODUCTION

1.1. *A sketch of the mathematical basis*

The main result of mathematical catastrophe theory consists in the classification of unfoldings (= evolutions around the center (the germ) of a dynamic system after its destabilization). The classification depends on two sorts of variables:

(a) The set of internal variables (= variables already contained in the germ of the dynamic system). The cardinal of this set is called *corank.*
(b) the set of *external* variables (= variables governing the evolution of the system). Its cardinal is called *codimension.*

In table 1 we show that the existence of a finite class of types depends on the number of external variables (the codimension). A finite classification is only possible when the codimension is smaller than 6 (cf. Gilmore, 1980:31).

codimension	1	2	3	4	5	6 ··· n−1
cuspoids corank = 1	A_2	A_{+3} A_{-3}	A_4	A_{+5} A_{-5}	A_6	$A_7, \ldots, A_n$
germ	x^3	$+x^4, -x^4$	x^5	$+x^6, -x^6$	x^7	$x^8, \ldots, x^{n+1}$
umbilics corank = 2			D_{+4}, D_{-4}	D_5	D_6 E_6	D_7 ..... E_7 ......
germ			$x^2y \pm y^3$	$x^2y + y^4$		
corank = 3	No simple germs in the sense of Arnold (1972)					

Table 1.

The *A*-unfoldings are called *cuspoids*, the *D*-unfoldings *umbilics*; applications of the *E*-unfoldings have only been considered recently (cf. Callahan 1982). By loosening the condition for topological equivalence of unfoldings, we can enlarge the list, taking in the family of *double cusps* (X_9) (cf. Poston and Stewart 1978: 121) which has codimension 8. The unfoldings A_3 (the cusp) and A_5 (the butterfly) have a positive and a negative variant A_{+3}, A_{-3}, A_{+5}, A_{-5}.

We obtain Thom's original list of seven "catastrophes" if we consider only unfoldings up to codimension 4 and without the negative variants of A_3 and A_5. Table 2 gives the list of unfoldings; their characteristic features will be described in chapter three.

Class	Name	Germ	Unfolding
A_2	fold	x^3	$x^3 + ux$
A_3	cusp	x^4	$x^4 + ux^2 + vx$
A_4	swallowtail	x^5	$x^5 + ux^3 + vx^2 + wx$
A_5	butterfly	x^6	$x^6 + tx^4 + ux^3 + vx^2 + wx$
D_{-4}	elliptic umbilic	$x^2y - y^3$	$x^2y - y^3 + ux^2 + vy + wx$
D_{+4}	hyperbolic umbilic	$x^2y + y^3$	$x^2y + y^3 + ux^2 + vy + wx$
D_5	parabolic umbilic	$x^2y + y^4$	$x^2y + y^4 + uy^2 + vx^2 + wy + tx$

Table 2.

In Thom (1970: 242, 246ff) the author argues that "gestalts" are locally constituted by maximally four disjoint constituents which have a common point of equilibrium, a common origin. This restriction is ultimately founded in Gibb's law of phases, which states that in three-dimensional space maximally four independent systems can be in equilibrium. In Thom's natural philosophy, three-dimensional space is underlying all abstract forms. He, therefore, presumes that the restriction to four constituents in a "gestalt" is a kind of cognitive universal. In spite of the plausibility of Thom's arguments we shall make the weaker assumption that the number of constituents in a gestalt should be finite and small. With this restriction we can select the unfoldings with simple germ in the sense of Arnold (1972) as a basis of our derivations. All unfoldings with codimension (i.e. number of external variables) smaller than or equal to 5 have simple germs. The unfoldings with corank (i.e. number of internal variables) greater than two have moduli. Table 1 contains the list of unfoldings delimited by these criteria. In chapter 3.6., we shall consider an unfolding with codimension 6 and corank 1 (the Star) because all unfoldings with corank 1 have simple germs (cf. Gilmore 1980: ch. 3). As the derivations in chapter 3 will show, the most prominent semantic archetypes will come from those unfoldings already considered by René Thom in his sketch of catastrophe theoretic semantics.

The mathematics of catastrophe theory are of rather recent data and a rapid development in this field can be expected. The results obtained by Thom, Mather and Arnold constitute, however, the kernel of every mathematical theory in this domain. The mathematical basis of our model can therefore be considered a very solid one.

1.2. *Catastrophe Conventions.*

The clear-cut results of catastrophe theory are partially due to the fact that in the larger framework of a theory of dynamic systems this theory presents the first and most elementary step. In the hierarchy proposed by Gilmore ("Where Elementary Catastrophe Theory Lives", Gilmore (1980:5)) it occupies the lowest stage labelled: Equilibria of Gradient Systems. As a consequence every application of catastrophe theory gives rise to a fundamental problem: one must apply this theory in situations which are normally too complex. More complete models are, however, either not available or they are too complicated. In this chapter we shall introduce some conventions to deal with this problem. These conventions introduce a new type of dynamism, which could be called thermodynamic or dissipative.

I. Prigogine in his book *From Being to Becoming – Time and Complexity in Physical Sciences* considers catastrophe theory (C.T.) to be a dynamic theory in which thermodynamic diffusion can be neglected, i.e. C.T. is a rather 'static' and conservative dynamic theory. None of the less 'static' theories, however, have the clarity or the classificatory power of C.T.. The conventions which will be introduced schematize the possibile dissipative features in such a way that we obtain two extreme types.

(a) The delay convention.
The dynamic system remains in an attracting state until the state ceases to exist. In a sense, the system has no 'knowledge' of other stable attractors and their potential; it reacts only locally.

(b) The Maxwell convention.
The system seeks to reach immediately the state which globally minimizes the potential. We can say that it has 'knowledge' about the global situation.

The choice between these two extremes depends on the rate of diffusion or fluctuation in a given dynamic system. If there is no diffusion or fluctuation, we apply the perfect delay convention. This convention presupposes that we know the initial state of the system. The system reacts as if it could "remember" this initial state.

If the system is rather "nervous" or if we deal with a stochastic system, we should preferably apply the Maxwell Convention. Parts of the system fluctuate and can thus "explore" other minima of the potential. We shall give an example of the operation of both conventions in chapter 1.4.

In our setting up of a semantic model, it is difficult to decide which one of the conventions to choose. As the Maxwell convention is more general, including 'noise', we prefer to use it in the case of compact catastrophes, i.e. when no global minimum at $-\infty$ exists. René Thom proposed choosing the Maxwell convention with physical interpretations and the delay convention with biological ones. He derived his archetypes of capture and emission, however, by using the Maxwell convention. We conclude that both possibilities should be systematically considered until more is known about the processes underlying the recognition of events and their cognitive storage.

1.3. *The finite set of typical paths in the elementary unfoldings*

The 15 separate unfoldings are only the basis from which the set of dynamic types can be derived. Dynamic primitives, which we may with Thom call archetypes, describe events in which a state of affairs (a stable state) is changed or created. We can find the archetypes, if we consider linear sections through the bifurcation set of the unfolding. Such a linear section is defined in the space of external variables (= variables which control the evolution of the dynamic system; cf. 1.1.). In the case of the *fold*, which has only one external variable, the linear section coincides with the external variable; it can, however, take a different orientation. In the case of unfoldings with more external parameters, where the bifurcation set is a plane or an n-dimensional space, we must find a proper classification of sections which exhausts the structural possibilities of an unfolding. Thom's sections have been chosen more or less intuitively, although he changed his strategy in the course of his later publications. He considered straight lines on the bifurcation set (relative to the geometry of the normal form), curves, circles and in Thom (1973a), he even considered a spiral movement around the centre of the unfolding which is attracted (and after a Hopf bifurcation repelled) by the centre. The general problem of an exhaustive classification of generic sections in the bifurcation set has not yet been solved mathematically. It will be a main concern of this study to find an exhaustive list of dynamically different sections in the bifurcation set. Only if this program succeeds can we derive a finite set of archetypes from the finite set of unfoldings (n= 15). It is clear at the beginning, that the number of archetypes will exceed by far the list of sixteen archetypes proposed by Thom.

We propose the following principles for the establishment of paths in the bifurcation set.

(a) The path has to be generic in relation to the singularity, i.e. it should not go through the germ of the unfolding, nor be in some special position to it (parallel to the bifurcation lines, planes etc., approaching them asymptotically or at a tangent to them).
(b) The path has to be non-intersecting.
(c) The path should be in the neighbourhood of the singularity, i.e. we should consider any approximation to the singularity (except the intersection) as an allowed deformation of the path.

In practice we shall consider straight lines in the bifurcation set (straight in relation to the normal form; as the normal form can be smoothly deformed, these paths are not straight in general); the intuitive classification is simplified by this convention.

The criteria (a) to (c) preclude the asymptotic and circular paths considered by Thom, but we shall show that Thom's archetypes can be derived with our principles.

In the unfoldings with codimension $\geqslant 2$ there exists an infinity of paths fulfilling conditions (1) to (3). We can, however, obtain a finite set of classes, if we consider only the catastrophes, their type, order and number occurring along these paths.

In diagram 1 we show some typical catastrophic structures found in the fold and in the cusp (cf. chapter three for details).

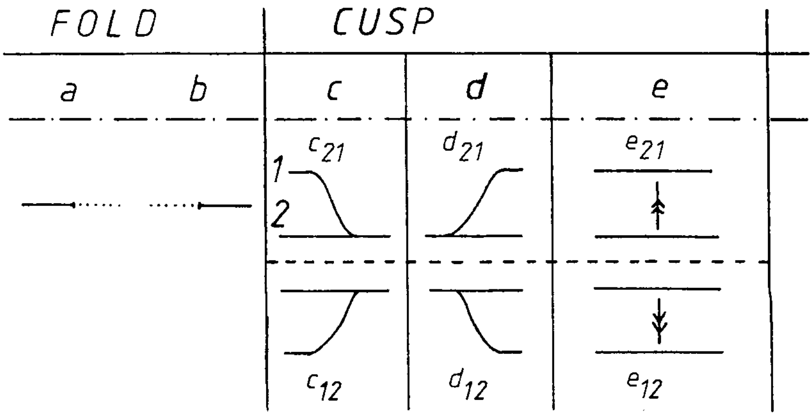


Diagram 1.

Using these types of catastrophic events we can characterize every path in the bifurcation set by an ordered set, called *ordered set of catastrophic features* (=CF) which can be used to classify the infinity of paths into a finite set of equivalence classes.

Def. 1: Two paths *A* and *B* are *equivalent* (catastrophically) if their CFs are identical.

Def. 2: A path *C* is called *composite*, if there exist two paths *C'*, *C"* such that the concatenation of their CF's is identical with the CF of C.

Def. 3: A path *D* is *simple*, if it is not composite.

These notions will be applied in the next section (see especially diagrams 2 and 3).

1.4. *An example: the standard cusp*

This section not only applies the concepts defined in the last section, it also introduces those techniques of catastrophe theoric modelling which are necessary for an understanding of our derivations in chapter three. For a more detailled introduction the reader is referred to Wildgen (1979: 71-108) and Wildgen (1981c: 247-262). Mathematically richer treatments are contained in

Poston and Stewart (1978) and Gilmore (1980).

Organizing center: (1) $V = x^4$

Unfolding: (2) $V = x^4 + ux^2 + vx$

Set of critical points: Σ : { (x,u,v) such that (3) obtains}

(3) $\frac{\partial V}{\partial x} = 4x^3 + 2ux + v = 0$

Bifurcation set: BIF: { (u,v) such that (3) and (4) obtain}

(4) $\frac{\partial^2 V}{\partial x^2} = 12x^2 + 2u = 0$

The solution of (3) and (4), such that the internal variable x is eliminated, gives us a semi-cubic parabola described by

(5) $27v^2 + 4u^3 = 0$.

As the unfolding of $V = x^4$ is contained in $\mathbb{R}^4$ (the dimensions being: V,x,u,v) we cannot represent it graphically. Fig. 1 gives the graph of the set Σ .

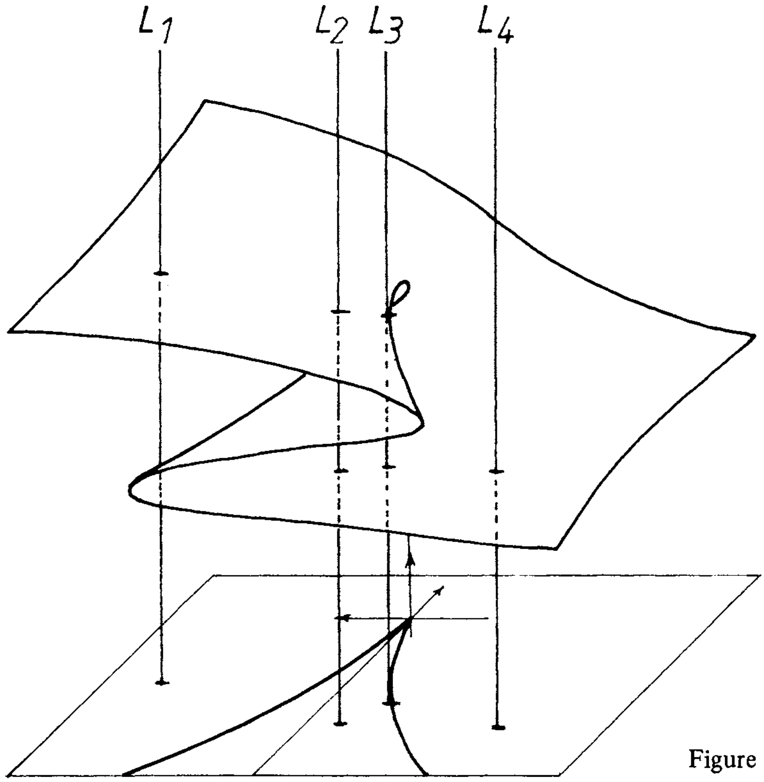


Figure 1.

We can represent the graph of the function V for single points in the plane of external variables (u,v). The lines $L_1, \ldots, L_4$ in Fig. 1 show that the number of critical points depends on the values one chooses in the (u,v)-plane. In Fig. 2 we show the potential function V along the parallels L_1, L_2, L_3 and L_4 (lines in (x,u,v) with u and v constant).

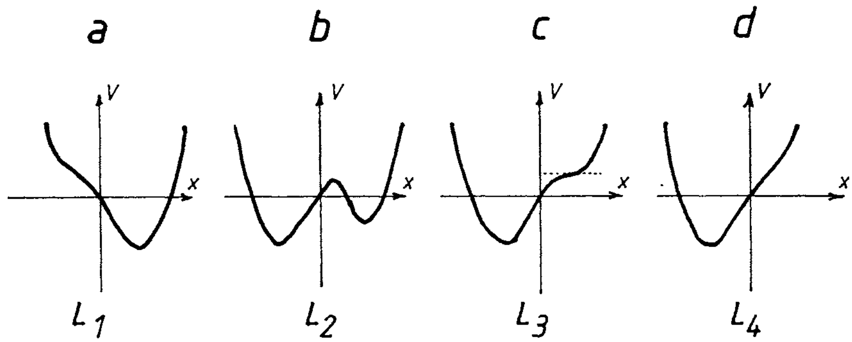


Figure 2.

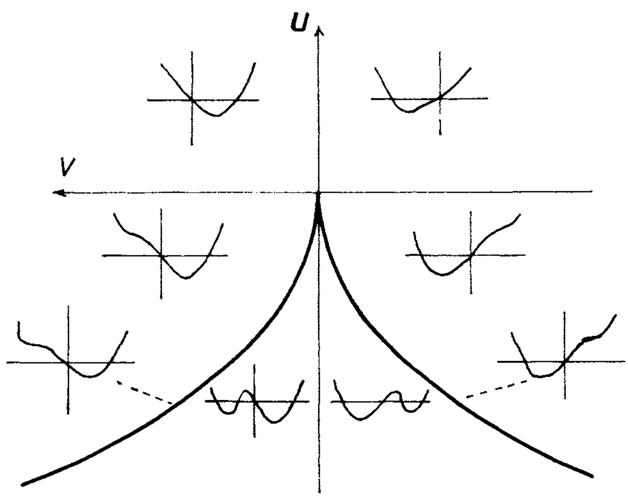


Figure 3.

In Fig. 2(a) and (d) the potential V has just one minimum (as the lines L_1 and L_4 cut the catastrophe set only once); in (c) there is a saddle-point and in (b) the function V has three critical points: two minima and one maximum. Line L_2 cuts through the 'conflict-area' where two attractors (minima) coexist. The different areas are defined by equation (5). Fig. 3 shows the graph of the semi-cubical parabola together with the graph of the function V dependent on x at single points in the (u,v)-plane.

As the actual processes described by this dynamic model change the external parameters u and v, we can represent them by different paths in the (u,v) plane. There are four classes of simple paths in the bifurcation plane of the cusp (cf. section 1.3. and Wildgen 1979: 215-227). Fig. 4 shows the paths K_1,K_2,K_2' and K_3. We have added a path K_4, which is composite, in order to illustrate the distinctions introduced in the last section.

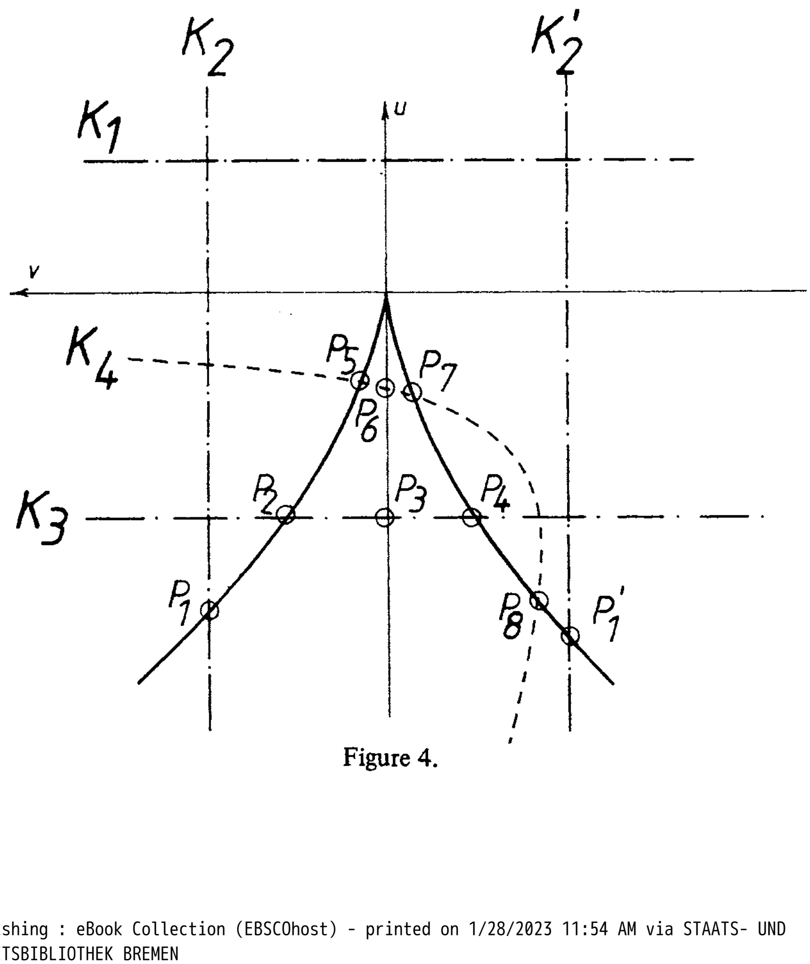


Figure 4.

The character of the corresponding processes can be read from the representation of the potential function $V(x)$ at different points of the paths. If we consider the 'evolution' of V along K_1 we see that no dramatic change happens. On the path which describes the evolution along K_2 a simple minimum bifurcates and we get a conflict of two minima. On the path K_3 we have a conflict area in the middle. There is a new minimum appearing at the intersection of K_3 with the bifurcation line at P_2. The old minimum disappears at point P_4. The conflict of minima is resolved by a change in dominance. Whereas K_2 encounters one catastrophic point in P_1 which is a bifurcation point, K_3 crosses two bifurcation points (P_2,P_4) and one conflict point (P_3) in the middle of the conflict area. K_3 is therefore catastrophically richer than K_2.

The relevant dynamic features of the classes of paths K_1, K_2, K_2', K_3 can be described by their CF (i.e. their set of catastrophic features, cf. section 1.3.).

$CF(K_1) = \{\phi\}$
$CF(K_2) = \{d_{21}\}$ or $\{c_{21}\}$ depending on the direction
$CF(K_2') = \{d_{12}\}$ or $\{c_{12}\}$ of the path
$CF(K_3) = \{d_{21}, e_{21}, c_{12}\}$ or $\{d_{12}, e_{12}, c_{21}\}$ "

The CF-sets show, that the paths K_1,K_2,K_2' and K_3 are simple; none of the CFs can be constructed by the concatenation of other CFs. It is immediately clear, that an infinite set of paths is equivalent to K_1,K_2,K_2',K_3; we need only displace these paths, preserving their intersecting qualities relative to the bifurcation lines. In Fig. 4 we have marked with a dotted line a path K_4 which has three intersections with the bifurcation line (P_5,P_7,P_8). Its catastrophic features are shown in diagram 2.

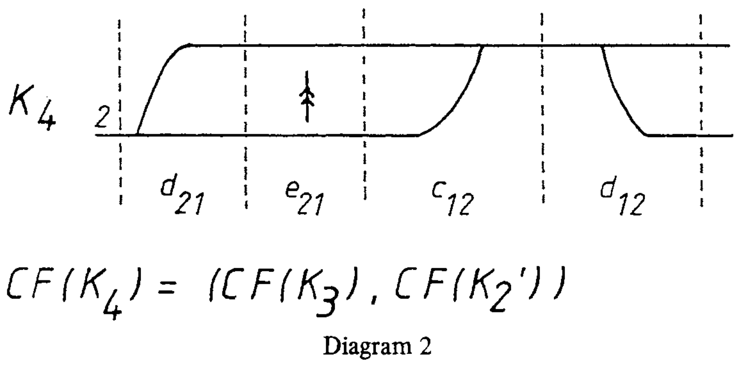
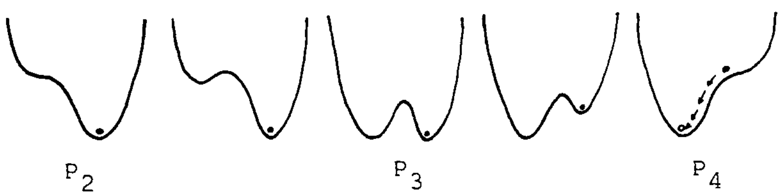


Diagram 2

We get the CF of K_4 if we concatenate the CF of K_3 and of K_2'. K_4 is therefore not simple but composite. Note, however, that K_3 is not minimal, in the sense that it contains sequences of catastrophic features already present in K_2 and K_2'. The conflict catastrophe e_{12} is the only new element in K_3. If by the use of the perfect delay convention (cf. section 1.2.) conflict catastrophes are neglected, K_3 becomes composite. It follows that the interpretation becomes simpler and poorer under the perfect delay convention. The paths K_2 and K_2' (with v a positive or negative constant) can be called symmetric, as the u-axis is a line of symmetry in the cusp. Thus K_2 and K_2' are equivalent in a wider sense. As v is not a line of symmetry, the different directions on K_2 and K_2' lead to different types of processes, which will get different interpretations. K_3 is perpendicular to the u-axis, the two directions on K_3 get the same interpretation. We could only sketch the principles of classification; a complete definition and demonstration of the procedures applied would be mathematically too complicated.

Until now we have only considered the appearance, disappearance, existence and coexistence of attractors (= minima). If we introduce one of the conventions (cf. chapter 1.2.), the dynamical system must always choose *one* optimal attractor. We shall exemplify the application of the two conventions discussed in paragraph 1.3. taking the path K_3 (in Fig.4) as an example. In Fig. 5 we show the different configurations of the potentials when moving along K_3 (in Fig. 4).

(a) Delay Convention



(b) Maxwell Convention

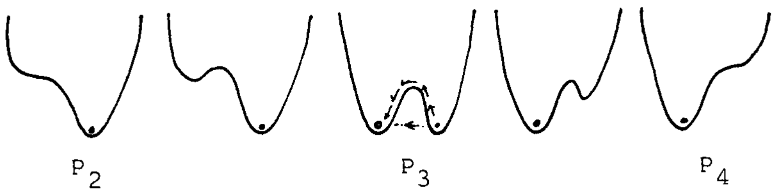


Figure 5.

Moving from P_2 to P_4 we get different catastrophic points. We shall give more examples when we derive the set of semantic archetypes in chapter 3.

2. SEMANTICS FROM A DYNAMIC PERSPECTIVE

Our dynamic perspective is first applied to semiotics, thus scheduling the frame of our notion of semantics. In the following sections we sketch the program of dynamic semantics underlying our model.

2.1. *Aspects of dynamic semiotics*

We must go back to the semiotics of Charles Sanders Peirce (1839-1914) who was a contemporary of Frege. His logical and semiotic conceptions are a good framework for the development of a dynamic semantic theory, because he was not yet affected by the reductionism typical of the semantics proposed by logicians (Wittgenstein was the most lucid critic of this "philosophy"; cf. Wildgen (1977a: 128-133)).

Peirce understands the semiotic sign as a triadic (irreducible) relationship between: representamen, interpretant and object.

> "A sign, or *representamen*, is something which stands to somebody for something in some respect or capacity. It adresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the *interpretant* of the first sign. The sign stands for something, its *object.* It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the *ground* of the representation. "Idea" is here to be understood in a sort of Platonic sense very familiar in everyday talk;" (Peirce 1954:2.228)

A first consequence of the irreducible triadicity of the sign is that although semantics is primarily concerned with the relation between *representamen* (sign form) and *object*, the relation of both to the interpretant cannot be simply eliminated. Unlike realistic semantics we must consider the 'subjective – internal' aspect of meaning. Semantics without consideration of the user is nonsense, because objects are only correlated with signs (representamens) in the context of the semiotic activity of a sign user. A secondary consequence concerns the relation of semantics to psychology and sociology. As the semiotic act has psychological and sociological aspects, every semantic analysis has to be integrated into the field of socio- and psycholinguistic research. The splendid isolation of logical semantics is theoretically unsound.

The relation between representamen and object (Peirce's Secondness) can be subdivided into three aspects: Icon, Index and Symbol. These aspects are ordered insofar as *Index* uses iconic principles and *Symbol* makes use of iconic and indexical devices. The iconic aspect is therefore the fundamental aspect of the relation between sign and object. Semantics must for this reason have an iconic foundation.

> "The only way of directly communicating an idea is by means of an icon; and every indirect method of communicating an idea must depend for its establishment upon the use of an icon. Hence, every assertion must contain an icon or a set of icons, or else must contain signs whose meaning is only explicable by icons." (Pierce 1965:2. 278)

An icon can be an *image,* a *diagram* or a *metaphor* (Peirce 1965:2.277). Its prominent feature is the similarity of object and representamen. The philosophical reflections of Peirce become more concrete if we interpret our perception and memory as a sort of similarity transformation from the outer world which is perceived and experienced to the inner world of thought and behavioural planning. The iconic basis of semantics is in this perspective correlated with a world of cognitive analoga in the mind of the sign users.

Peirce's conception of a similarity as the basis of the iconic aspect of things is too rough. There are two aspects which have to be added:

(a) Stability.

As the similarity underlying the iconic relation is always partial, it is astonishing that changes in situations and different constellations of sign users do not destabilize the similarity. Each term of the triadic relation is exposed to deformations. The object in the triad can take different forms in time. The sign can change in time or with different sign users. The interpretants themselves are exposed to social and psychological variation. Moreover the kernel of the similarity relation, i.e. those features which are constitutive for the existence of a specific iconic relation can change without dramatically altering the relation. The calculi developed in differential topology over the last twenty years allow a theoretically much more precise modelling of the nature of the iconic relationship.

(b) Selectivity.

Even a photograph reproduces the object only modulo certain simplifications. Selectivity becomes even more dramatic if we consider diagrams or metaphors. Two sources of selectivity can be considered:

(i) Catastrophic selectivity. Our internal model of the world selects prominent features, i.e. it prefers dramatic (high energy) features to smooth (low energy) features. Looking at a picture, the eye follows the edges, the lines which separate relatively smooth areas. The borderlines are lines of catastrophic changes (changes from one area to another). Looking at an event we select periods of rapid change for the focussing of our attention and for memory storage.

(ii) Social selectivity. Certain features are of special interest for our self-evaluation, social position and our goal-oriented activities.

In our theory of archetypal dynamics we shall consider aspects (a) and (bi); aspect (bii) should be elaborated in a socio-psychological framework. We call this level socioattributive dynamics.

In his article "De l'icone au symbole" René Thom gives an excellent and very rich semiotic examination and elaboration of Peirce's trichotomy: icon, index and symbol. He points out that the semiotic process is:

(a) A kind of transformation in space-time, i.e. objects situated in space and time are the real substance of human semiosis. He concludes: "Every ontology, all semantics have to start from an investigation of space – be it a geometrical or a topological one." (Thom 1973b: 249).

(b) The second basis of semiotics is selfregulation, which has two main tasks. On the one hand it helps positive changes and events, thus achieving necessary biological activities such as: chasing, seeking, producing, manufactoring, taking, eating etc. On the other hand it helps to prevent negative catastrophes. Index signs are references to future catastrophes or traces of past catastrophes. At primitive evolutionary levels all signs are imperative or performative; i.e. they help to guarantee survival and to control actions. As signs became longer and more complex, this global regulatory force was no longer characteristic of the constituents of the sign-complex. The constituents realized a secondary function, which can be called descriptive (compare Thom, 1973c: 246).

The semiotic theory of René Thom is the most advanced holistic theory existing today. It would be an important undertaking to explore the details of his arguments and the consequences of his proposals. In this book we shall try rather to unfold Thom's proposals for a semantic theory. We hope that the sketch of his semiotic theory given in this section will be an aid to understanding his semantics.

In spite of the fact that our dynamic programme for semantics departs from more traditional positions taken currently in semantic theory, we shall try to show the positions of both our model and Thom's in relation to present theorizing in semantics. As the dynamic view is basically a holistic one, we shall first consider an advanced holistic proposal by Fillmore (1977b). As our model is a formal one we shall compare it in section 2.3. to modern logical semantics.

2.2. *The type of semantics aimed at by our model construction*

In a certain sense every model construction creates its object. This is true insofar as the relevance of problems, questions and the direction of explanatory enterprises depends on the theoretical framework one chooses. It is not true insofar as there exists a kind of common sense perspective on the objects of research, which in a natural way calls for the unity of the field. Thus we can choose a special perspective when we build a model, but we must make sure that this partial perspective can be integrated into the common sense view (in extreme cases the common sense view can, however, be dramatically changed by scientific results).

René Thom took his compatriot Tesnière, one of the founders of dependency grammar, as a linguistic reference and tried to represent the "schémas actantiels" of Tesnière in his framework. Today, other semantic models have been put forward which are much nearer to Thom's enterprise and which are more adequate as a linguistic background. In Wildgen (1979: 109-194) we gave a comprehensive overview of the holistic models for the description of sentences put forward since Panini (400 B.C.). Tesnière (1959) represents a single phase in this evolution. It would be interesting to discuss this development here, but lack of space forces us to choose one of the preliminary endpoints of this line: the frames-and-scenes semantics proposed by Fillmore (1977b) and accompanied by similar proposals in the research on Artificial Intelligence.

The keywords of this new development are "frame", "scene", "perspective of a scene", "scenario", "script", "knowledge representation" and "semantic memory", In his article "The Case for Case Reopened" (1977a), Fillmore reviews the criticism of his theory of deep cases (Fillmore 1968). He regrets the lack of consensus in the classification of deep cases (the proposals ranged from three to about seventy). As a consequence, he puts forward a more general concept: "frame structures". Using specific "perspectives", the case frames can be derived from these more universal structures. Fillmore calls those frames which describe events in their prototypical shape "*scenes*". As a central example he discusses the scene called "commercial event", which represents an exchange between different persons. The scene has several centres which can be focussed on: the seller, the buyer, the objects exchanged, the money, the values of the objects and of the money and other factors such as the time and place of the event. In a minimal sentence we select parts of this scene, focussing on single phases of the event. We use subframes of buying, selling, taking, giving, paying etc. A specific choice of noun phrases and verbs realizes such a perspective on the scene, indicating simultaneously the background of the subframe focussed on, i.e. those parts of the scene which are cognitively present but not realized in expressed language forms. Fillmore says:

> "The study of semantics is the study of the cognitive scenes that are created or activated by utterances. Whenever a speaker uses ANY of the verbs related to the commercial event, for example, the entire scene of the commercial event is brought into play – is "activated" – but the particular word chosen imposes on this scene a particular perspective." (Fillmore (1977a: 73)

The concept of a "cognitive scene" points to a psycholinguistic model which seems to be the ultimate goal of Fillmore's semantic theory. Fillmore continues:

> "what I mean is that we choose and understand expressions by having or activating in our minds scenes or images or memories of experiences within which the word or expression has a naming or describing or classifying function." (Fillmore 1977a: 74)

It becomes clear that Fillmore has left traditional grammatical theory to follow the direction of a theory of language which comprehends language as a kind of intelligent symbolic activity on the basis of perception and cognition. That is, he considers language theory to be a central part of a global theory of human mind. He says:

> "One of the goals of the kind of frame that I am speaking for is that of having a uniform representation for word meanings, sentence meanings, text interpretations, and world models" (Fillmore (1976a: 28)

Frames, scenes and schemata are not independent of one another but are organized into systems, which are called "semantic networks" (in the sense defined in Artificial Intelligence) or "semantic memory" (in the sense defined in Cognitive Psychology).

Fillmore hoped that his framework could help to solve the problems of case theory which he reviewed in Fillmore (1977a):

> "I believe now that there might be a solution. It involves what I said earlier about meanings being relativized to scenes." (Fillmore 1976a: 72)

Fillmore's design of a new language theory is lucidly programmatic and we hope that catastrophe theory can furnish the classificatory schemata Fillmore is eager to find.

2.3. *Formal semantics on the basis of catastrophe theory: a comparison with logical semantics*

In this section we shall give a modelling procedure adequate for the building of a model of the correlation form-meaning, i.e. of semantics. The formal objects, called archetypal morphologies, can be compared with uninterpreted logical structures which are employed in logical semantics. In contrast to these, our formal objects are:

(a) continuous,
(b) dynamic,
(c) irreducible,
(d) structurally stable.

These features guarantee a much better approximation of real world structures in the plane of referents (denotata). This means that our formal model is world-orientated whereas the logical structures employed in logical semantics are rather language-orientated.

The consequence of the language orientation of all logical models is that the semantic model built on this basis is very shallow. The reduction of linguistic structures to logical structures mirrors typical generalization and simplifications in logic, thus generating a systematic model (via reduction). The basic terms of logic are, however, language-dependent, which means that the reduction is still immanent to linguistics in a wider sense. The correlation of language forms with non-linguistic entities (real world structures) stops at a very poor distance from language forms (and Wittgenstein would even challenge the direction of abstraction, connecting it rather to specific commodities sought by logicians).

In a certain sense catastrophe theoretic and logical semantics seem to be complementary rather than competitive. We shall try to enumerate some of their complementary features.

(a) Catastrophe theoretic semantics is real world-orientated, logical semantics is language- orientated. But it is important to see that compared with classical mechanics catastrophe theory furnishes very rough and qualitative pictures of natural processes, thus taking a human perspective. The criterion of structural stability is roughly correlated with a human criterion of relevance. Logical structures are also tools to capture real world phenomena, but they neglect the whole problem of structural stability and thermodynamic diffusion, choosing an a priori stable, quasi eternal level of consideration. Thus the two procedures are solutions to the same problem.

(b) The main feature of logical semantics consists in the so-called Fregean principle which ultimately is a consequence of the atomistic perspective of these models. The semantic structures derived in logical semantics are heavily dependent on the syntactic combinatorics, i.e. on unidimensional concatenation regularities. They are shallow in the sense that deeper multidimensional regularities, which for the purpose of an optimal transmission in an acoustic code are coded unidimensionally, cannot be found when starting from too simple a combinatorial scheme for the construction of utterances. Whereas the underlying cognitive structures ask rather for a topological model, the complicated convential and historically accumulated patterns of language seem to be more amenable to modelling using combinatorial devices (for instance algebraic and logical models). Thus catastrophe theoretic models cannot replace traditional formal models; they rather fill a large theoretical gap left (and masked) by traditional semantics.

2.4. *Principles of interpretation*

The strategy of interpretation in catastrophe theoretic semantics is similar to the method of indirect interpretation used in model-theoretic semantics (cf. Montague 1970). Instead of a translation of natural language utterances into a formal language and the interpretation of these transforms, we consider a projection of catastrophe theoretic dynamic schemata:

(a) into the set of basic linguistic structures (linguistic 'gestalts', mainly propositional entities),
(b) into the set of basic cognitive structures, which organize the perception, storage and retrieval of events and actions.

This indirect correlation of form and meaning is governed by basic principles; its results achieve a first degree of interpretation, called *basic attibution.* This basic attributional level is structured by the introduction of a hierarchy of levels. In table 3, our method of indirect interpretation is represented schematically (the elaboration of basic attributions is not considered in our semantic model).

The results of the indirect interpretation of simple paths in the bifurcation set of an elementary universal unfolding (called elementary catastrophe by Thom) are called *semantic archetypes*[1].

The attributional process has been experimentally observed by Michotte (1954) and was theoretically elaborated in social psychology by Heider (1958). The normal observer is able to attribute movement, action, causation, motives etc. to rudimentary geometrical and dynamic configurations. Further reseach in this domain constituted the modern field of research called "attribution

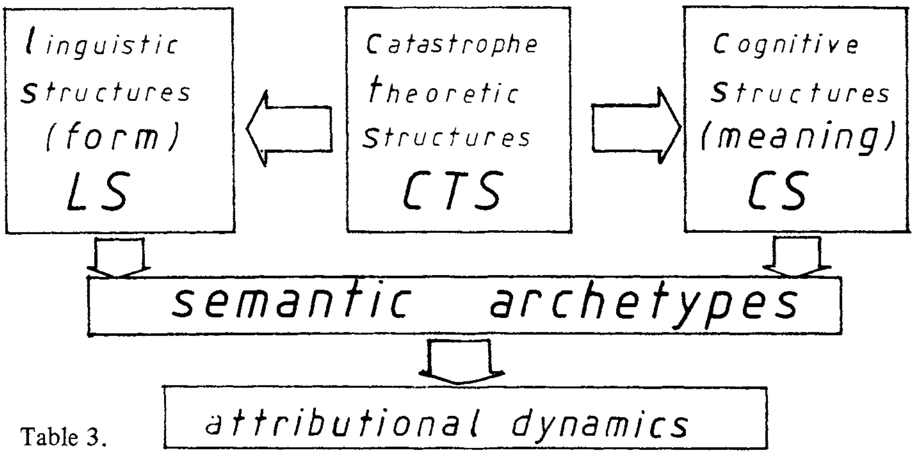


Table 3.

theory" (cf. Görlitz *et al.* 1978).

As the dynamics of attributional processes constitutes in itself a difficult and not yet fully explored domain, we choose a minimal set of attributional procedures containing two principles and one assumption. Two further principles will be added in section 3.7. and 4.1..

Principle 1

The *stable attractors* of an elemenatry unfolding are interpreted as:

LS: satellites of the dynamic centre of a sentence. In most languages these are: pronouns, noun phrases, names.

CS: stable entities, or classes of entities (stable in the real world from the perspective of the language user); such as individuals, objects, substances, natural kinds, qualities, states and phases in a dynamic frame, etc.

Principle 2

The *catastrophes* occurring along a simple path are interpreted as *semantic archetypes*, i.e. they are attributed to:

LS: verbs and other expressions designating the kernel of a gestalt (relational terms, terms with strong valence); expressions of change, event, action and interaction linking stable states, agents or parts of agents (limbs).

The precise subdivision between dynamic parts of speech, which are the centres of valences, and the complementary roles, depends on the type of language, i.e. it can be conventionally fixed.

CS: In the perceived and cognitively stored real-world experience, events (changes in state, position, quality, etc.) and actions are the correlates of the set of catastrophic processes in the formal model.

Catastrophe theoretic semantics can therefore be compared to event and action logic. These subdisciplines lack, however, a true concept of dynamism and do not contain a mathematically derived classification of events and actions. Catastrophe theoretic semantics can be considered a better context for the intuitive ideas developed in the logic of action (cf. Wildgen 1979:190-193 for a short summary).

Assumption

We assume that the attributive process has different levels of elaboration which operate on the same formal basis. We distinguish:

(a) the localistic interpretation,
(b) the qualitative interpretation.
(b) the phase interpretation,
(d) the agent interpretation,
(da) the possession/transfer of possession interpretation,
(db) the (instrumental) interaction interpretation.

(ad a) *The localistic interpretation*

This interpretation is either an abstract one, i.e. concerns only the mere existence of objects and beings, their appearance upon the scene (birth), their disappearance (death), their reappearance, simultaneous existence etc., or it refers to concrete places and domains. The existence of an object, being etc. is given by the existence of a stable attractor; in this sense existence in catastrophe theoretic semantics is more than existence in logic (as indicated by the quantor $\exists$). An object exists if it is stable in time and space (relative to the observer/language user). Thus many things can exist in an absolute way (unknown particles) or they can have a chaotic form of existence; if they do not acquire a minimal stability in space-time they are not perceived as existing objects and do not enter the world underlying the semantics of a natural language.[2] The most typical way in which an entity can exist stably is seen in its having a stable position in space and time, such that no other object can take the same position at the same time. As space-time is a very important basis for human behaviour and its cognitive control, we suppose that the localistic interpretation is very fundamental.[3] We do not suppose, however, that it strictly underlies the following interpretations. The perception and control of space-time is surely an important achievement of our perceptio-motoric mechanism, but other senses like the auditive and olfactory are quality-orientated rather than shape-orientated.

René Thom proposed to consider the stable entities involved in a process as contractible balls in space, such that their evolution in time can be represented by a line (cf. the passage translated in section 2.5.). In this case the dynamics given by the catastrophes occurring on a path (in the bifurcation set) are sudden and remarkable displacements in space-time (small and erratic movements in the domain of the normal position do not destabilize the object in position). The "catastrophic" character of these displacements (which quantitatively depends on the size of the object and the position of the observer) is the prerequiste for their perceptual classification and the mapping into a linguistic label (their naming).

(ab b) *The qualitative interpretation*

The qualitative interpretation differs from the localistic interpretation only by the fact that the substratum of the dynamics is now a space of quality-dimensions and not space-time. As the processes which are considered in catastrophe theory are local and minimal (i.e. only those dimensions which affect the structural stability are considered), the number of quality-dimensions is always very small.[4] The dynamic features of the formal model correspond to changes on a quality scale (an entity loses/gains a quality, it changes the quality in a bipolar or a tripolar field defined on the quality scale). As in the case of the localistic interpretation, a continuous range of values (belonging to a quality) is presupposed, i.e.. the qualities involved in a process of change must be on a continuous scale (otherwise the entity loses one quality and gains another, a process which in catastrophe theoretic terms is not simple but composite, cf. section 1.3.).

(ad c) *The phase interpretation*

The following interpretations are more specific, as they presuppose frames which interpret the states and the catastrophes. The most general interpretation presupposes only the existence of a (natural) dynamic system which has stable states. Thus, many biological processes have a state of rest and one or several states of excitation (cf. muscles, the heart, the limbs etc.). The dynamics consists in a change between these positions. Thus, the arm can hang neutrally or swing with a stable rhythm. It changes its state of rest as soon as the animal/person directs the arm into a specific movement, for example grasping something. After a state of maximal activation and the attaining of the goal (this constitutes a stable state of excitation), the movement returns to the neutral state. The phase interpretation is the ultimate basis for rhythmic events.

In the phase interpretation the dynamic system was still general in the sense that it could be a physical, chemical or biological system. In the next interpretation we presuppose the existence of goal-orientated energy governing the process. The substratum of the process is a space of interaction with animal beings that are able to act by 'will'. The ontological presuppositions are anthropocentric. This does not preclude, however, their application to other entities which, in the perspective of the language user, show similar abilities (animals, objects which seem to have human capabilities, ghosts, demons, natural forces etc.). We call this class of interpretations: agent interpretations.

(ad d) *The agent interpretation*

The attractors are now agents in an interaction space; they can enter/leave the scene in a similar way to that in which objects do (dependent on the focus of human attention and movement). Normally their existence is presupposed as a background to a scenario of interaction. The catastrophes are processes of possession (taking, having, giving), of dominance and control (capture, release). In higher catastrophes these processes can be enriched by the use of instruments and/or indirect causation. This interpretation opens a large field for the classification of human and social activities.

Only the most basic ones, where the dynamic type is not yet hidden by a bulk of elaborated attributions, will be discussed in this section. Further elaboration depends heavily on the social structure of the linguistic community, on historical events and transmitted classifications. The specific structures found in the elaborated system for the classification of social relations cannot be modelled using catastrophe theory alone, but fundamental types described in the following chapter constitute a valuable basis for the differential description of the elaborated systems in specific languages.

The next chapter, which gives an exhaustive deduction of primary archetypes from the set of simple paths in the elementary catastrophes, will exemplify the principles propounded in this section and concretize the different types of interpretation.

2.5. *Rene Thom's list of semantic archetypes*

René Thom's application of catastrophe theory in linguistics began with his article of 1968, "Topologie et signification", and was somewhat elaborated in Thom (1970). In Thom (1973a), "Langage et catastrophes: Eléments pour une sémantique topologique", he modified and specified his use of the central catastrophe: the cusp. In Thom (1972) and (1977) he gives a summary of his results. In this chapter we shall try to give a similar summary, which, however, cannot give a true picture of Thom's new philosophical and epistemological orientation. His perspective on the whole scene of contemporary sciences and their developmental principles is given in Thom (1974) ("La Linguistique, discipline morphologique exemplaire"). Briefly, he states that a structural theory of natural morphologies was developed very early in linguistics as a consequence of the low dimensionality of linguistic phenomena (i.e. unidimensional concatenation of signs). The algebraic treatment of language which resulted from this evolution does not, however, have a true concept of time: time in process and time in evolution. The catastrophe theoretic model is a synthesis which reintroduces real time in the structuralist framework, thereby creating a *dynamic* model of language. The *General Morphology* proposed by Thom could replace the reductionist formal models considered up to now and bring linguistics to a new level of theoretical reasoning. We cannot deal with Rene Thom's philosophical perspective in more detail, as our aim is a presentation and elaboration of his proposals in semantics.

The shortest and most recent summary of his linguistic proposals is given in Thom (1977: 309 - 315) under the heading "L'homo loquens". His more specific proposals have been integrated into the more technical chapters 3.1 to 3.7.. To preserve the originality of the presentation of Thom's theory we translate the central paragraphs (p. 310 - 311):

> Syntax and archetypal morphologies
>
> It is well known that every section of discourse can be decomposed into elementary sentences (we neglect those difficulties – still discussed by specialists – which arise if we define the traditional grammatical categories such as noun, adjective, verb, preposition etc. The fact that every text can be translated from one language to another leads us to assume that these categories are rather universal). Given a process in space and time, which is described using language, are there formal criteria related to the intrinsic morphology of the process, which will allow us to predict its decomposition into sentences?
>
> To this end we must first objectively describe a given morphology in space-time. It is true that every process described by linguistic means refers to domains in space-time, bounded by catastrophe hypersurfaces which play a privileged role: these are the *agents* (actants) of the process – the beings or objects whose interactions are described in the text. As a general rule, each of the agents is topologically a contractible ball. This is the case, for example, with animate (living) beings. At each moment, we are contracting each of the agents at one of its points, and if two such agents interact, we must suppose that their domains of existence come into contact in a beach of catastrophe points, which can also be contracted to a point, the common node of two arcs associated with the agents which were in contact in the above mentioned construction.

I have proposed that the total graph of interaction which describes the process can be covered by sets U_i such that:

1. The partial process with support U_i is described by one of the sentences of the story.
2. The interaction subgraph contained in U_i corresponds to one of the sixteen archetypal morphologies given in the table below (fig. 13 - 18).

Each of these morphologies is in principle generated by a construction of the following type: in the universal unfolding of an elementary singularity, we choose a line starting from the organizing center 0 such that it has contact of maximum order with the discriminant variety. The line is then displaced parallel to itself in order to avoid a confusion of agents in 0. This line is now lifted to the space of internal variables to observe the corresponding interaction. Each of the agents is represented by an attracting minimum. To make sure that the agents are permanent for $t = +\infty$, it may be necessary to treat by bending the line as it goes to infinity. Furthermore, certain verbs, called iteratives, point to an indefinite repetition of an action. In this case, only the fundamental unit is described by the archetypal morphology (thus  stands for the verb "to jump" "to hop"). Note the presence of "excision" morphologies which characterize the processes of sexual reproduction.

This theory of a spatial origin of syntactic structures explains many facts: that an elementary sentence has at most four agents, and in the case of inflected languages it points to the origins of most of the cases: the nominative (ergative) case for the subject; the accusative case for the object; the dative case for the goal of verbal expressions which corresponds to the morphology of *giving*, the instrumental (or ablative) case for those verbs which contain the morphology of excision (or of union). The only classical case which cannot be interpreted by this table is the genitive case: this is an operation of semantic destruction, which separates a concept into subconcepts with regulatory force applying a kind of inverted "embryology" which is probably reversible. (Thom 1977: 310-311).

In Thom (1970: 235-241), where a sketch of the derivation of these archetypes is given, two modes of interpretation are distinguished (cf. Thom, 1970:233 ff.)

(a) physical interpretation,
(b) biological interpretation.

In the first case, the attractors represent objects which move in space-time, in the second case the attractors are animate agents. Thom prefers the modelling procedure called the Maxwell convention for the derivation of physical process-types and the procedure called the perfect delay convention for modelling biological process-types (cf. section 1.2.).

In the next chapter the following problems must be solved:

(a) A more systematic and linguistically richer procedure of interpretation must be given using the method of indirect interpretation (cf. table 3)

Table of archetypal morphologies
(Thom, 1977: 312; table 13–18)

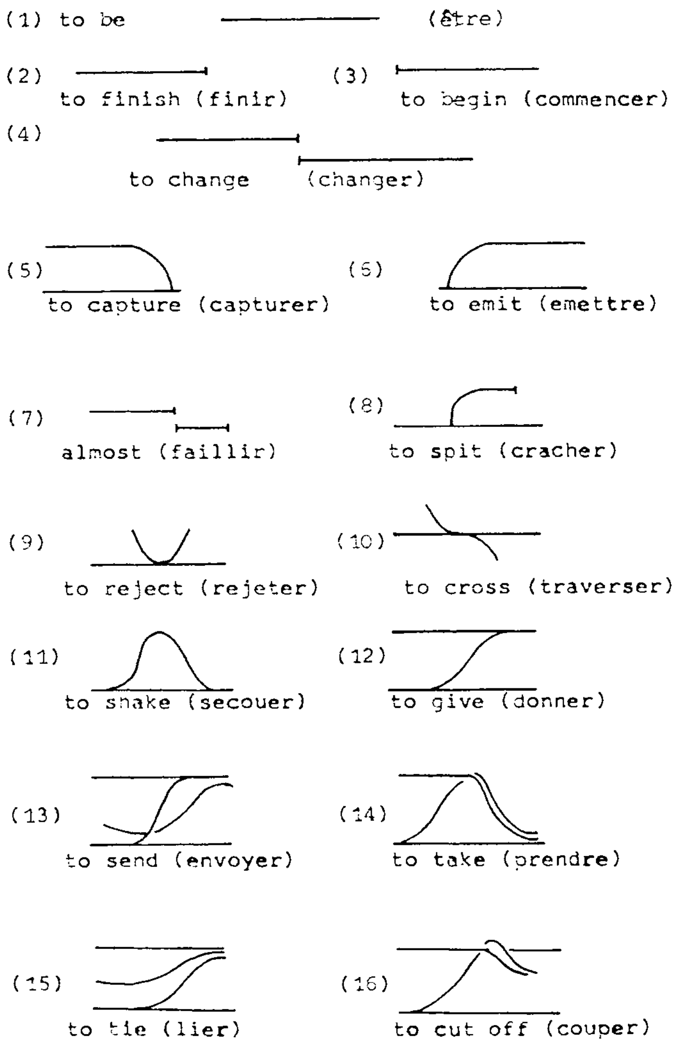


Table 4.

and applying the principles and assumptions introduced in section 2.4.

(b) The set of archetypes must be explicitly derived such that this set achieves a kind of completion. Thus the arbitrarity of choosing special (good) sections must be avoided.

(c) Thom was rather uncertain about some of the derivations he proposed; in Thom (1970:233) he said "I do not know the catastrophe set of the umbilics, which is very complicated." Nevertheless he proposed the archetypes (13) (14) (15) (16) which are derived from the parabolic umbilic (ibid. 236f). We must correct this chapter of his theory using the knowledge available to date.

(d) We shall show that the set of catastrophes allows the derivation of semi-elementary and of higher semantic archetypes.

3. THE HEART OF CATASTROPHE THEORETIC SEMANTICS: THE SET OF SEMANTIC ARCHETYPES

In section 2.5. Thom's list of semantic archetypes was shown (cf. table 4) and his commentaries were translated. In this chapter we shall develop a more exhaustive and linguistically richer theory of semantic archetypes applying those concepts and principles put forward in chapter two. The following sections deal with the unfoldings given in table 2 and add some further derivations taken from the 'Wigwam' (A_6) and the 'Star' (A_7). Section 3.7. deals with the derivations from the umbilics considering their compactification by the 'double cusp' (X_9).

3.1. *The semantic archetypes derivable from the zero-unfolding*

The organizing centre of this unfolding is $V = x^2$ which is structurally stable under small deformations. Consequently no fundamental process type can be derived from this unfolding. Nevertheless, the internal stabilization of this function under deformation has analogues in the field of semantics.

(a) The semantics of mass terms (gold, water, wood etc.). It is characteristic for the referents of these terms that they can be deformed and divided without changing their identity (not including the molecular or atomic levels of decomposition). Their independence of influences and deformations can be correlated with the stability of the zero-unfolding. This *archetype of stable existence* is a specialization of principle 1, which interprets every attractor (attractors have locally the shape of the zero-unfolding) as nominal entities. In the case of mass terms the regulation of the stability and identity of the objects referred to is particularly simple. Other objects need complicated mechanisms to regulate their stability, as is most obvious in the case of living beings. These mechanisms are only in part elementary; they will not be described extensively in this study. The archetype of stable existence is a sort of mothertype for the semantics of nominals.

(b) If we consider versal unfoldings of the same function, we arrive at more interesting structures. Fig. 6 shows the germ $V = x^2$ unfolded by a versal (non universal) parameter p.

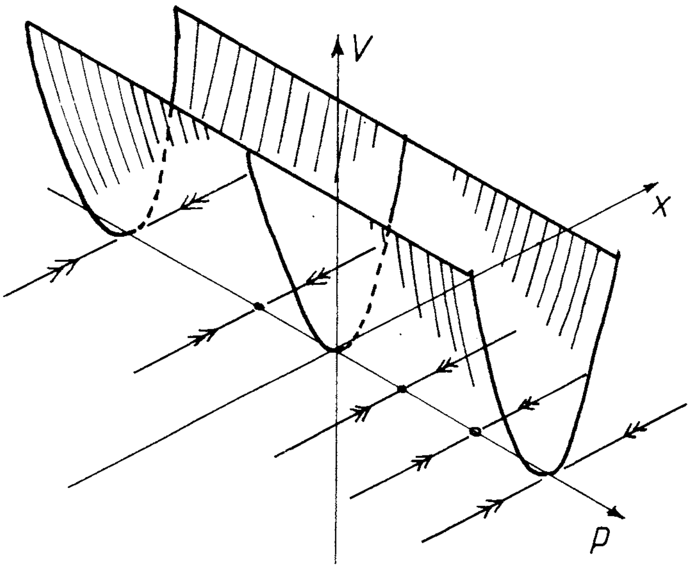


Figure 6.

The external parameter *p* is the axis of possible processes (the external time). This is the *archetype of continuous processes without accidents.* Schematically we can represent it by a line which has open ends at both sides.

The interpretations are rather simple:

– *localistic:* to be (exist, live, stay) in an unbounded domain.
  example: *A* exists (somewhere)
– *qualitative:* persistent quality
  If an individual who possesses the quality in question is presupposed as the background, we get the type of inalienable qualities. They appear and end with their support; relative to their background (possessor) they are unbounded.
  example: *B* is animate / human / . . .
  If *B* is a person these qualities are inalienable; i.e. those qualities which constitute the identity of an object are invariant qualities of this object as long as it exists (in its proper form).
– *possession:* In the case of inalienable possession, the possessed object is stable as long as the individual who possesses it exists.
  example: *B* has his head (on his neck).
– *interaction:* The basic archetype is that of living, belonging to the field of

potential interaction. The same process structure can be derived from the cusp ($V = x^4$) which is the next 'compact' catastrophe.

The archetype of stable existence is mostly realized as a perspective of superordinated archetypes. The following examples point to such archetypes.

Examples:
B sits, lies, stands / is placed, situated on / at / in *P*
B owns, has, contains (some object *0*)

More generally we get positions of rest before or after a phase of change which is not explicitly mentioned. It is clear that a person sitting in a chair can move, that a man having ten dollars can lose them . In a local (restricted) perspective the verbs: *sit, lie, stand, be situated at, own* refer to a state of stability. The integration of this low archetype into higher archetypes has already been indicated above (cf. section 4.1. for a systematic treatment of 'dynamic inferences').

3.2. *The semantic archetypes derivable from the fold*

The universal unfolding called the "fold" is the first dynamic system which is unstable under small deformations. It evolves in a way describable by *at least* one parameter *u*; i.e. there exist many possible transformations of this sytem under deformation which can be topologically reduced to *one* normal form containing just one external parameter, which governs the stable evolution of the system. The fold is the first member of an infinite series of unstable dynamical systems with *one* internal variable, whose germs are:
$x^3, x^4, x^5, x^6, \ldots, x^n$

Organizing center: (1) $V = x^3$
Universal unfolding: (2) $V = x^3 + ux$
Set of critical points: { (x,u): such that (3) holds }

(3) gradient of $V = \frac{\partial V}{\partial x} = 3x^2 + u = 0$

Bifurcation set Σ := { u: such that (3) and (4) hold }

(4) $\frac{\partial^2 V}{\partial x^2} = 6x = 0$; i.e. $x = 0$

In the case of the fold, all the elementary notions can be represented graphically. Fig. 7 shows the unfolding (2). Fig. 8 gives the set of critical points which is a parabola (3). The minima form the upper branch of it. At the saddle point, $x = 0$, where minima and maxima touch, we have the unstable (degenerate) bifurcation point (4).

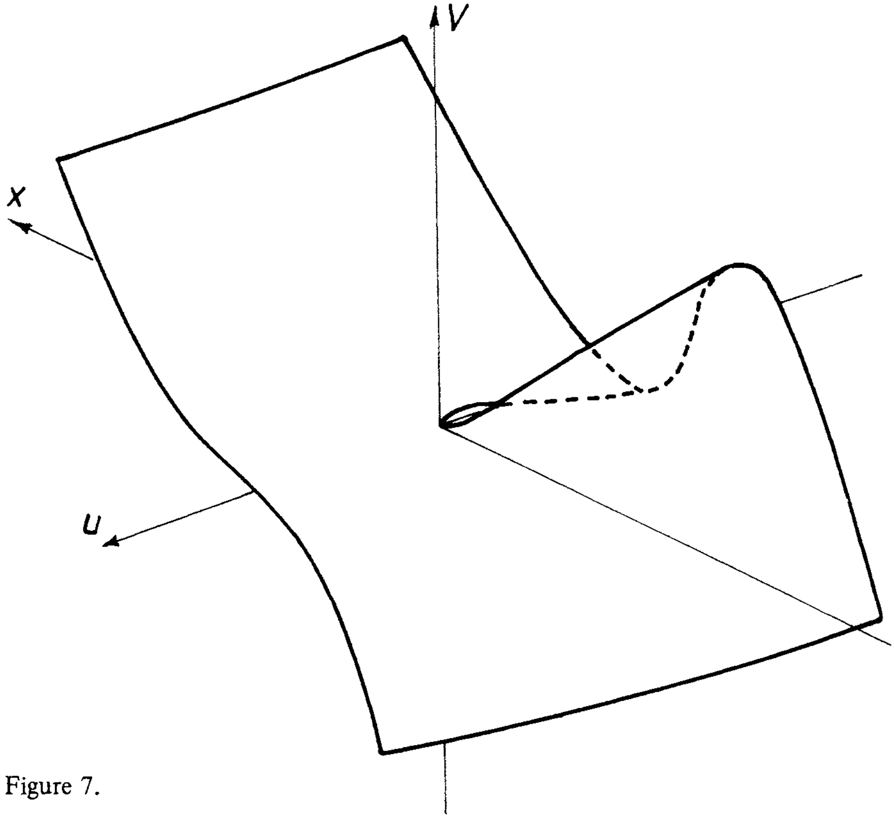


Figure 7.

As we have only one external parameter, u, the axis of possible processes coincides with u. We may, therefore, consider two types of processes: one from $u < 0$ to $u > 0$ and the inverse process from $u > 0$ to $u < 0$. In the case of the fold, which is the first non-zero unfolding, two basic semantic archetypes can be derived:

(a) The slow dynamics travel along a path from $u < 0$ to $u > 0$. A domain of stable existence is followed by a domain of instability. The fold catastrophe marks the change from stable existence to nonexistence. We can distinguish three subdomains:
- The process is (still) stable.
- The environment of a catastrophic change where stability is destroyed, the 'death of stability'.
- The process has (locally) no equilibrium.

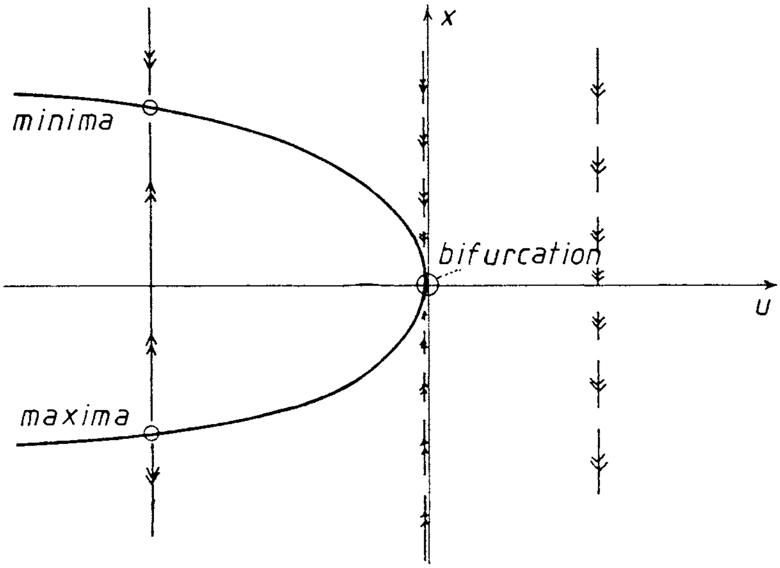
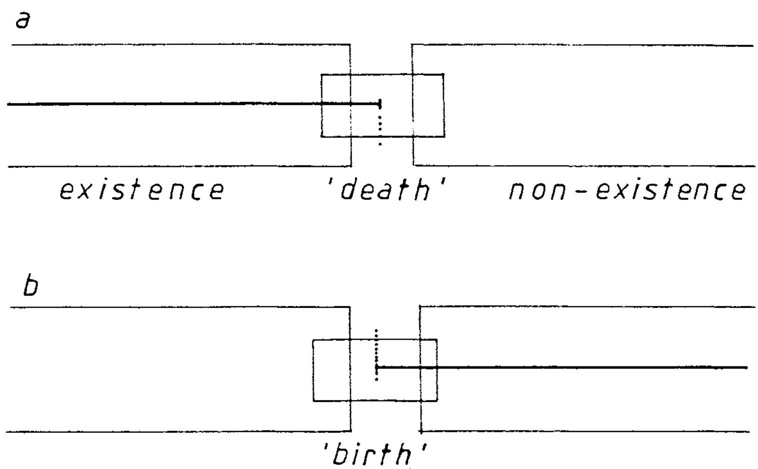


Figure 8.

(b) The direction is inverted. From instability stability is reached by crossing a catastrophe (the 'birth' of stability).

The diagrams 3 and 4 simplify the set of critical points to a line and represent the basic events interpreting the formal process derived above.



Diagrams 3 and 4.

This basic archetype is lexicalized in the form of verbs like: to *begin* / to *be born* / to *appear* / to *rise* (the sun) / to *come* (to the floor) / versus / to *end* / to *die* / to *disappear* / to *set* (the sun) / to *leave* (the scene) /. We call it the *archetype of birth/death.* In many languages this type of dynamics is grammaticalized as an inchoative or perfective aspect. It is natural that the place of conventionalized realizations is specific for different languages.

This interpretation assumes a sort of temporal parameter underlying the process parameter in our model. We arrive at another basic interpretation – the localistic interpretation – if the domains of stability are interpreted as regions in three-dimensional space ($\mathbb{R}^3$). The fold-catastrophe furnishes the *archetype of frontiers*, borderlines etc. To derive this interpretation formally, we must consider a second non-basic external variable *p*. The variable *p* does not introduce new catastrophic patterns (as it is reducible), it only adds a second dimension to our bifurcation set. The line of minima is transformed into a curved surface, the bifurcation point becomes a line. Fig. 9 shows this three-dimensional setting.

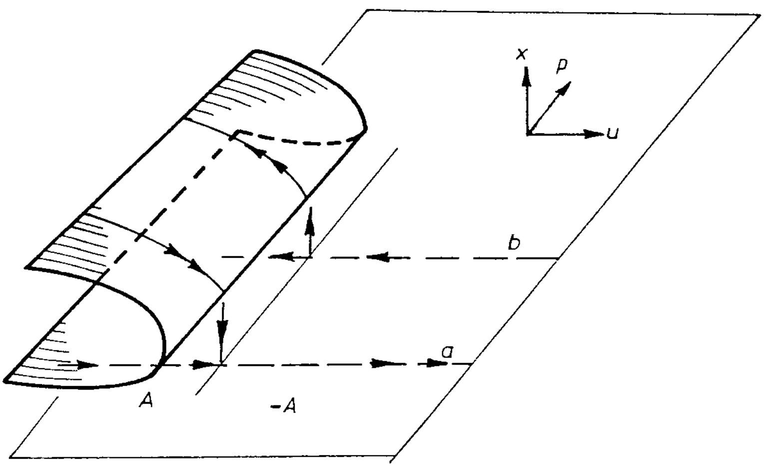


Figure 9.

The process is still parallel to *u* (the only 'catastrophic' parameter). As the paths *a* and *b* show, the fold catastrophe constitutes a borderline; path *a* leaves the stable domain *A*, crosses the bifurcation line and comes to a domain which is undefined in terms of structural stability. The new interpretation in terms of local domains is given by diagram 5.

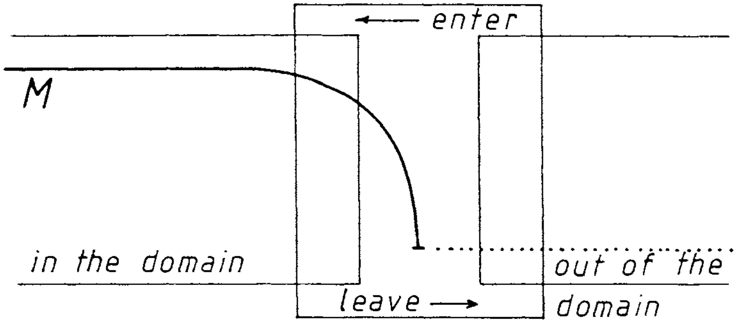


Diagram 5.

The central field (which contains the frontier or borderline in Fig. 9) can be crossed in two directions:

(a) Leaving the stable domain A, losing stability. Examples: to *leave,* to *go away*, to *lose* (something), to *give* (something) *up.*
(b) Entering the stable domain, gaining stability. Examples: to *enter*, to *go into*, to *find* (something), to *pick* (something) *up.*

If the line which is parallel to the parameter p (in Fig. 9) is seen as a compact interval and brought into a circular form, we obtain the classical picture of a spot (or a hole). This is illustrated in Fig. 10.

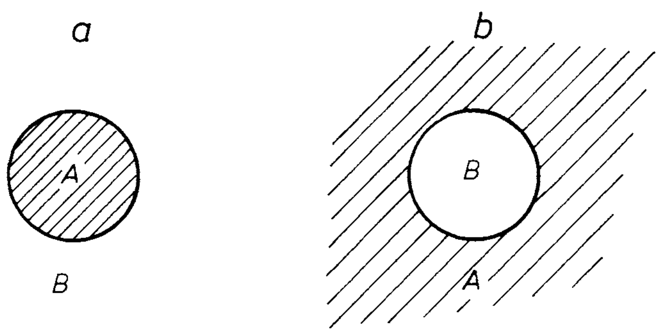


Figure 10.

The archetypes derived from the fold are an explication of the first dimension in Hjelmslev's reconstruction of localistic cases, called: *direction* and characterized by the features: 'approximation' (rapprochement) – 'rest' (repos) – 'departure' (éloignement) (cf. Hjelmslev 1935: 112, 134). This dimension had already been proposed by Maximus Planudes (ca. 1260 - 1310 A.D.). This Byzantine linguist explained the system of Greek cases with these localistic categories. In Fig. 11 we try to bring together this information about natural languages and the archetypes derived in this section. An even better approximation exhibiting similar structures can be derived from the negative cusp (A_{-3}) (compare section 3.3.2.).

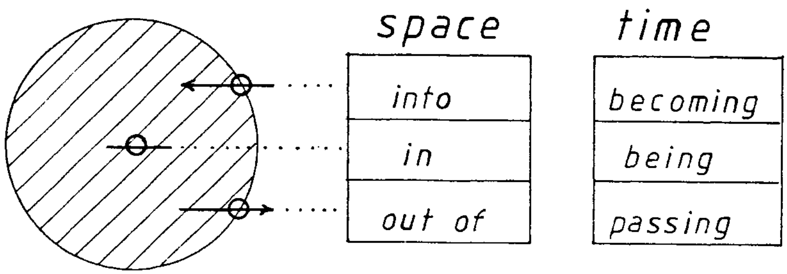


Figure 11.

The archetypes derived in this section are asymmetical, i.e. they contain two states, which are fundamentally contradictory: stability (= existence) and instability (= nonexistence). This archetype is therefore the dynamic basis of *negation.* Negation is at the same time a logical prime (in most of the logical systems proposed up to now)[5]. Catastrophe theoretic semantics gives rise to an elementary scheme shared with logical semantics. As we shall find other similar correspondences, it is not unnatural to assume that catastrophe theoretic semantics could give a foundation to logics. This assumption is the more plausible as logics *are* special languages and insofar catastrophe theoretic semantics is fundamental for all types of languages.

3.3. *The semantic archetypes derivable from the cusp*

Completing René Thom's treatment, we shall consider all elementary unfoldings including the dual ones as there is no apparent reason for omitting these.

3.3.1 *The standard cusp (A_{+3})*

The geometry of this unfolding was described in section 1.4.. In Fig. 4 we saw that four classes of typical paths could be considered: K_1, K_2, K_2', K_3. The path K_1 crosses no bifurcation line; it corresponds qualitatively to the process derived from the versal unfolding of A_1 (the zero-unfolding). Thus K_1 would be the direct site of some structures derived in section 3.1..

The paths K_2 and K_2' cross the bifurcation line where a fold catastrophe occurs. Depending on the direction chosen, an attractor is created or annihilated. The process is thus an integration of a steady process like that along path K_1 (described in section 3.1.) and a death/birth archetype such as those derived in section 3.2. The new information is in the fact that these process-types appear now bound together in *one elementary* unfolding: this relational structure is *new*. Fig. 12 shows the vector field underlying this process. We can easily recognize the parabola typical of the set of critical points of the fold.

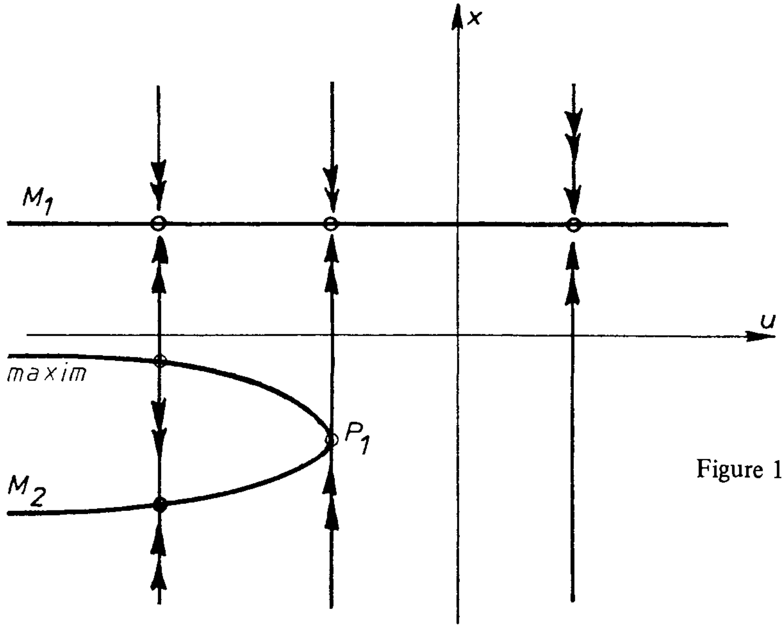


Figure 12.

The process along the parameter *u* can take two directions:

(a) If it has the same direction as u in Fig. 12, we can derive the *archetype of capture* (see Thom's list Nr. 5). Diagram 6 gives a good picture of this process. It can be immediately derived from Fig. 12 omitting the repellors (= maxima).

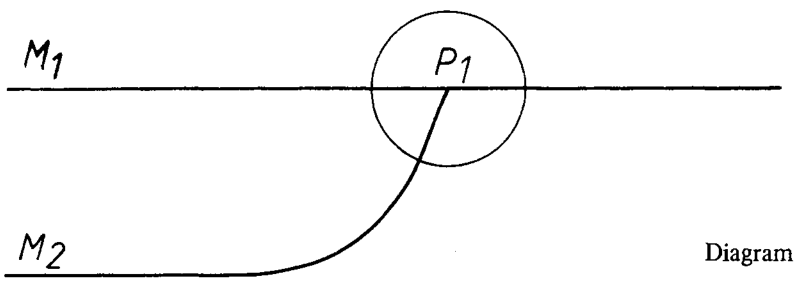


Diagram 6.

This archetype takes into account three basic dynamic facts:

- There is an agent M_1 which is not created or destroyed; it is stable and corresponds to the zero-unfolding (cf. section 3.1).
- There is a fold-catastrophe at P_1 which destroys an attractor (= an agent).
- The two processes are dynamically synthesized by the fact that P_1 lies in the attracting field of M_1. After passing P_1 it is merged with this field, losing its own attracting capacities. This fact is new in the cusp, whereas the first two facts appeared already in the zero-unfolding and the fold-catastrophe.

In diagram 6 we have marked a small domain around the catastrophic point P_1 to indicate the local character of archetypes. Only the things happening in the immediate environment of the catastrophic point are relevant. Thus the larger context of this controlled, caused disappearance of an agent is irrelevant for our interpretation. We can derive an *archetype of conditioned / caused / controlled disappearance / death (capture)*. The event of capture is only one very specific example out of this large class of process-types.

(b) Choosing the inverse direction, the *archetype* called *emission* by Thom can be derived (cf. Thom's list, Nr. 6). Diagram 7 shows the type of process underlying our interpretation.

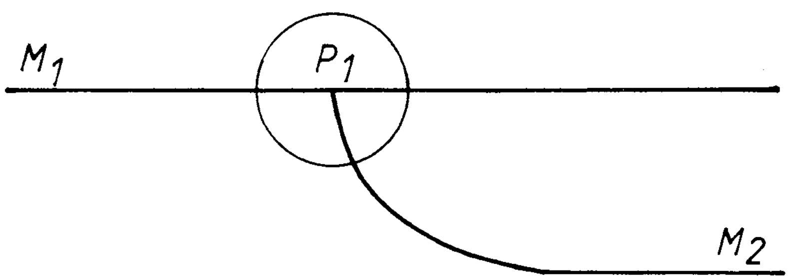


Diagram 7.

In this process we find:

- A dominant agent M_1 exists continuously.
- A second agent is created at P_1, in the attracting domain of M_1. The vector field beneath M_1 (in Fig. 12) is divided. The appearance of M_1 is 'nested' in the basin of M_1.

This dynamic configuration can be attributionally enriched in several ways, leading thus to different interpretations. The new phenomenon, i.e. the embedding of a fold catastrophe (archetype of birth/death) in the dynamic field of a stable attractor can be seen as a local separation of domains which were one before the catastrophe took place, or as an emission, an act of creation. We call this the *semantic archetype of conditioned / caused / controlled / appearance / birth / (creation/emission)*

Many elementary sentences with two agents are marked by the asymmetry of the agents, one being dominant, the other dominated. In some sentences there are even replicas of the process-types derived.

Examples:
Peter throws the ball
The cow gives milk

The relation of conditioning / causing / creating may be less concrete; in some cases the secondary agent is redundant as in:

Susan sings (≙ a song)
Paul talks (≙ 'gives' a talk)

or it is incorporated in the verb thus transforming the possible transitive sentence into an intransitive one:

The fire smokes (M_2 = smoke)

We cannot therefore relate this archetype with transitive sentences. Thom's application suffers from an over-direct syntactic interpretation of semantic archetypes. These are rather basic cognitive schemata, which organize the content we want to communicate. The syntactic form has to transport this content, but its own form is largely regulated by the economy of social communication and influenced by the solutions to thousands of different coordination problems in a linguistic community. The archetypal schemata are therefore rather deep. A more exhaustive application will be possible as soon as the social dynamics of the forming and changing of linguistic tools are fully understood (we presume that this can be done using catastrophe theory in the framework of game theory).

The last and richest path in the bifurcation set of the cusp crosses the Maxwell-line and there appears a new structure: the conflict of attractors. Path K_3 which crosses the conflict-line has already been described in chapter 1.4.. We summarize the qualitative features of the process in diagram 8.

In K_3 the main facts which characterize the archetypes derived from catastrophes with one internal variable (i.e. x) are present:

– The fold-catastrophe leading to the archetypes of death and birth,

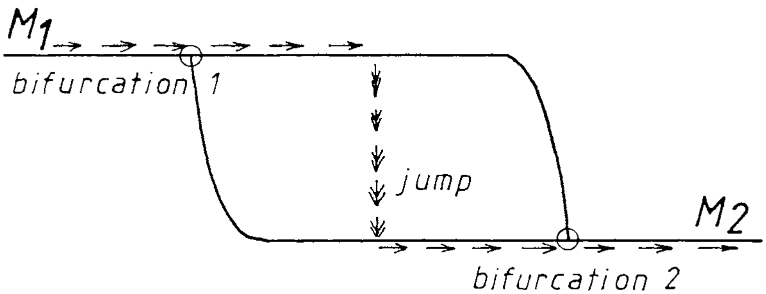


Diagram 8.

- the conditioning of fold catastrophes leading to the archetypes of conditioned death/ birth,
- the conflict of attractors.

This completeness of path K_3 in the bifurcation set of the cusp justifies the centrality of the cusp for catastrophe theoretic models. We shall give a short summary of the different semantic structures correlated with this process-type. For further details see Wildgen (1979:265 - 307).

(a) *The localistic interpretation*

This results in the *archetype of local change* from place (domain) M_1 to place M_2.

A moves from M_1 to M_2 (*walks, drives, travels,* . . .)

(b) *The qualitative interpretation*

This results in the *archetype of bipolar quality change.* The dynamics can be illustrated if we consider the pair of adjectives: awake - asleep.

Fig. 13 shows the areas of the two qualities 'awake' and 'asleep' and considers two processes in the quality space corresponding to A *falls asleep* and A *wakes up*.

The bipolar organization of a quality scale is a very productive principle in all languages. The methodology of the semantic differential introduced and applied by Osgood (cf. Osgood, Suci and Tannenbaum, 1967 and Osgood 1976) takes advantages of this universal principle.

Examples:

good	-	bad	active	-	passive
strong	-	weak	nervous	-	calm
big	-	small			

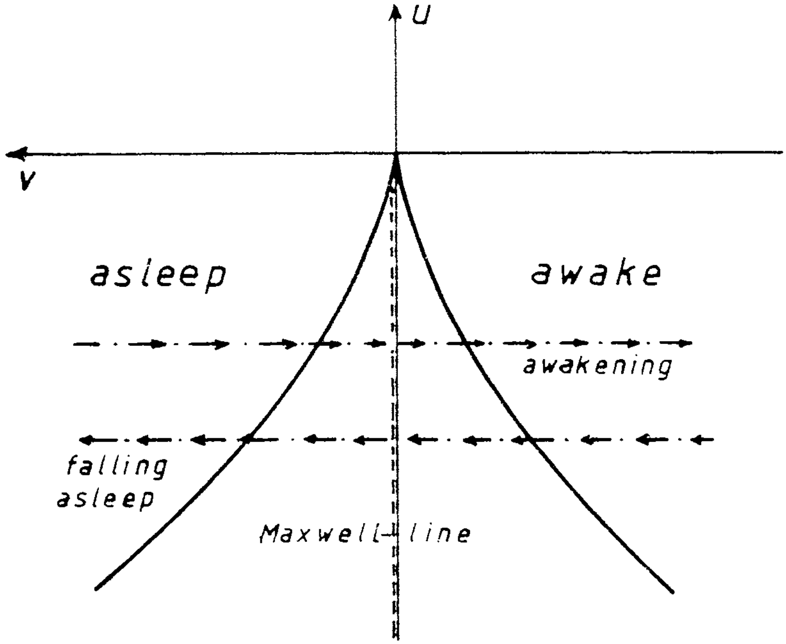


Figure 13.

(c) *The phase interpretation*

If instead of quality scales we consider phases of activities, we obtain the following bipolar oppositions as realizations of the archetype. Corresponding processes (changes) can easily be imagined.

Examples:

rest - tension
war - peace
attack - flight
gas - liquid

(d) *The possession interpretation*

We obtain the ***archetype of change in possession.*** As this archetype has only two stable attractors, the object which changes the possessor is not focussed on. The archetype of 'giving' can be derived from the next compact catastrophe in the hierarchy, the butterfly ($V = x^6$). Some realizations of the archetype of change in possession are:

(i) Object 0 changes from / passes from possessor M_1 to M_2 (0 is an invariant of the process; it is not the interpretation of an attractor but stands for the point which moves on the path K_3 through the bifurcation plane).

(ii) All the interpretations of the process-type illustrated by diagram 8 can be subsumed under the heading 'change' (cf. Thom 1977: 312).

(e) *The interaction interpretation*

This interpretation is the one which motivated René Thom most. We have two attractors M_1 and M_2 which come into conflict. The central 'jump' can be interpreted as a change in dominance (presupposing the Maxwell convention) thus yielding another archetype of change. We can, however, consider separately the two bifurcations along path K_3 in Fig. 4. If the attractors M_1 and M_2 are interpreted as agents we obtain very naturally the *archetypes of capture* and *emission*, which have already been discussed in more detail.

Examples for the archetype of emission:
Agent M_1 emits / throws / gives away / lets free / secretes agent M_2.
Exemples for the archetype of capture:
Agent M_1 catches / takes / grasps / subjugates / absorbs / devours agent M_2.

The process diagram also allows the separation of two types of agents:

M_1: the *primary* agent, is *not* created or destroyed by the catastrophe,
M_2: the *secondary* agent, is created / destroyed by the catastrophe.

This dynamic distinction can be correlated with traditional semantic labels such as: agent - object (agentive case - objective case), agent - experiencer, causer - affected / effected.

(f) *The instrumental interpretation*

The interactions described under (e) are biologically basic as we can find similar dynamic interactions in all living beings. In later evolutionary stages almost all creatures have developed an opposition between central and peripheral body parts. With the existence of limbs and the prolongation and differentiation of limbs by the use of instruments, new action types have evolved, which can be called *instrumental*. The secondary agent can now be interpreted as a limb or an instrument. Applying this interpretation to diagrams 6 and 7 we get the following (instrumental) interactions:

(a) reaching, tending (with the arm, with the instrument)
(b) taking back (the limb), recovering (the instrument).

The actions performed with the aid of limbs and instruments very often have a cyclical and repetitive character. If we consider cyclical paths in the bifurcation set of the cusp, we can derive some basic archetypes of body movements.

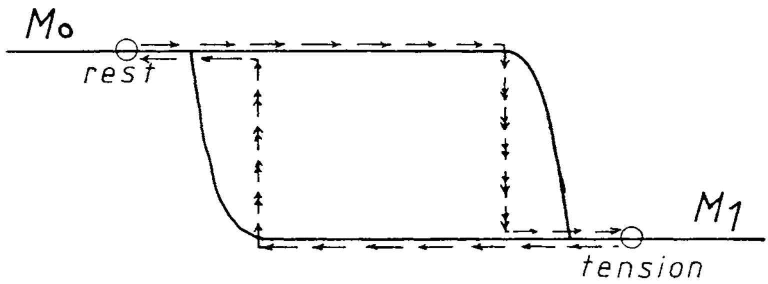


Diagram 9.

We consider M_0 as a state of rest and M_1 as a state of tension. According to Zeeman (1972) we obtain a qualitative model of heart beating (where the two states are called diastole and systole). The *archetype of beating* which can be derived is rather rudimentary as it describes only the change between two states:

(a) the body has its limb close to itself (in a neutral position of rest): M_0,

(b) the body has emitted / erected the limb (instrument) (in a position of tension): M_1.

Examples:
Agent *A* beats (with its limb / instrument *B*)
Agent *A* jumps

If the cycle is run through repeatedly, this results in: A waves, wags, etc.

More generally it can be said that most movements such as *walk, run, dance* . . . are perceived as combinations of such 'beating' processes (cf. Johansson (1976, 1977) for experimental results confirming this hypothesis).

There remains the class of abstract interpretations, which are transpositions of physical actions to the domain of mental, emotional and social activities. We prefer to treat these on the level of attibutional dynamics as they are too remote from the basic biological mechanisms which are the proper domain of the universal morphology developed by René Thom. Our separation of different interpretations of basic process-types was already a first step into this domain, although we aimed exclusively at a better approximation of the semantic structures of natural languages. Attributional dynamics needs a broader interdisciplinary foundation, especially in social psychology and anthropology.

3.3.2. *The dual cusp (A_{-3})*

This unfolding corresponds to the positive cusp with the difference that minima are converted into maxima and vice-versa. It is therefore called the anti-cusp or the dual cusp.

Organizing center: (1) $V = -x^4$
Unfolding: (2) $V = -x^4 - ux^2 - vx$
Set of critical points Σ : { (x,u,v): such that (3) holds }

$$(3)\ \frac{\partial V}{\partial x} = -4x^3 - 2ux - v = 0$$

The bifurcation set is identical to the one derived for the positive cusp in section 1.4.. Fig. 14 shows the bifurcation set with local potentials along path K_3' which corresponds structurally to the path K_3 considered in the last section.

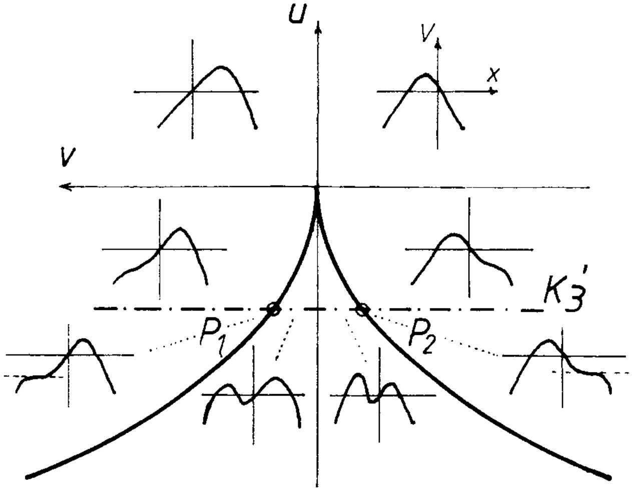


Figure 14.

At the left border of the bifurcation set, in P_1, a minimum is created, which disappears at the right border, in P_2. As there is only one minimum, no conflict is possible. Diagram 10 shows the character of this process, which combines features derived from the fold (A_2): the beginning *and* ending of a process.

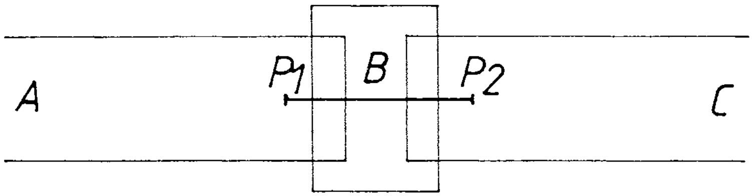


Diagram 10.

We can call this dynamic gestalt the *archetype of transient existence.* In Wildgen (1979: 321) we referred to those archetypes which contain only a sequence (or concatenation) of archetypes derived in unfoldings more basic in the hierarchy (cf. section 1.3.) as *semi-elementary archetypes.* The archetype of transient existence is such a semi-elementary archetype.

This archetype integrates the processes of entering / leaving a domain, of coming into existence / being born versus going out of existence / dying into a single gestalt: location / existence in a limited domain, which is typical of biological existence and for most of the areas relevant for animate beings. These areas can be considered ideally as circles or balls in space. The process enters and / or crosses and / or leaves the domain. Fig. 15 shows this spatio-temporal interpretation of K_3'.

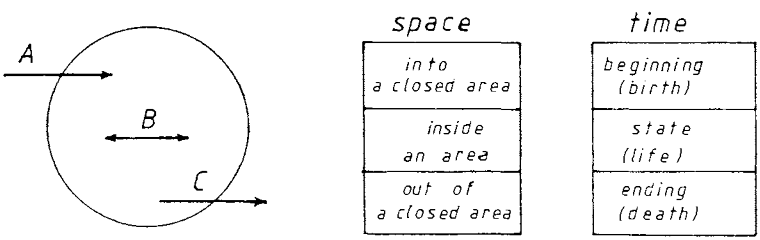


Figure 15.

This archetype has only one attractor, therefore the local or temporal background against which a process is taking place cannot simultaneously be referred to. The next section will fill this gap.

3.3.3. *Versal unfoldings of the standard cusp*

As in section 3.2., we can consider a versal unfolding i.e. an unfolding which is not universal, as one or more of its unfolding parameters can be eliminated by a transformation of the system of coordinates. Thus we can introduce a parameter *w* in the manner given in equation (1) of the unfolding of the cusp.

(1) $V = x^4 + (u - w^2)\, x^2 + vx.$

If we compute the function for different values of *w*, we see that the structure of the bifurcation set is not changed but that it occupies different positions relative to the coordinates. As similar partial curves can be encountered in higher catastrophes, these structures are relevant to our model. Fig 16 shows the bifurcation set of this unfolding.

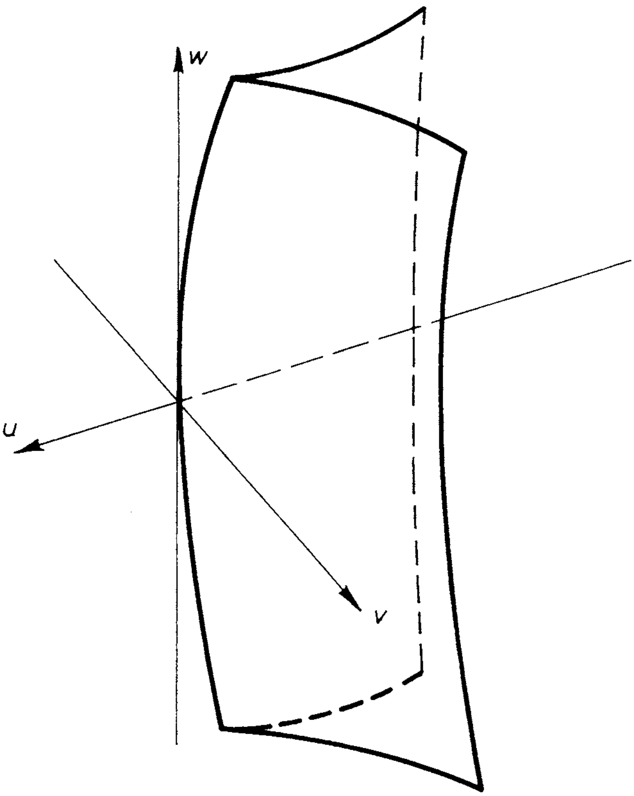


Figure 16.

We consider sections of this curved plane such that *u* is a constant ($u \leqslant 0$). Fig. 17 shows the bifurcation set (now in the plane of the coordinates *w* and *v*) at different values of *u*.

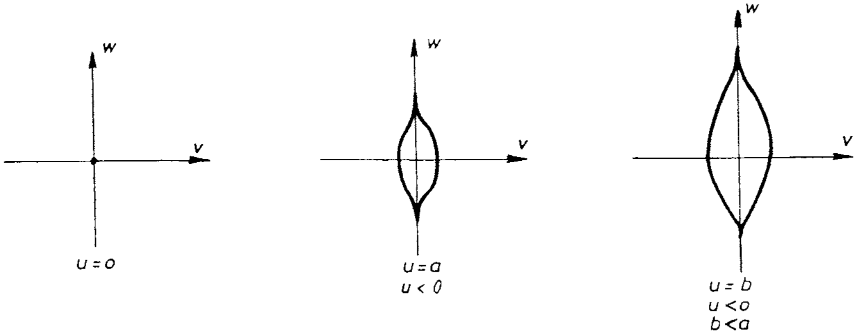


Figure 17.

Thom calls the configuration, which appears when $u < 0$, $u \neq 0$: the *lips*. If we consider the path K_5 which is parallel to the versal parameter w we obtain the type of processes scheduled in Fig. 18 and in diagram 11.

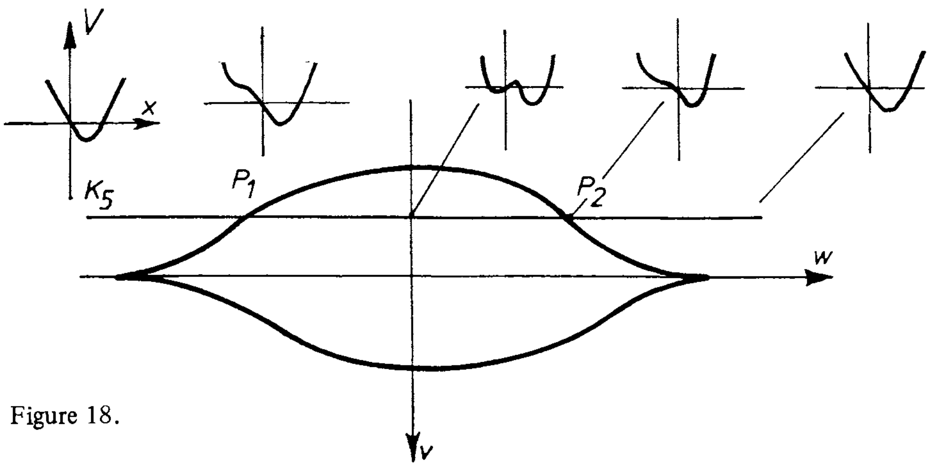


Figure 18.

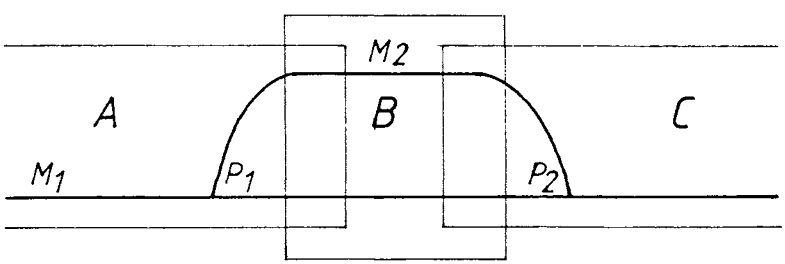


Diagram 11.

With a local interpretation we derive elementary sentences for the phases A, B, C. In each case an agent which is permanent *enters, is in* or *leaves* a domain.

Examples:
(i) Paul comes to (Amsterdam) A
(ii) Paul is in (Amsterdam) B
(iii) Paul leaves (Amsterdam) C
(iv) Paul passes through (Amsterdam) A, B, C.

The local domain corresponds to the attractor M_2 which is limited on both sides. The agent M_1 (in our case Paul) has no catastrophic frontiers. The gestalt-character of this archetype creates a dynamic background such that in (i) to (iii) the total process is virtually present. Those who *come to,* will *be in* and probably will *leave* later; the ones who *are in* a domain probably *entered* it and will *leave* it again, and those who *leave* it, probably *entered* it and certainly *were in it.*

It is interesting that the inference from B to A or C is less certain than the inference from A to C and vice versa. B is without a catastrophic event; it could be of the zero-type (everlasting existence derived from the unfolding A_1). The fold catastrophe in A and C presupposes, however, the zero-event in B. The integration of two fold catastrophes in A and B presupposes an unfolding at least of the level A_3 (cusp). These remarks give only a first hint of the rich inferential structure inherent in catastrophe theoretic semantics (compare chapter 4.1.).

These archetypes and others which can be derived from versal unfoldings of the cusp belong to our category of semi-elementary archetypes, as they contain no totally new structural information. They rather complete the elementary archetypes derived at more basic levels. Thus the archetypes (9) *to reject* and (10) *to cross*, proposed by Thom (cf. section 2.5.) are semi-elementary in our sense. We described them in detail in Wildgen (1979: 296 - 303). Our explicit derivation pointed rather at more general archetypes than those given by Thom; we could call them the archetypes of *interrupted domains* or *interrupted existence.*

3.3.4. *Introducing higher archetypes: The archetype of bipolar differentiation*

In chapter 3.3.1. we have seen that the richest path in the bifurcation set (K_3) is parallel to the v axis and that the second external variable u is a negative constant. We can now move this path, changing the values of u. The path on which this movement is parametrized may be parallel to the axis *u*. In this case we can observe a process which changes an archetypal pattern parametrized by *v*. The process-type obtained along *u* and affecting the archetype along *v* is called a *higher archetype*. This notion was introduced for the first time in Wildgen (1979: 329, definition 16). It is a substantial elaboration of Thom's proposals.

In the case of the positive cusp we can represent the higher archetype by a twodimensional diagram which shows a series of typical stages along the axis *u*;

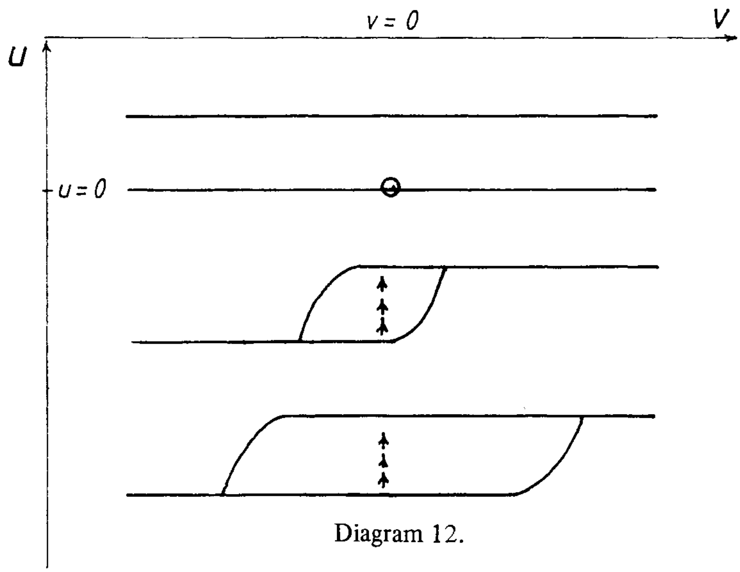


Diagram 12.

The effect of this archetype depends on the direction chosen on the axis *u*.

(a) Moving downwards in diagram 12 (from $u > 0$ to $u < 0$) we get the (higher) *archetype of bipolar differentiation*. The attractor M_0 (in the domain $u > 0$) is divided into M_1 and M_2 at $u = 0$. The zone of conflict becomes wider as *u* is negatively increased.

(b) Moving upwards a bipolar opposition is abolished; the conflict zone disappears. We get the *archetype of reduction in a bipolar field*.

As the cusp has only two external (unfolding) parameters *u* and *v*, it is natural that higher archetypes appear for the first time at this level. We shall derive more complex (higher) archetypes which elaborate the archetype of bipolar differentiation (respectively the archetype of reduction in a bipolar field). Compare especially chapter 3.5.5..

3.4 *The semantic archetypes derivable from the swallowtail*

In Wildgen (1979: 308 - 338) this elementary unfolding is systematically exploited. As the derivations are mathematically rather difficult we shall only present one central result: the derivation of Thom's archetypes No. 7 (almost) and No. 8 (to spit).

Organizing center: (1) $V = x^5$
Unfolding: (2) $V = x^5 + ux^3 + vx^2 + wx$
Set of critical points Σ (= catastrophe set): $\{(x, u, v, w)$ such that (3) holds$\}$

$$(3)\ \frac{\partial V}{\partial x} = 5x^4 + 3ux^2 + 2vx + w = 0$$

The bifurcation set is a curved surface in $\mathbb{R}^3$, the parameters being u, v, w. The most interesting feature of this unfolding lies in the fact that it is the first unfolding whose germ has an odd exponent and at the same time also a conflict of minima. It thus combines characteristics of the fold and of the cusp. Our derivation needs some more geometrical details. Fig. 19 shows the bifurcation set with the characteristic 'swallowtail' beneath. This crucial region has three bordering surfaces.

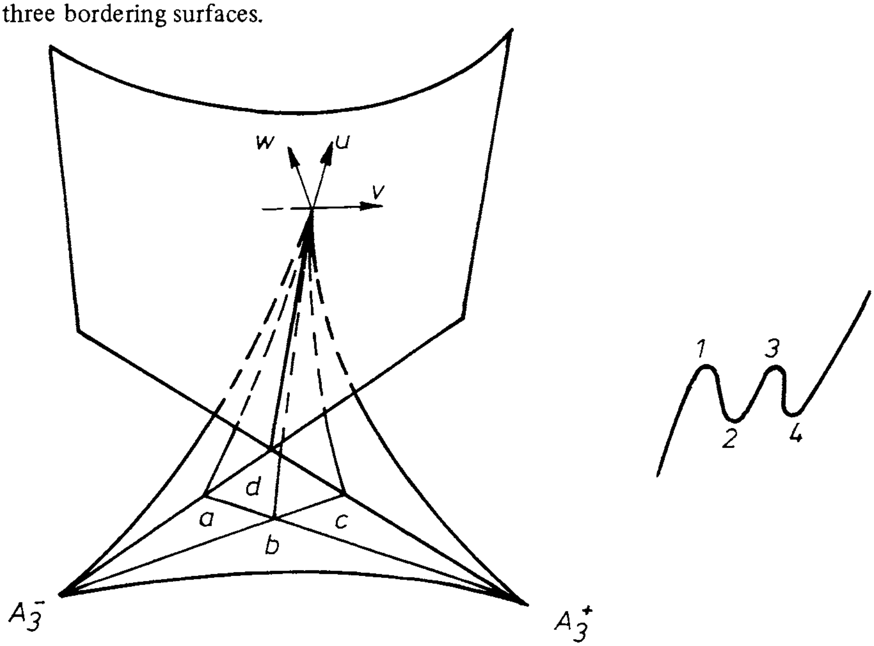


Figure 19.

Inside the 'swallowtail' we can separate four domains: a, b, c, d. They are defined by the specific relations obtaining among its extrema (maxima, minima) (By •> we mean "higher than").

a: 3 •> 1 and 2 •> 4
b: 1 •> 3 and 2 •> 4
c: 1 •> 3 and 4 •> 2
d: 3 •> 1 and 4 •> 2

If we consider only minima, we get one frontier which separates two distinct parts A and B.

A: a, b : 2 •> 4 : M_4 dominates
B: c, d : 4 •> 2 : M_2 dominates

The conflict lines of the bifurcation set (applying the Maxwell convention) have the shape shown in Fig. 20.

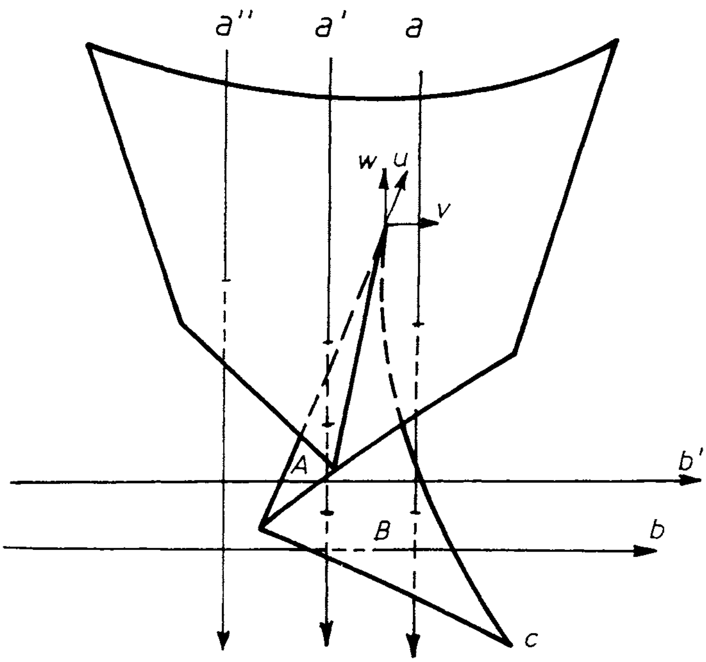


Figure 20.

René Thom considers the region where $u < 0$ i.e. where the swallowtail exists. In Fig. 21 we give such a section indicating the rather complicated field of potentials. We shall consider the paths *a, a'* and *b, b'* (cf. Wildgen (1979) for a classification of typical classes of paths).

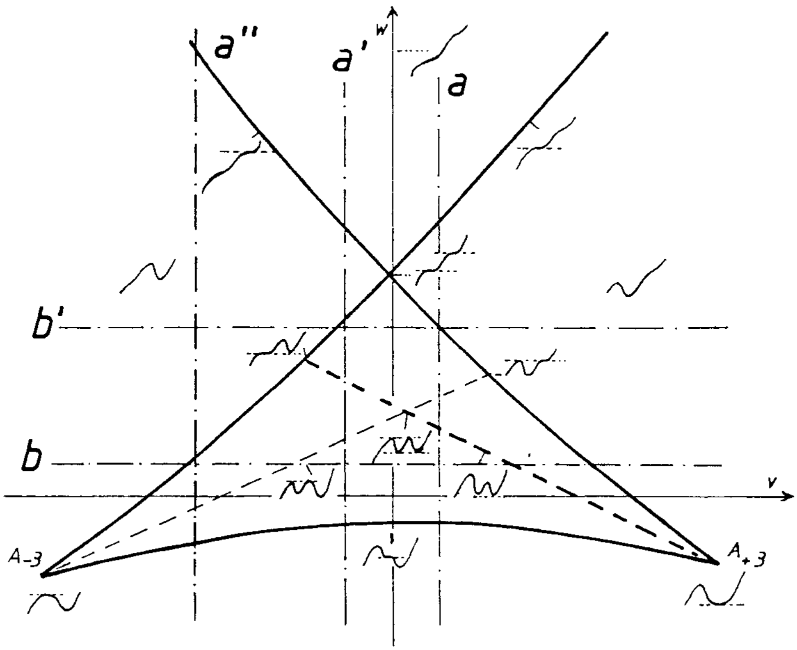


Figure 21

If we apply the convention of perfect delay we can only derive semi-elementary archetypes. Thus path *a* leads to the *archetype of gradual death / birth.* In this case a cusplike change of attractors precedes the death catastrophe or follows the birth catastrophe. The semi-elementary catastrophe can be enriched, introducing more gradual levels (if we consider higher catastrophes of corank 1 and an odd exponent of the germ; i.e. A_6, A_8, A_{10}; cf. chapter 3.6.).

Fig. 22 gives a section in the set of critical points along path *a*, which shows gradual death (= destabilization).

The corresponding derivations in Thom (1970: 236,239) are misleading. His archetype No. 8: "cracher, étinceler" is a special elaboration of the archetype of gradual death derived above. If the cuspoid change from M_1 to M_2 in Fig. 22 is interpreted as emission (compare section 3.3.1.), we match Thom's description of his archetype No. 8: "émission d'un actant qui périt: cracher, étinceler" (Thom 1970: 239). Thom gives almost the same description for the archetype No. 7 "presque, faillir" (almost). He says:

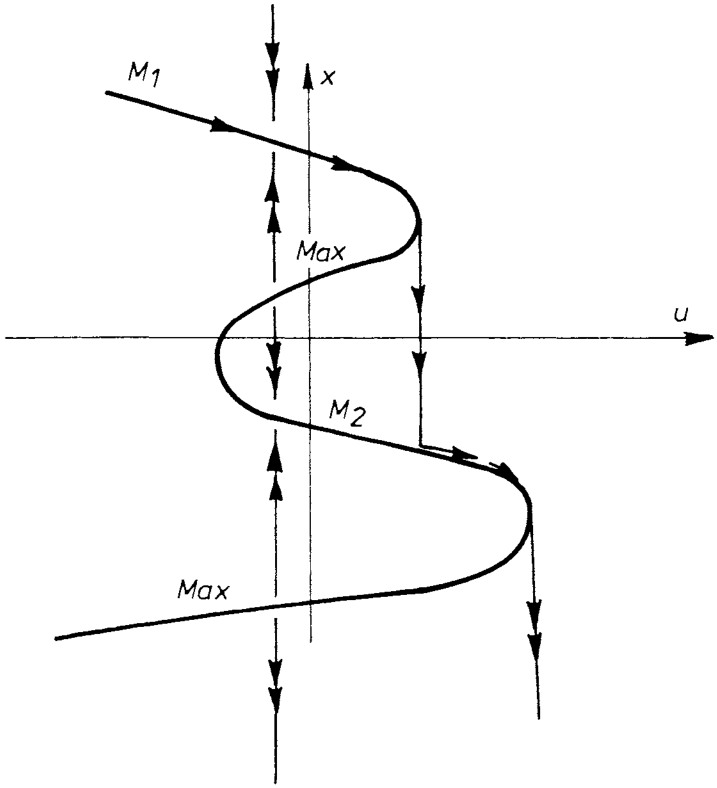


Figure 22

"La singularité section par 13α – en tant que morphologie physique s'interprète comme une régime condammé à disparaitre mais qui avant de périr, saute dans un régime métastable qui lui aussi disparait (soubresaut d'agonie). Cette morphologie est à l'origine du sémantisme exprimé par l'adverbe "presque", l'auxiliaire "faillir" en français" (Thom 1970: 239)

This description is another elaboration of the archetype of gradual death derived above, but it makes no sense with the linguistic items *presque* i.e. *almost*. As graph 13 (Thom 1970: 236) is rather unspecific and as Thom's remark: "Par l'application de la convention de Maxwell, on a une onde de choc partant d'un point cusp et aboutissant au voisinage du point double" (ibid.) is incorrect (compare Fig. 21) we shall give a new independent derivation of archetype No. 7 *almost*.

If we consider as Thom proposed the (v,w) plane in the bifurcation set, we notice that the central area of the swallowtail is cut by a Maxwell-line (line where the minima are of equal potential) which starts from the right corner, the origin of a cusp (A_{+3}) and touches the line coming from the left corner, a negative cusp (A_{-3}). It is of eminent importance for us to localize the path in relation to this conflict-line. In Fig. 20 we marked two surfaces of the conflict plane A and B. For the class of paths parallel to *w* (*u* being a negative constant) it is crucial to know if they:

(a) touch neither A nor B (but intersect with the swallowtail at the left of A and B): a″;
(b) cross through A and B: a′;
(c) touch only B: a.

These considerations show that the variable *v* is a higher control for the derivation of semantic archetypes. If we move the position of the path parallel to *w* on a line parallel to *v*, we get a higher archetype, i.e. an archetype controlling a set of archetypal processes in the bifurcation set of an elementary catastrophe.

Case (a) is rather simple; only three fold catastrophes take place. Diagram 13 gives the corresponding process.

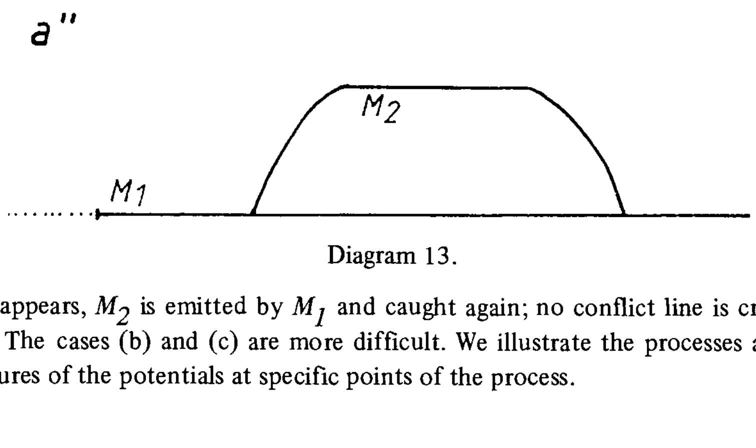


Diagram 13.

M_1 appears, M_2 is emitted by M_1 and caught again; no conflict line is crossed.

The cases (b) and (c) are more difficult. We illustrate the processes adding pictures of the potentials at specific points of the process.

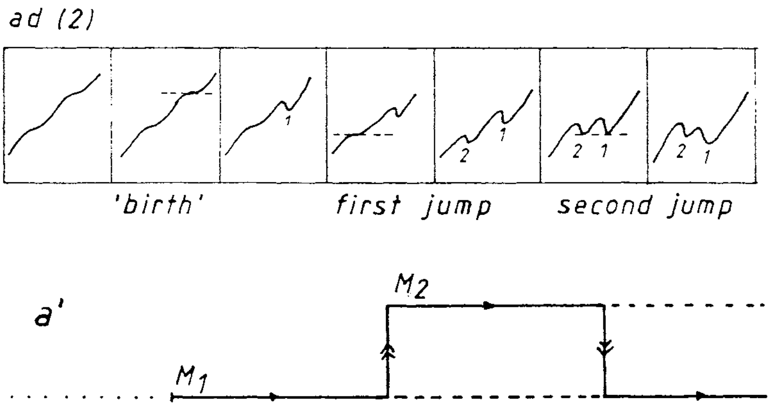


Diagram 14.

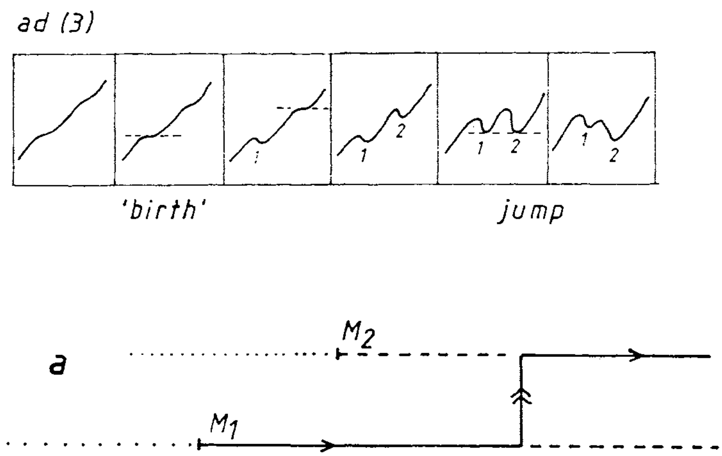


Diagram 15.

Only case (b) corresponds roughly to Thom's intuition of a change which *almost* happens[6]. This intuition becomes clearer if we consider the higher archetype, i.e. a process changing the simple archetypal structure continually. In diagram 16 ν is the parameter of the higher archetype. Changes on this axis cause the differences observable between a and e.

At first no change takes place (cf. diagram 16), then a metastable change occurs, whose domain is broadened until in (e) a stable archetype of change is established. We can call this *higher* archetype the ***archetype of metastable change***; it fills the continuum between the A_1-type (no change) and the A_3-

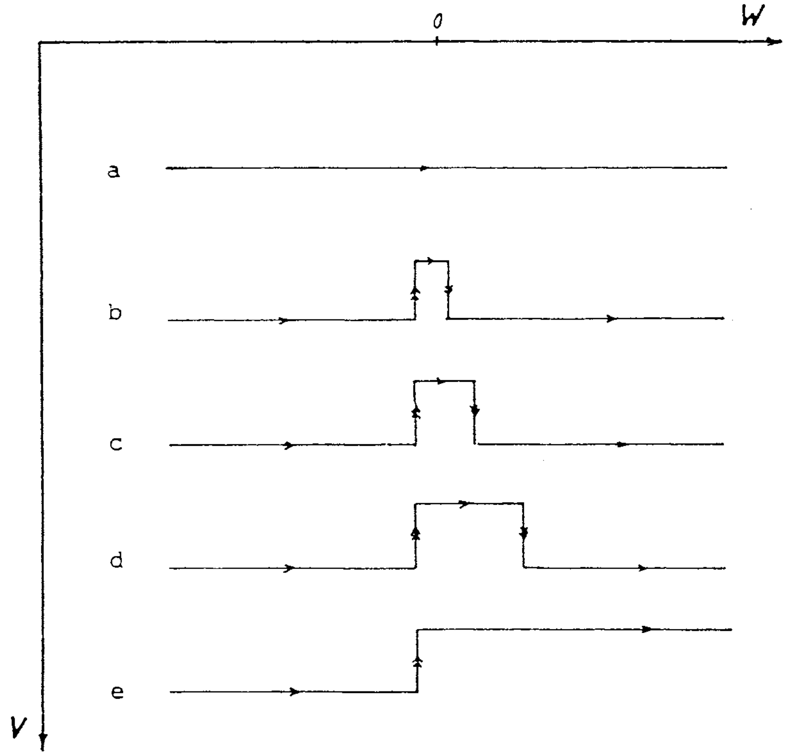


Diagram 16.

type (simple change). The fact that this higher archetype is rendered linguistically by an adverb has a natural explanation. Adverbs have the function of modifying verbs (in general), thus filling the semantic gap between different semantic archetypes. Closing our summary of the archetypes derivable from the swallowtail we can say that these unfoldings give rise only to semi-elementary and higher archetypes. This seems to be a general characteristic of unfolding whose germs have an odd exponent.

3.5 *The semantic archetypes derivable from the butterfly*

3.5.1 *Sketching the geometry of the standard butterfly* (A_{+5})

Organizing center: (1) $V = x^6$

Unfolding: (2) $V = x^6 + tx^4 + ux^3 + vx^2 + wx$

The set of critical points: $\{(x, t, u, v, w)$: such that (3) obtains$\}$

$$(3)\ \frac{\partial V}{\partial x} = 6x^5 + 4tx^3 + 3ux^2 + 2vx + w = 0$$

The bifurcation set is the set of quadruples (t, u, v, w) such that equations (3) and (4) hold:

$$(4)\ \frac{\partial^2 V}{\partial x^2} = 30x^4 + 12tx^2 + 6ux + 2v = 0$$

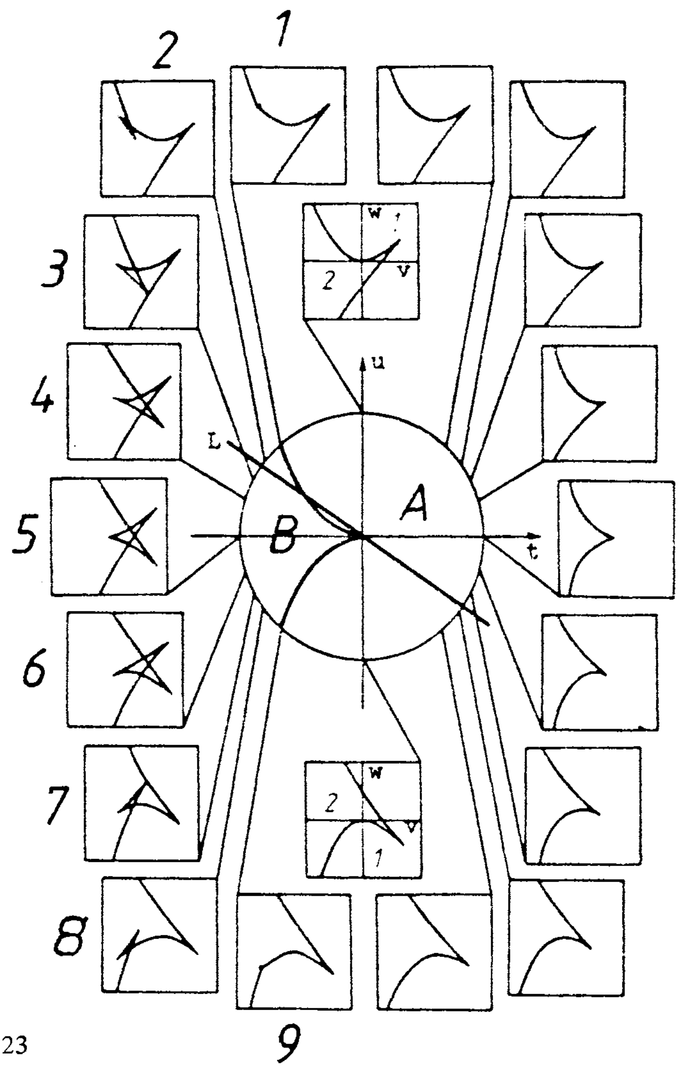


Figure 23

Whereas the bifurcation set of the swallowtail could be graphically represented, the bifurcation set of the butterfly has four dimensions and we can only show sections of it. In Fig. 23 (cf. Bröcker and Lander 1975: 163), we have a two-dimensional cusp-like curve in the central area with the parameters *u* and *t*. A line *L* goes through the centre of the circle. For selected points on the circle, i.e. for specific pairs of values in the plane (*u*, *t*), small two-dimensional pictures showing the values of the variables *w* and *v* are given. The circle contains two main areas: A and B. If a point in B is chosen, the small pictures (1 to 9) show the appearance and disappearance of a 'pocket', which contains new structural information, exploited in our further derivations.

For the derivation of new archetypes the domain where the corners of the 'pocket' pierce through the lateral lines (4 to 6) are of special interest. For our further consideration we concentrate on the symmetric picture 5 (*u* = 0, *t* is a negative constant). For a fuller treatment, cf. Wildgen (1979: 340 - 380).

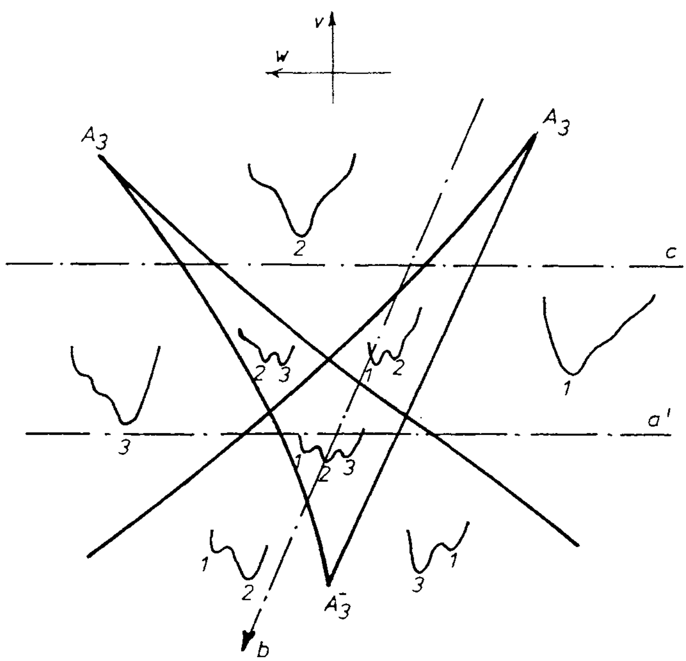


Figure 24

Fig. 24 allows the separation of three zones:

(a) an area outside the butterfly with *one* attractor,
(b) an area adjacent to (a) with *two* attractors,
(c) the central area with four corners adjacent to area (b) which has *three* attractors.

3.5.2 *Derivations on the basis of the perfect delay convention*

In Fig. 24 we considered three types of paths (*a'*, *b*, *c*) out of a larger set which was classified in Wildgen (1979). Only path *c* leads to a temporary dominance of the middle attractor, thus creating a new phenomenon. Diagram 17 shows that we obtain a sequence of two archetypes of change, corresponding to those derived from the cusp. We call it the *archetype of passage* or of mediated effect.

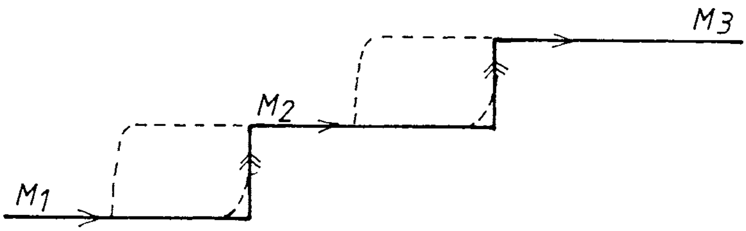


Diagram 17.

This archetype, which is semi-elementary, compactifies the archetype of *gradual birth / death* derived from the swallowtail. Linguistically it introduces a notion which corresponds to the deep-case "path" introduced by Stratton, 1971. We can give exemples at different levels of semantic attribution.

(a) Localistic interpretation
– Mike travels from Germany to Italy crossing Austria
(M_1 = Germany, M_3 = Italy, M_2 = Austria)

(b) Qualitative interpretation
– The blue sky clouded over and became black
(blue - clouded - black)
(M_1 - M_2 - M_3)

(c) Agent interpretation
– *Ball 1* hit *ball 2* which moved *ball 3*

(d) Transfer interpretation
– The watch went from *Peter* to *Josha* and finally to *Jean.*

As path c is constrained to a small area in Fig. 24, we must generalize our interpretation introducing a higher archetype which moves path c along the axis v. We can distinguish three distinct areas:

(a) When v is a large positive constant the path parallel to w does not intersect the butterfly figure.

(b) Path c intersects the two "horns" which originate at the cusp singularities (A_3) and does not touch the inner area.

(c) Path c cuts the inner area or it lies below this area, cutting only the two bifurcation lines which form the 'legs' of the whole figure.

Fig. 25 shows a section through the catastrophe set at different positions of the path (a, b, c).

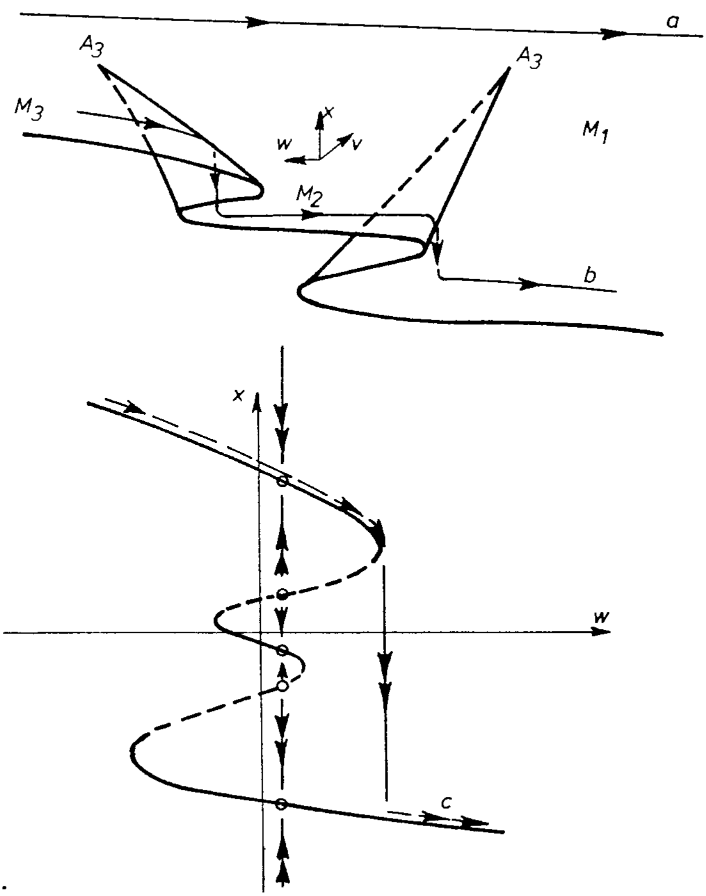


Figure 25.

In position (a) the process is without accidents, corresponding to a zero-unfolding (A_1) (with versal parameter, cf. chapter 3.1.).
In position (b) the archetype of passage is exhibited. The path has to cross two conflict zones of type A_3 (falling on an intermediate surface of minima) before it reaches the minimum M_1.
In position (c) the intermediate minimum is irrelevant (under the convention of perfect delay). The jump corresponds simply to those encountered in the cusp (cf. chapter 3.3.).

Diagram 18 shows that these consecutive phases define a higher archetype, which creates a metastable archetype of passage, which mediates between the archetype of zero-change and the archetype of bipolar change.

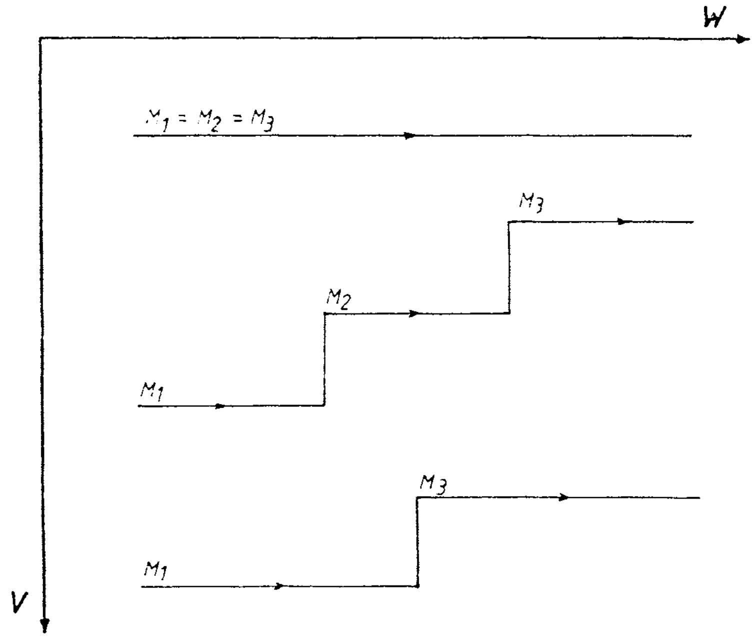


Diagram 18.

3.5.3. *Derivations on the basis of the Maxwell convention*

If we apply the Maxwell convention, we must consider the distribution of the potentials V and the conflict-lines (containing points with an unstable equilibrium between competing attractors). Fig. 26 gives such a detailed picture. The broken lines (---) are the conflict lines which separate the areas where M_1, M_2 or M_3 dominate. We note that there exists a point of triple conflict where all three minima have the same potential. Paths *a* and *b* cut the area above the triple point where M_2 is dominant.

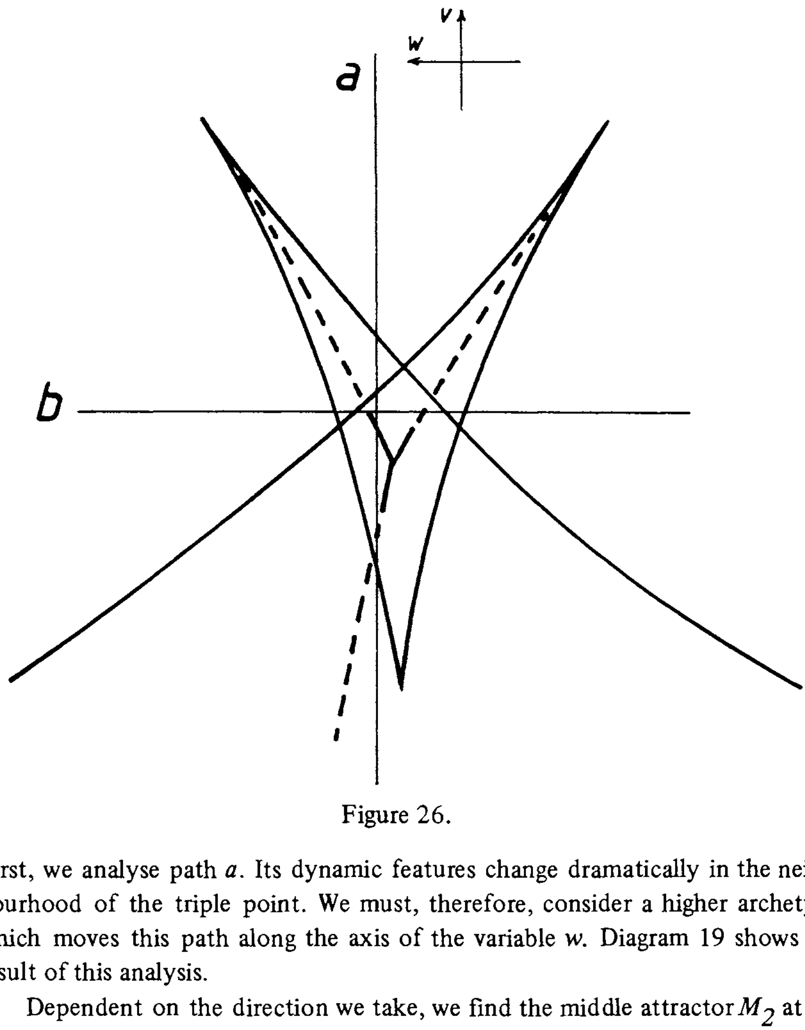


Figure 26.

First, we analyse path *a*. Its dynamic features change dramatically in the neighbourhood of the triple point. We must, therefore, consider a higher archetype which moves this path along the axis of the variable *w*. Diagram 19 shows the result of this analysis.

Dependent on the direction we take, we find the middle attractor M_2 at the beginning or at the end of the process. If we move from top to bottom, the catastrophic jump goes to M_1, then this jump is preceded by a short (almost) jump to M_3 and finally the jump moves in the direction of M_3. We can interpret this process globally as:

– ***archetype of polarization*** (with growing v)
– ***archetype of neutralization*** (with decrease of v)

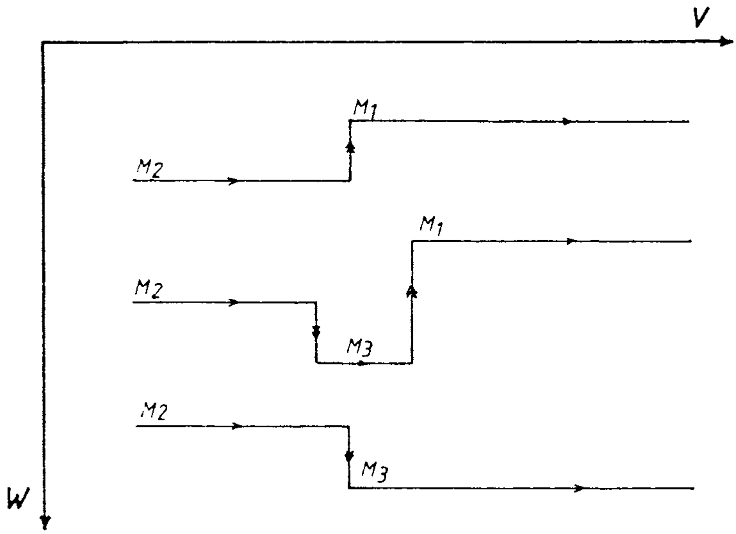


Diagram 19.

The dynamic character of path *b*, which is parallel to *w*, depends essentially on the constant value chosen for the variable *v*. Diagram 20 shows different stages dependent on *v*. Stages (a), (b), (c) lie above the triple point, stage (d) beneath.

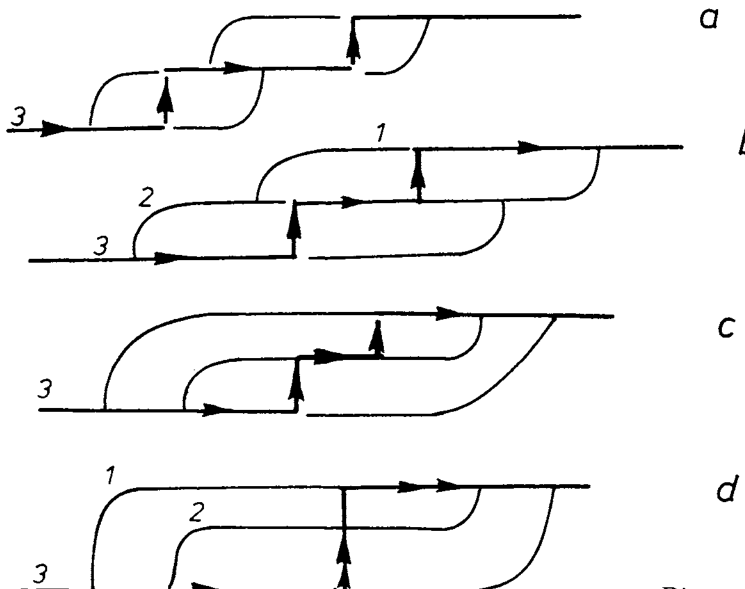
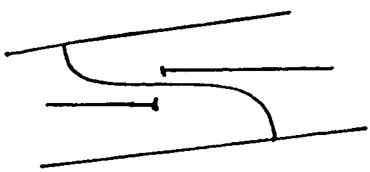


Diagram 20.

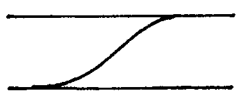
In (a) two cusp-like processes overlap, in (b) the distance between the catastrophic jumps is narrowed, in (c) both M_1 and M_2 originate in the immediate basin of M_3 and finally in (d) the two jumps collapse; the attractor M_2 has lost its faculty to dominate the process. The change in archetypal structure from (d) to (a) can be interpreted as a higher archetype of *trimodal differentiation* in a bipolar field or ((d) to (a)) of the *reduction of a trimodal field* to a bipolar field. Such processes occur in the development of languages, where grammatical and lexical differentiations appear or disappear. This points to a prominent area of application for higher archetypes: the dynamics of language development

René Thom proposed to derive an archetype of *giving* from the butterfly. We quote the hints he gave in Thom (1970: 236), adapting the name of the variables to our formulae, given at the beginning of this chapter.

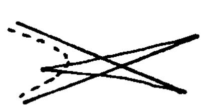
"The *butterfly* (14).
$V = x^6/6$, whose unfolding is $V = x^6/6 + tx^4/4 + ux^3/3 + vx^2/2 + wx$.
A section of the bifurcation set by a plane defined by $t = -h^2$, w = constant leads to a diagram of type



i.e. to a physical morphology of type



the morphology of giving.
In a plane section defined by t = u = constant, it is possible to obtain the same morphology of *giving*, which is, now, associated with a curved section indicated below."



(Thom 1970: 236)

Up to now we considered sections with *t* and *u* constant, such that *t* is negative. The path proposed as a second possibility by Thom is, however, rather peculiar.

(a) It is very specific, asymptotically approaching the legs of the butterfly.
(b) It is not specific enough as we have no information about its position relative to the triple point of conflict.

We shall therefore neglect this suggestion and reconstruct a derivation corresponding to Thom's first proposal (we suppose he gave the second possibility only to avoid complicated comments on the geometry of the butterfly). It is true that the first solution is rather complicated. We consider a slice of the four-dimensional bifurcation set of the butterfly in the three-dimensional space with the variables (u, v, w), where t is a negative constant (compare Fig. 23). In Fig. 27 a picture of the curved surface is given, together with a projection into the two-dimensional (u, v) and sections in the (w, v) planes.

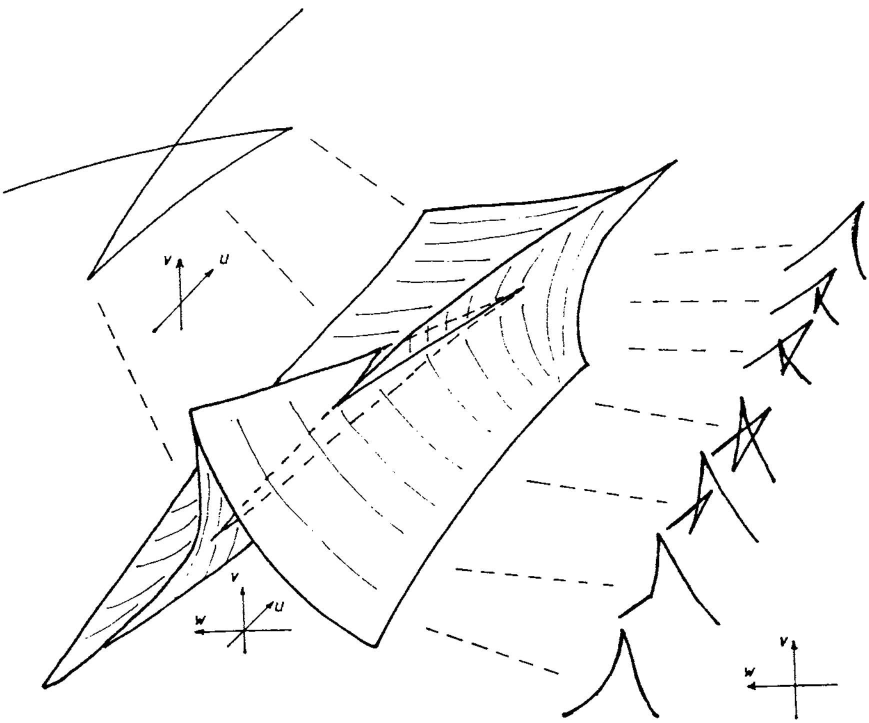


Figure 27.

The path which leads to Thom's archetype of *giving* (our archetype of transfer) must seek its way under the 'roof' in Fig. 27 and through the pocket inside the intersection of right and left parts of the 'roof'. As we presuppose the Maxwell convention, we must first show the form of the Maxwell set which is the exfoliation of a surface in the (u,v,w) space.

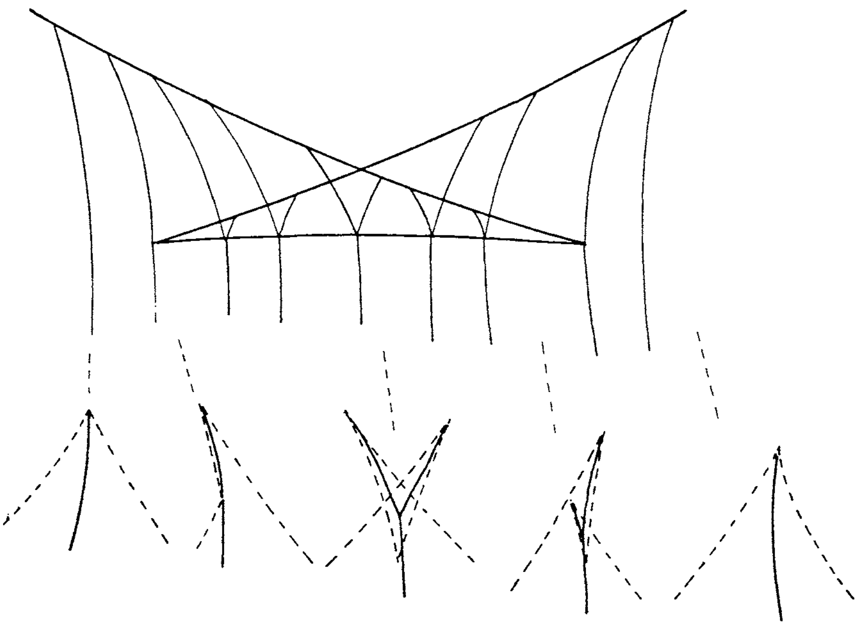


Figure 28.

The cross sections shown in Figure 28 show the triple points on the basic line and their bifurcation. Beneath, the position of these Maxwell lines in the bifurcation set is illustrated for different values on the u- axis. The paths which will be considered lie on a surface which is a slice in the neighborhood of the (u,v) plane. Figure 29 gives a rough picture of such a slice with three parallel paths.

The paths (1), (2) and (3) cross the domain where three minima M_1, M_2 and M_3 coexist. Their characteristic features are shown in the diagrams 21 to 23 (p. 74):

- Path (1) causes two catastrophes of conflict: e_{32} and e_{21} (compare section 1.3. and diagram 1). They are, however, outside the domain of coexistence of the three attractors.
- Path (2) gives rise to a new structure, where an attractor is created in the basin of M_1 and captured by M_3. Moreover it achieves dominance between the conflict points e_{32} and e_{21}. This diagram corresponds to the one

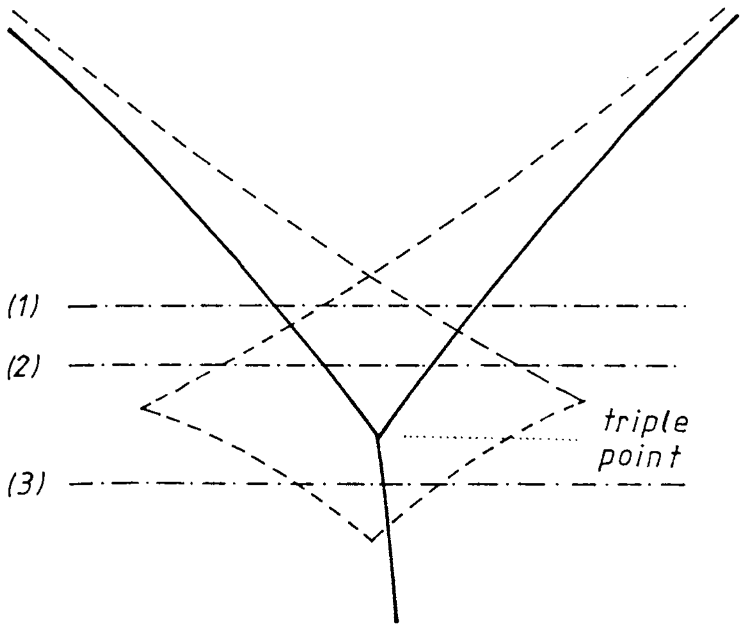
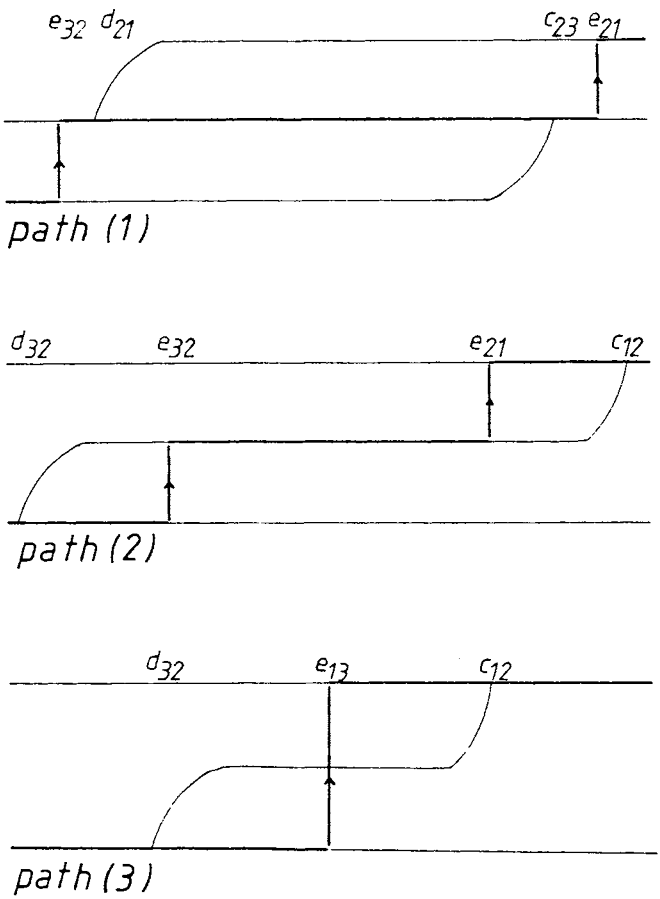


Figure 29.

given by Thom for his archetype of giving (morphologie du don). We choose a more general term, calling it the *archetype of transfer.* Contrary to the archetype of passage derived earlier, there are two attractors M_1 and M_3 which exist continually; i.e. M_1 and M_3 are primary agents, not created or destroyed by the catastrophes taking place. The agent M_2, however, is created in the field of M_3, gains dominance, loses its dominance and disappears in the field of M_1. The archetype of transfer is thus a really new elementary archetype, adding new structures to the system derived in the last chapters.

– Path (3) shows a similar transfer but the middle attractor does not achieve dominance.

As the paths (1) to (3) are parallel to the *u* axis, they can be considered to be a family of paths controlled by the variable *v*. The corresponding archetypes, which were not interpreted in detail, give rise to a higher archetype which controls the existence and the extension of the domain where M_2 is dominant. We can call it the *(higher) archetype generating or abolishing transferred objects / instruments / compromises* (dependent on the type of interpretation chosen). The different stages are:



Diagrams 21, 22 and 23

(0) Two cuspiod changes occur. A corresponding path would lie above path (1) in Figure 29 in the domain where the cusp lines do not intersect.

(1) There is a domain of coexistence of three attractors. The middle attractor is, however, dominant throughout this domain. Compare path (1) in Figure 29 and diagram 21.

(2) The middle attractor has a period of dominance in the domain of coexistence with M_1 and M_3. Compare path (2).

(3) The middle attractor loses its dominance but coexists with the other attractors. Compare path (3) and diagram 23.

(4) Only a cuspiod change between two attractors occurs. This would correspond to a path (4) beneath path (3) in Figure 29.

If we interpret the simple archetype by a concrete action of transfer between two persons, the higher archetype modifies the manner of transfer in a way apparent in the following examples:

(i) Peter throws a ball towards John (the ball is free for a moment)
(ii) Peter gives John a ball (the ball is focussed on)
(iii) Peter makes a present to John (the object is *not* focussed on)

As the archetype of transfer is elementary, we shall develop the whole range of linguistic models (summarizing the treatment in Wildgen (1979: 364-379)).

(a) *The localistic interpretation*

In this rather simple interpretation, we obtain one domain where two areas overlap (a zone of common influence). In this domain, separated by a conflict-line, a third domain emerges, which can achieve a kind of metastable dominance creating thus a 'compromise pocket' between the two conflicting attractors. This rather complicated situation can be associated with political domains and neutral zones between two opposed blocks. As the higher archetype derived above shows, the neutral zone is only small. The opposed blocks can absorb it, thus reducing the tripolar field to the simpler bipolar one. It is difficult to give linguistic examples for this process. We suppose that in general the level of interpretation follows the level of dynamic complexity of an archetype. In the case of the zero-unfolding and the fold, localistic interpretations were dominant, the cusp showed the whole spectrum of interpretations; the unfoldings higher in the hierarchy tend to be interpreted at a higher attributional level.

(b) *The qualitative interpretation*: The archetype of compromise

The bipolar opposition of M_1 and M_3 is interpreted as an opposition between adjectives or nouns on the same quality scale. Most languages are very rich in this respect. We distinguish a static and a dynamic perspective.

Examples (static):

M_1:	young	good
M_2:	middle-aged	satisfactory, sufficient
M_3:	old	bad

Examples (dynamic):

A (agent) overcomes his mediocrity.

A (agent) becomes normal.
A (agent) seeks for a compromise.
A (agent) gives up his indifference.
The racing driver who was last at the start joined the middle field and finally won the race.

As this archetype synthesizes two events of change, the whole process is normally not expressed in one elementary sentence. The archetype of compromise (as we call this interpretation of the archetype of transfer) seems to be rather composite from a linguistic point of view. The whole archetype is, however, often implicitly given in elementary sentences (see the examples above).

(c) *The phase interpretation*

As in (a) and (b), we obtain phases of a dynamic process which are realized in more than one elementary sentence. We can now insert a compromise zone into the bipolar fields enumerated in chapter 3.3., thus obtaining a trimodal field.

Example:

war	←------	mobilization	←———	peace
	———→	armistice	------→	
M_1		M_2		M_3

The two compromise zones 'mobilization' and 'armistice' are not equivalent. We observe a delay phenomenon such that the point of catastrophic change depends on the direction of the process. The two positions of zone M_2 developed into one compromise zone, called cold war in the European context.

(d) *The possession interpretation*

This interpretation was considered a central one by René Thom and we have taken up his suggestion, calling the whole archetype the ***archetype of transfer***. Some examples serve to illustrate the depth of this propositional primitive.

Examples:

(i) Peter (M_1) gives John (M_3) an apple (M_2).
John (M_3) takes an apple (M_2) from Peter (M_1).
An apple (M_2) is exchanged by Peter (M_1) and John (M_3).

(ii) Peter's apple goes to John.
John's apple comes from Peter.

(iii) Peter's apple becomes John's apple.

Although the syntactic structures are different and different verbs are used, the substance of these sentences is the same. This equivalence is only recognized at a deep semantic level which roughly corresponds to the concept of "scenes" introduced by Fillmore (1977a,b) and others. The semantic archetypes seem to be the deepest and therefore the most primitive level of propositional semantics. The apparent similarity of archetypal semantics and the frames- and scenes-semantics proposed by Fillmore could be the subject of a separate study.

(e) *The interaction interpretation*

If we recall the interpretation given for the cusp (path K_3), we notice that the transfer archetype combines an archetype of emission with an archetype of capture. The secondary agent (M_2) which is emitted is now specialized or instrumentalized with the aim of touching, affecting, hurting the other primary agent. In diagram 24 we consider a cyclical path such that the starting point b_0 of the process is a position of rest which, after a phase of maximal tension b_1, attracts the movement, thus completing a hysteresis cycle.

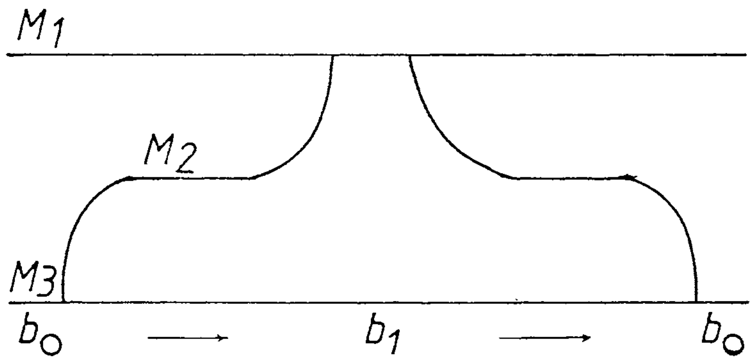


Diagram 24

The primary agents (M_1 and M_3) are interpreted by animate entities copresent in the scene. The secondary agent M_2 is considered as an ancillary agent, controlled by M_3 (as he is part of M_3 in the phase of rest). M_3 emits the agent M_2, M_2 gains a relative autonomy and is captured by M_1 (or actively it affects, touches, hurts M_1). In the phase of return M_2 separates from M_1 and is captured by M_3. We get the ***archetype of indirect action / instrumental interaction.*** The prominence of M_2 is governed by a higher archetype. Thus we obtain different realizations:

(i) Peter (M_3) hits John (M_1).
(ii) Peter (M_3) hits John (M_1) with his fist (M_2)

(iii) Peter (M_3) hits John (M_1) with a stick (M_2).

We call this higher archetype the *archetype of object / instrument prominence.*

At a richer attributional stage, which is not considered in this book, we can interpret this archetype as a basic scheme of causation or motivation where specific means are used to bring about a state of affairs.[7]

Examples:

(iv) Peter causes John to hit Paul.

(v) Peter creates a situation which brings about the damage of John.

etc.

3.5.4. *Some semi-elementary archetypes derivable from the dual butterfly (A_{-5})*

The unfolding of the dual (negative, anti-) butterfly is:

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

Fig. 30 shows a two-dimensional section in the bifurcation set of the dual butterfly. We notice that minima and maxima are interchanged, the general shape of Fig. 30 corresponding to Fig. 26 in chapter 3.5.3..

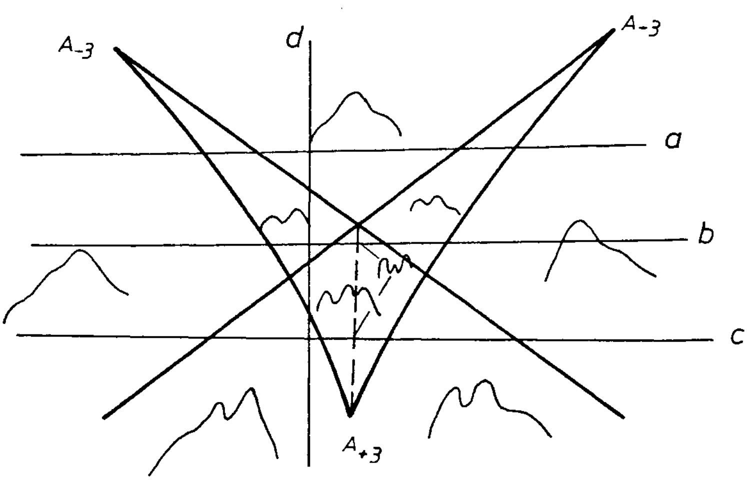


Figure 30.

(a) The upper 'horns' of the bifurcation lines are singularities of type A_{-3} (= dual, negative cusp); the 'horn' beneath is of type A_{+3}. Thus the singularities have changed their sign.

(b) The conflict line (- - -) starts from the positive cusp (A_{+3}) and ends at the intersection of the foldlines coming from the upper 'horns'.

The paths *a, b, c and d* drawn in Fig. 30 lead to different semi-elementary archetypes which are shown in diagram 25.

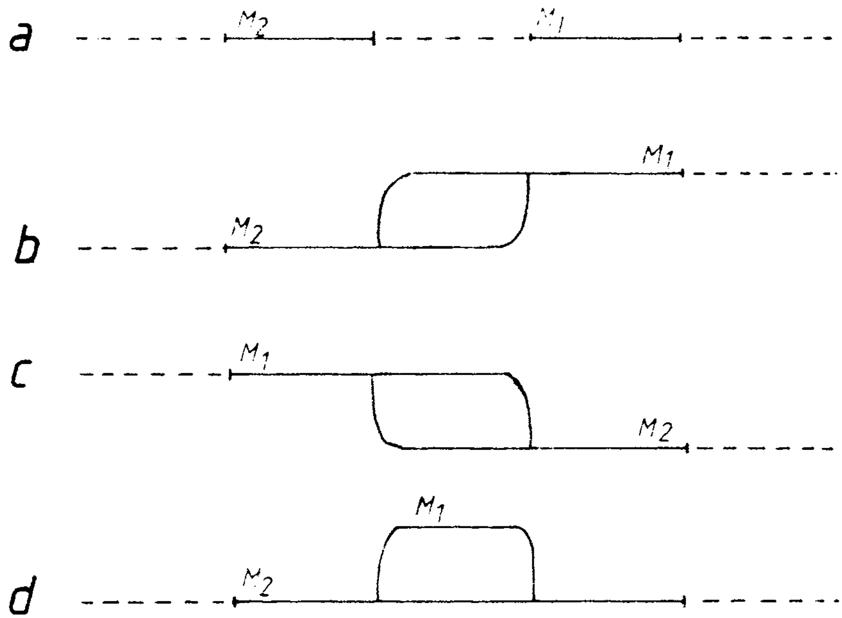


Diagram 25.

Path (a) exhibits a combination of fold catastrophes (death/birth), paths (b) and (c) combine fold catastrophes with cusp catastrophes and path (d) leads to a combination of fold catastrophes and a process derived from the dual cusp (cf. chapter 3.3.2).

3.5.5. *Summary of the archetypes derived from the butterfly*

The unfolding called the 'butterfly' allowed the derivation of very important archetypes, thus completing the set of archetypes derived from unfoldings lower in the hierarchy (compare section 4.1.). We give a short summary of the main results.

(1) *Elementary archetypes.*

We have derived three central archetypes

(a) The archetype of compromise
(b) The archetype of transfer
(c) The archetype of indirect action/instrumental interaction.

These archetypes interpret *one* path (completed by a circular path in (c)) in the (u,v) plane such that t is a negative constant and w a small constant. In (a) we chose a qualitative or phase interpretation, (b) uses the possession (control) interpretation and (c) presupposes a frame of interaction.

The archetypes (b) and (c) can be further elaborated if we accept symbolic objects as transferred entities or even as instruments. In this attributional elaboration of the archetype, information may be seen as emitted by a source and captured by a goal. In a more pragmatic interpretation of language use, language is a kind of symbolic instrument influencing the goal and returning to the source. It is in fact the ambivalence between these schemes of archetypal communication which creates frontiers in semiotics. The non-instrumental interpretation (transfer interpretation) mirrors:

(a) An early stage in communication, where signs are emitted quasi naturally; the subject 'loses' traces of its internal state which are 'found' by the interpretant[8]. The level of semantics which ignores the intentionality of the sign user and reifies the sign gives a similarly reduced picture of communication.
(b) With the general evolution of the instrumental scheme, communication becomes more indirect and more complex. The sign is not 'lost' but rather the source produces copies of it, which reach the goal, i.e. the sign is not really transferred from the source to the goal, it touches the goal and is recovered by the source. This scheme contains as a basic feature the intentionality of the sign-user who wishes to affect, influence or control his addressee. In a broad interpretation we can say that pragmatics is created at this level. The full elaboration of the frame of communication is achieved at a further level of archetypal morphogenesis, in the archetype of indirect instrumental achievement. We shall derive this archetype in chapter 3.7..

(2) *Semi-elementary archetypes*

We have not derived all semi-elementary archetypes which combine fold catastrophes and cusp catastrophes. One semi-elementary archetype derived on the basis of the perfect delay convention deserved our attention, as it combined two cusp catastrophes and contained three different phases of stability. We called it the ***archetype of passage*** (cf. chapter 3.5.2). It corresponds to the frame containing the case called *path* by Stratton (1971: 222) which was considered as rather dubious, thus mirroring our category of semi-elementary archetypes.

(3) *Higher archetypes*

As the bifurcation set of the butterfly is four-dimensional, the class of typical paths is very large and we could in principle find several levels of higher archetypes. In fact we only considered higher archetypes in the immediate context of those paths which led to elementary archetypes. Higher archetypes modifying semi-elementary archetypes were neglected. We found three different higher archetypes called:

(a) The (higher) archetype of polarization or neutralization.
(b) The (higher) archetype of trimodal differentiation.
(c) The (higher) archetype of the prominence of the object or instrument.

(a) *Polarization and neutralization*

In the field of three competing attractors, we can start from the intermediate (compromise) attractor M_2. In the archetype of polarization, dominance changes directly to M_1, to M_1 via M_3 or directly to M_3. As M_1 and M_3 are the poles of a stable bipolar field, this change can be called *polarization*. The process in the other direction leads from M_1 or M_3 to the intermediate (compromise) attractor M_2 thus neutralizing the bipolar opposition betweeen M_1 and M_3. This change can be called neutralization. This higher archetype is *one* elaboration of the (higher) archetype of bipolar differentiation versus reduction in a bipolar field derived from the cusp (in section 3.3.4.).

(b) *Trimodal differentiation*

The higher archetype of trimodal differentiation is the natural and consequent elaboration of the higher archetype of bipolar differentiation. It is obvious that the higher dimensional 'butterfly' allows the derivation of more higher archetypes than the 'cusp'.

(c) *Prominence of the object/instrument*

The higher archetype of object/instrument prominence corresponds dynamically to (b); it presupposes, however, a special type of semantic attribution called 'interaction interpretation'.

3.6 *Archetypes derivable from unfoldings with codimension > 4 and corank 1*

Thus far, only the unfoldings A_2, A_{+3}, A_{-3}, A_4, A_{+5}, A_{-5} have been discussed, i.e. we have considered unfoldings with corank l = 1 and codimension

$k \leqslant 4$. This set can be expanded in three directions:

(a) If we take codimension $k \leqslant 4$ as a natural limit because of the application of the models to phenomena either occurring in space-time or derived from such processes, we can add three further unfoldings of corank 2, which are simple in the technical sense of Arnold: D_{+4}, D_{-4}, D_5. They are called umbilics (D_{+4}= *hyperbolic umbilic*, D_{-4} = elliptic umbilic, D_5 = parabolic umbilic). The total set of unfoldings with codimension $k \leqslant 4$ is called the set of *elementary catastrophes* by René Thom.

(b) If we were to consider only unfoldings of corank 1, we could theoretically take all the unfoldings (k is a positive integer). We shall give two examples of such an expansion of Thom's list in this chapter.

(c) If the limitation to $k \leqslant 4$ is considered irrelevant, further umbilics (i.e. unfoldings with corank = 2) can be included. We shall see in chapter 3.7. that such an expansion is necessary if we want to reconstruct the semantic archetypes No. 13 to 16, proposed by René Thom. The double cusp (X_9) plays a special role in this expansion as it is a kind of compactification of the hyperbolic, elliptic and parabolic umbilic (it is, however, codimension 8).

The following sections can only give a first approximation of further elaborations on Thom's theory. More details are given in Wildgen (1979: 385 - 415). The geometry of the unfoldings A_6 and A_7 is rather difficult to trace graphically. We shall only point to central features of the unfoldings: A_6 (Wigwam) and A_7 (Star) (cf. Woodcock & Poston (1974: 194) for a computational treatment).

(a) The *Wigwam* (A_6)
Organizing center: (1) $V = x^7$
Unfolding: (2) $V = x^7 + ux^5 + vx^4 + wx^3 + tx^2 + sx$

The bifurcation set has five parameters: u, v, w, t, s. A three-dimensional section is obtained if only the swallowtail (A_4) points are drawn, i.e. every point on the plane shown in Fig. 31 is a swallowtail singularity. The upper edges are butterfly points (A_{+5} and A_{-5}). A similar section is given by Callahan (1977: 787).

Inside the area bordered by A_5-singularities is the two-dimensional structure given in Fig. 32 (cf. Callahan ibidem).

The path (a) drawn into Fig. 32 crosses all typical domains, thus meeting potential curves with 0, 1, 2 and 3 minima. It can easily be seen that this path leads to a semi-elementary *archetype of gradual death / birth* similar to the one derived from the swallowtail in chapter 3.4.. Instead of two steps we have three

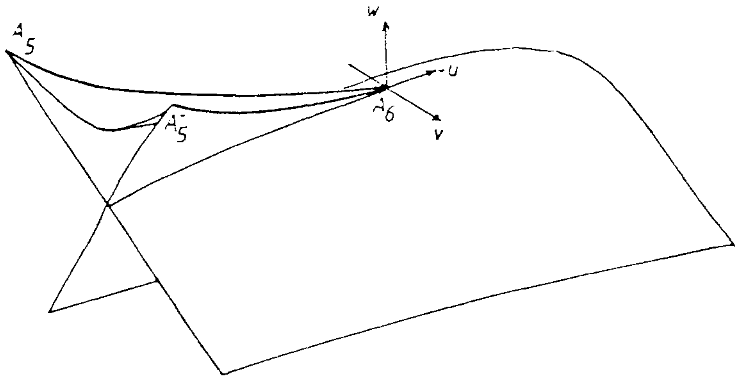


Figure 31.

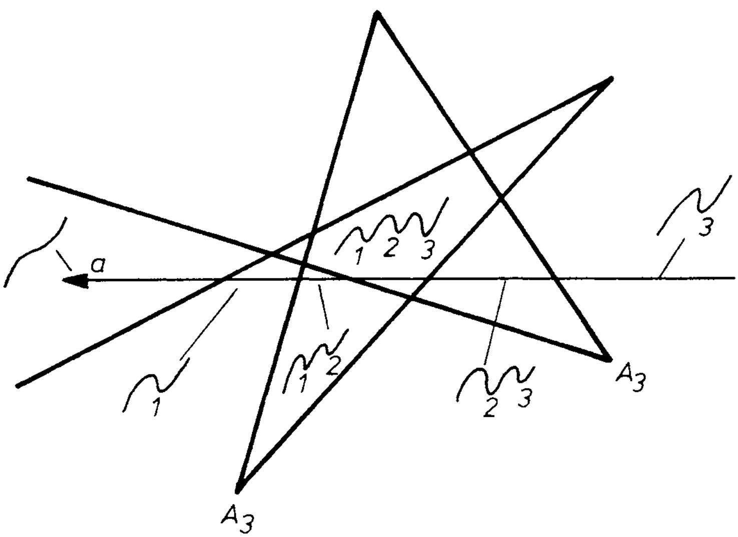


Figure 32.

steps. Fig. 33 gives a section along path (a) in the catastrophe set (with the internal variable x as vertical axis). Compare Fig. 33 to Fig. 22 in chapter 3.4. (cf. also Woodcock and Poston 1974: 210).

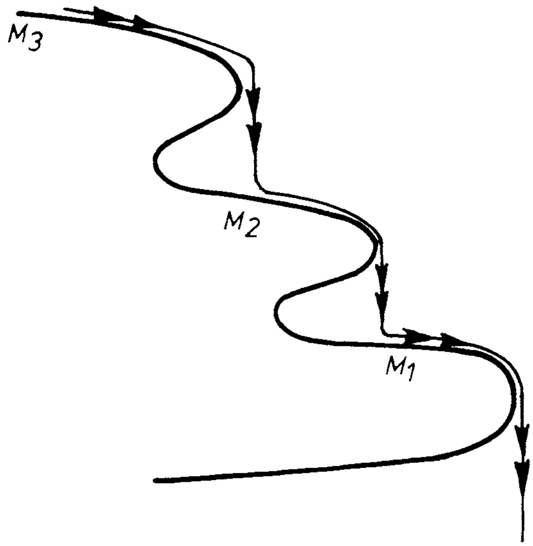


Figure 33.

It is possible to generalize these results, stating that the unfolding of germs with uneven exponents $V = x^{2k+1}$ leads to archetypes with $k - 1$ steps (degrees). This result shows that specific archetypes are recursive at the level of unfoldings with corank 1. This type of recursiveness is, however, different from the one encountered in formal grammars (we could call it topological recursiveness).

(b) *The Star* (A_7)

Organizing center: (1) $V = x^8$
Unfolding: (2) $V = x^8 + ux^6 + vx^5 + wx^4 + tx^3 + sx^2 + rx$

The main result obtained here is a compactification of the archetype of gradual birth / death which was a recursive elaboration of the archetype of passage. As in the case of the Wigwam (A_6), we can derive an archetype which adds one intermediate stage to the *archetype of passage* derived from the butterfly (A_5). The system changes from the stable state in M_1 to the stable state in M_4 via the states in M_2 and in M_3.

We conjecture that similar elaborations for the archetype of transfer occur, but we could not prove it, as the geometry of the Star – especially its conflict strata – has not yet been explored.

3.7 *Semantic archetypes derivable from the compactified umbilics (D_{+4}, D_{-4}, D_5)*

In his paper of 1968, "Topologie et signification", René Thom proposed to derive two archetypes called the archetype of excision and the archetype of the messenger. He suggested deriving the first from the parabolic umbilic and the second from the elliptic umbilic. In Thom (1970) he gave further details and proposed four archetypes, derivable from the elliptic and the hyperbolic umbilic. These archetypes were:

(a) The *archetype of messenger*
(b) The *archetype of taking away* ("prehension")

Both are derived from an elliptical deformation of the "parabolic umbilic" (Thom 1970: 237).

(c) The *archetype of synthesis*
(d) The *archetype of excision.*

He proposed to derive these from the hyperbolic umbilic (Thom 1970: 237, 240ff.).

In the second edition of his book, *Stabilité structurelle et morphogénèse* (1977), new information is added. He says (ibidem: 91)

> "Concerning the umbilics, we can only associate a catastrophe of bifurcation which is structurally stable if we consider them in the unfolding of the singularity $V= x^4 + y^4$ (the "double cusp", according to Zeeman). This singularity has the algebraic codimension eight (topological codimension seven). Thus, it appears generally only as the product of associations of catastrophes on $\mathbb{R}^4$. The unfolding of the double cusp can have four minima; we can thus obtain interactions involving four attractors in the universal unfolding of this singularity. Some of these interactions can be localized in the neighbourhood of a parabolic umbilic; we shall give a linguistic interpretation for them in chapter 13".

In Chapter 13 of his book Thom states only that all the morphologies he proposed are present in the universal unfolding of the "double cusp" (ibidem, 303). In the table of archetypal morphologies (which we reproduced in chapter 2.5.) he only changed minor details compared with his derivations of 1970.

This insecurity is due to the fact that the geometry of the parabolic umbilic was first explicitly investigated in Godwin (1971). His results showed that the parabolic umbilic (D_5) has at most two minima. The archetypes with three or four agents which Thom proposed could thus impossibly be derived[9]. In the second edition of his book Thom acknowledged these facts. His more recent statement, that the double cusp can have four minima, was, however, supplemented by Callahan (1978): "The double cusp has five minima'.

In this situation we prefer to give only a brief hint at the possible results of further investigations. The present difficulties are:

(a) The double cusp is *not* an unfolding of a simple germ, thus it breaks the frame we chose for our modelling.
(b) The geometry of the couble cusp is not yet known in all its details. Thus we cannot classify typical paths and derive a complete set of archetypal structures.
(c) The archetypes (14) *to take away* ("Prendre"), (15) *to bind* ("lier") and (16') *to cut* ("couper") make a rather arbitrary choice among instrumental processes. It is only archetype (13) *to send* (*by messenger*) ("envoyer") which is a necessary and important elaboration of the archetypes found in the unfolding of the butterfly (A_5).

We shall derive the archetype of sending; the other archetypes have been shown to exist in the compactified parabolic umbilic (cf. Wildgen 1979: 400-410). The geometry of the parabolic umbilic is too complicated to be described here.

The geometry of the *elliptic umbilic* (D_{-4})

Organizing center: (1) $V = x^3 - 3\,xy^2$
Unfolding: (2) $V = x^3 - 3x^2y + w(x^2+y2) - ux - vy$ [10]

The bifurcation set of the elliptic umbilic is three-dimensional. Fig. 34 shows the typical form with two needles joining at the point where $u = v = w = 0$. The singularity D_{-4} is situated at this point.

Figure 34.

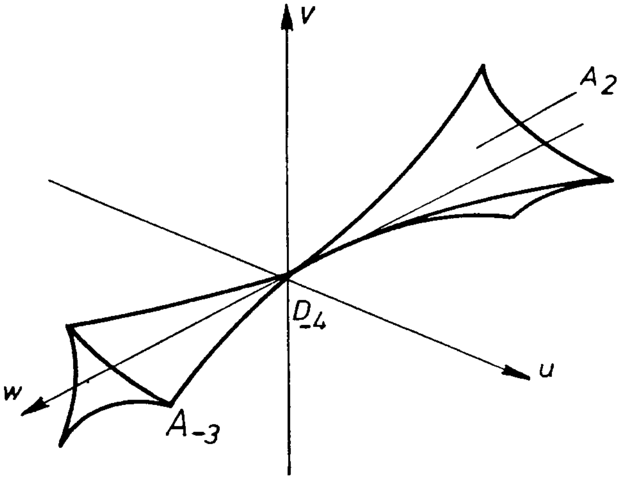


Fig. 35 shows two sections with constant values of w ($w < 0$, $w > 0$). The corners of the curved triangle are of the type A_{-3} (the dual cusp) (cf. Gilmore, 1980:78-89). In the domain where $w < 0$ we find a minimum (⊕) and three saddle points (○), in the domain where $w > 0$ the minimum is replaced by a maximum (⊖).

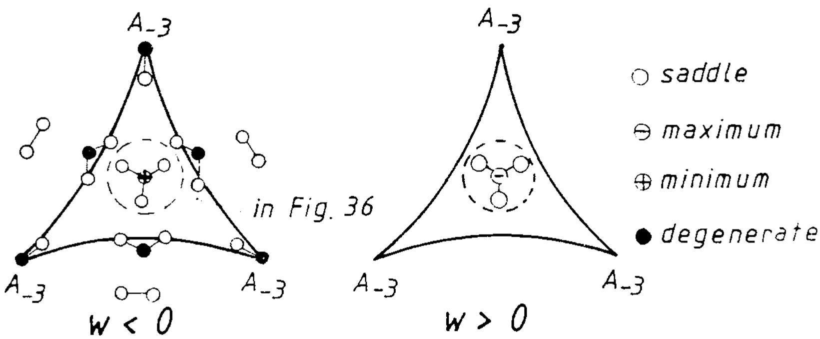


Figure 35.

A more detailed picture of the dynamical configuration in the domain where a minimum exists ($w < 0$) must introduce new techniques of graphical representation as the potential V depends on two internal variables, x and y. In Fig. 36 we show a map indicating altitudes in the three-dimensional 'landscape' (V, x, y). This picture describes the situation in the center of the elliptic umbilic (the section where w = constant and $w < 0$). The minimum, a basin in the center, is enclosed by summits and valleys which give rise to three passes, corresponding to the saddle points indicated in Fig. 36.
The minimum is connected to the valleys by the saddles, which in the center of the umbilic are of equal height thus forming an unstable equilibrium. The lines which form a triangle in the center of Fig. 36 are a kind of secondary passway between the valleys.

As the elliptic umbilic has only *one* minimum it cannot lead to new *and* richer archetypes. If, however, the valleys could be closed to form basins we would arrive at four minima. This can be achieved if the elliptic umbilic is embedded in the double cusp (X_9).

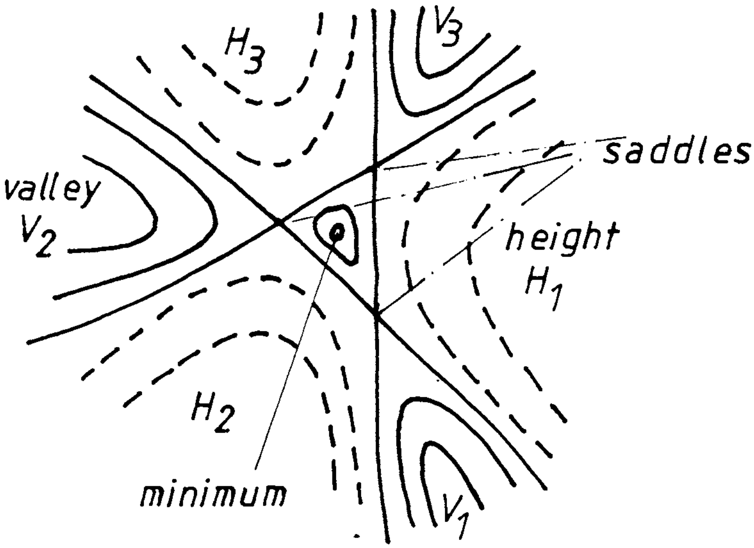


Figure 36.

"The way to compactify the fold is to add a term x^4; in other words the fold catastrophe can be regarded as a section of the cusp-catastrophe, which is compact. In this sense we may call the cusp the *compactification* of the fold. Similarly the double-cusp is important because it is the compactification of each of the three umbilics, the hyperbolic $x^3 + y^3$, the elliptic $x^3 - 3xy^2$, and the parabolic $x^2y + y^4$." (Zeeman 1977:564)

In the compactified elliptic umbilic we observe three peripheral minima (relatively large and deep) and one central but shallow minimum (cf. Figure 36). Speaking loosely, the central minimum represents a kind of link connecting the big attractors. In this situation the height of the saddles between minima is of paramount importance. We can interpret a low saddle as a kind of connection between minima, that is, one attractor *influences* the other via a low saddle. This influence presupposes, however, the existence of fluctuations as in the case of the Maxwell convention. This interpretation is summarized in the third principle of interpretation:

Third principle of interpretation

If a low saddle lies between the minima M_i and M_j, we say that the agent A_i which interprets M_i *binds/directs/leads/guides/transports* the agent A_j which interprets M_j.

This secondary process is less dramatic than the catastrophe of emission and capture derived from the cusp, it can therefore be considered as a subsidiary process, 'helping' in the establishment of the primary process. This interpretation is natural as all archetypes derived in the previous chapters reappear in the domain of catastrophes with corank 2.

In Fig. 37 we give a rough picture of the dynamic landscape in different areas of a section in the elliptic umbilic. The three saddle points form unstable equilibria. These equilibria are situated on three lines starting from the anticusp-points.

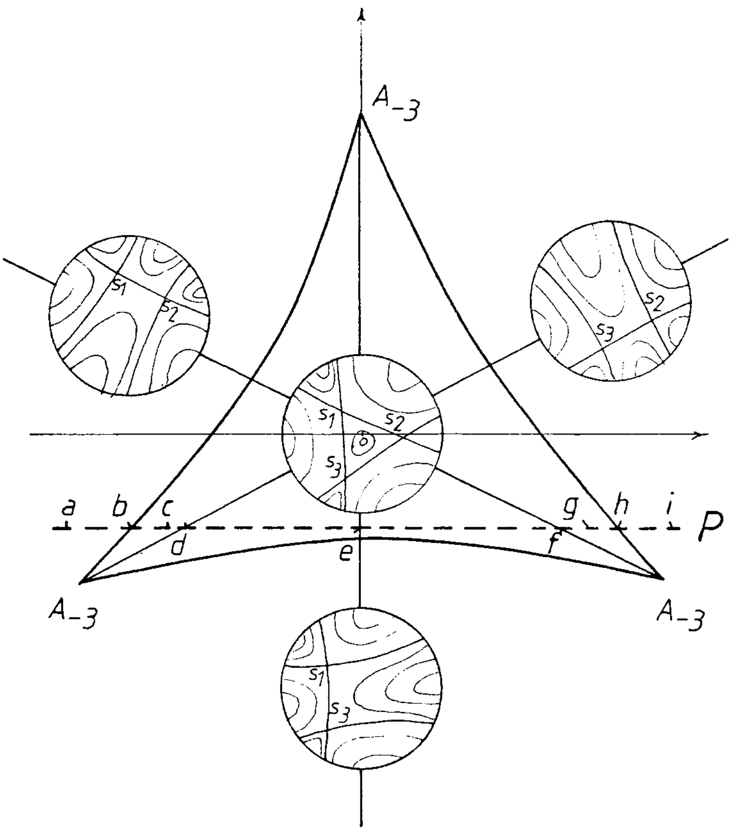


Figure 37.

If we take path *P* through this section, we get globally a process corresponding to the archetype of transfer derived from the butterfly.

An attractor M_4 is created in the basin of the attractor M_1 and disappears in the basin of the attractor M_3 ('emission'/'capture')

There is, however, a fourth attractor which neither emits nor catches the attractor M_4, it rather helps the transition of M_4 from M_1 to M_3. This rather complicated process can be illustrated by local maps of the situation in the space (V, x, y) at the points $a, b, c, d, e, f, g, h, i$ on path P in Fig. 37.

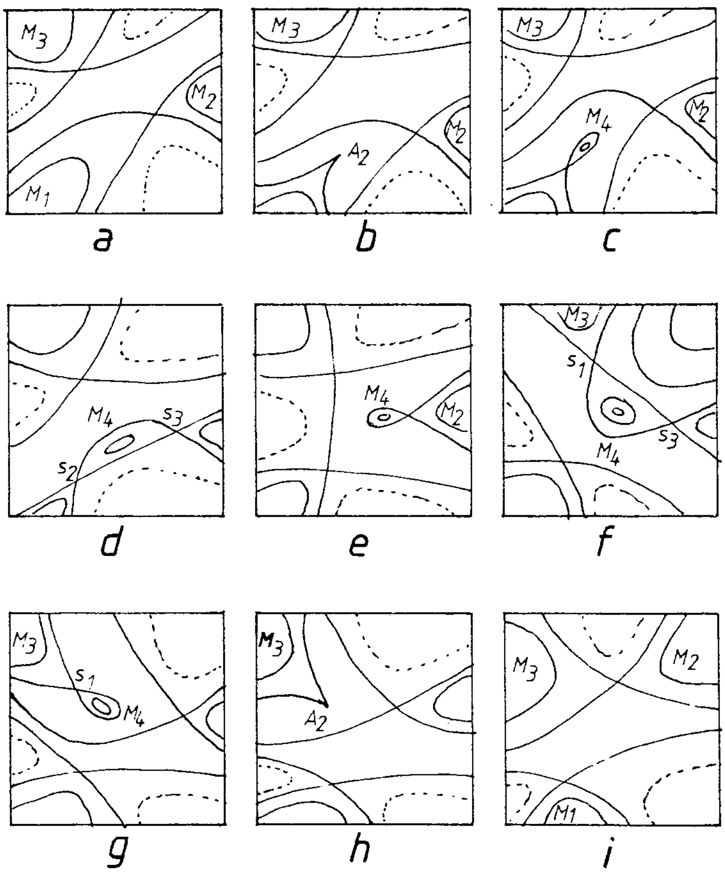


Figure 38.

We can clearly see how in (b) a fold point appears, which in (c) creates a new minimum M_4 (out of M_1): M_1 *emits* M_4. In (d) a line of equilibrium between saddles is reached (which is unstable). In (e) M_4 and M_2 communicate via a low saddle whereas the connection of M_4 to M_1 and M_3 is relatively weak (higher saddles): *The attractor M_2 transports /leads / guides the attractor M_4.* In (f) we cross a line of equilibrium between saddles. In (g) M_4 is bound to M_3 by the existence of a saddle (which emerged in (f)). The connection to M_2 is interrupted. The attractor M_4 is taken over by M_3: *M_3 catches M_4.* In (h) we finally reach a fold point which is now situated in the field of M_3. In (i) the attractor M_4 disappears in the field of M_3. The semantic archetype which interprets this dynamic structure is called the *archetype of the messenger.*

René Thom used the same type of diagrams to represent the archetypes derived from unfoldings with corank $l = 1$ (cuspoids) and corank $l = 2$ (umbilics). We prefer another diagrammatic representation which is more economic as it is a line in the case of the cuspoids and a two-dimensional graph in the case of the umbilics. The horizontal direction which gave the process axis in Thom's diagrams is represented by simple arrows (⟶). The new feature, attraction and influence without a catastrophe of bifurcation or of conflict, is represented by the deviation of the main path and by a field of attraction represented by arrows with two points (⟷). In diagram 26 we compare the archetype of sending derived from the butterfly (A_5) and the archetype of the messenger derived from the compactified elliptic umbilic (in X_9).

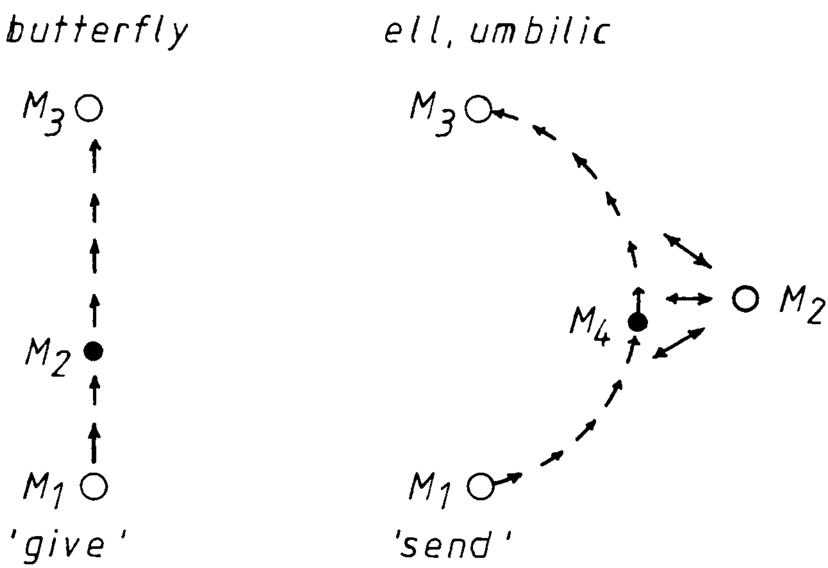


Diagram 26.

In Wildgen (1979: 400 - 410) we sketched the derivation of Thom's archetypes No. 14, 15, 16 from the compactified parabolic umbilic. We conjecture that:

(a) more archetypes can be derived if we consider E_6 which has a simple germ and is also compactified by the double cusp. The double cusp is a kind of closure on the set of elementary catastrophes (compare table 5 and Callahan (1980:284)).

(b) New higher archetypes can be derived. In Wildgen (1979:395ff.) we could derive the archetype of giving, considering another path in the compactified elliptic umbilic. It seems to be certain that a higher archetype exists which fills the continuum between these two archetypes thus controlling the appearance of a secondary instrument.

The fact that higher unfoldings locally embed more basic ones tends to close the set of elementary archetypes in a very natural way. It constitutes a highly organized system of dynamical primitives thus forming a system of dynamical *monads* (in the neo-Leibnizean sense proposed by Prigogine, Stengers and Pahault (1979:55)).

4. APPLICATION OF CATASTROPHE THEORETIC SEMANTICS

In chapter 4.1. we shall briefly summarize the propositional gestalts associated with the semantic archetypes derived in the last chapters. These archetypes appear to have a very rich internal coherence, thus creating a hierarchy in which simpler archetypes abut more complicated ones. This hierarchy allows us to define dynamic inferences, in this way reconstructing the concept of a perspective on a scene proposed by Charles Fillmore (1977a: 52). The reconstruction of basic scenes or propositional gestalts (cf. Wildgen 1982a) is the most prominent application of catastrophe theoretic semantics. In our derivations we have systematically given examples of this type. Chapters 4.2. to 4.5. give short summaries of further applications: word semantics (4.2.), linguistic vagueness (4.3.), theory of word formation (4.4.) and neurolinguistics (4.5.). As our presentation must be very short we can only give hints of the different types of applications.

4.1. *Dynamic inferences*

Our derivations in chapter three (and those proposed by René Thom and elaborated upon in Wildgen (1979)) considered the following unfoldings:

A_2:	the zero-unfolding,
A_{+3}, A_{-3}:	the standard and the dual cusp,
A_4:	the swallowtail,
A_{+5}, A_{-5}:	the standard and the dual butterfly
A_6:	the wigwam,
A_{+7}:	the star, (the dual A_{-7} should be considered)
D_{-4}:	the elliptic umbilic,
D_{+4}:	the hyperbolic umbilic,
D_5:	the parabolic umbilic

(E_6 should be considered to get a complete list of archetypes)

These unfoldings have a rich internal structure such that low unfoldings reappear locally in higher unfoldings. We say they *abut* higher unfoldings. Table 5 gives the hierarchy of abutment relations (cf. Arnold 1972 and Gilmore 1980: 135-140).

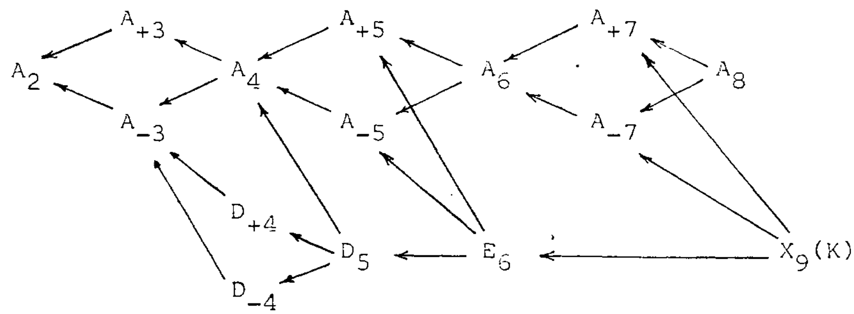


Table 5.

We have derived *elementary semantic archetypes* from A_2, A_{+3}, A_4, A_{+5} and the compactified D_{-4}. As a consequence, we can also derive a relation of abutment between those archetypes, which mirrors the general abutment hierarchy. The semantic relation in our linguistic model which corresponds to the formal relation of abutment will be called *dynamic inference.* As a fourth principle of interpretation we postulate:

Fourth principle of interpretation

If we have two elementary semantic archetypes a_i and a_j which were derived from different unfoldings U_i and U_j, we say that a_i can be dynamically inferred from a_j if:

(a) U_i abuts on U_j (cf. table 5). It follows that U_i has lower codimension than U_j.

(b) The mode of interpretation of a_i is identical to the one chosen for a_j (i.e. localistic, qualitative, phase, possession, agent or instrumental)[11]

The abutment is particularly simple if we compare those archetypes derived in the A_k-series. We shall, however, begin with an example of dynamic inference which connects the A_k - and the D_k - series.

(a) Dynamic inference from D_{-4} (compactified by X_9) to A_{+5}

From the compactified elliptic umbilic we derived the elementary archetype of the messenger. From this archetype we can infer the elementary archetype of transfer. These two archetypes have already been compared in chapter 3.7. (cf. diagram 27).

Examples

D_{-4}: (a) *Tom* sends *a letter* to *Jim* by *post*

M_1 M_4 M_3 M_2

A_{+5}: (b) Tom sends a letter to Jim
(c) Tom gives Jim a letter

We notice that the messenger can be omitted; in (b) the choice of the verb *send* creates a background which implicitly refers to the archetype of messenger, whereas (c) does not contain this implicit elaboration. It seems that the lexicon of verbs has a kind of archetypal substructure which either enforces the choice of a correspondent set of agents or gives hints at presupposed but not realized dynamic features. We hope that a dynamic study of the verbal lexicon will be accomplished using catastrophe theory.

(b) Dynamic inference from A_5 to A_3 and to A_2 (A_1).

In the following examples of archetypes taken from the A_k-series we can show that dynamic inference can be formalized by considering areas in a catastrophe diagram. If a larger area includes a smaller one, we can say that one of the corresponding semantic archetypes includes the other, i.e. the simpler archetype can be inferred dynamically. We arrive, thus, at a quasi-geometrical notion of inference.

In diagram 27 we analyse subfields of the catastrophe diagram underlying the archetype of transfer.

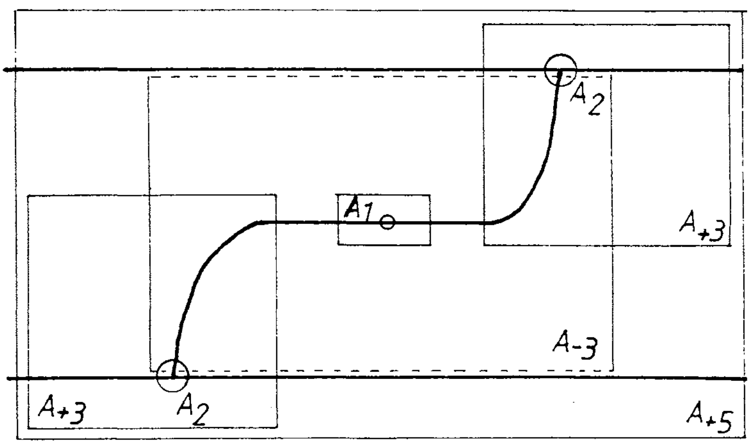


Diagram 27.

We can distinguish four different types of fields:

(i) The whole field corresponds to a section in the butterfly (A_{+5}). The corresponding archetype was called the archetype of transfer.

Example

Eve gives *Adam* *an apple*
M_1 M_3 M_2

(ii) In diagram 27 we find two subfields of type A_3 (the cusp). They are the basis for two semantic archetypes: the *archetype of emission* and the *archetype of capture*

Examples

Eve gives away *an apple* (emission)
M_1 M_1

Adam takes *an apple* (capture)
M_3 M_2

(iii) The attractor M_2 exists only between the two fold-points (A_2). Thus we have an archetype of transient existence which was derived from the negative cusp (A_{-3}).

Example

The apple appears (in the scene) and disappears again.
M_2

(iv) The archetype of delimited existence was considered to be semi-elementary as it was a concatenation of two elementary archetypes derived from A_2 (the fold). In diagram 29 we have two fold points – one where M_2 appears and one where M_2 disappears.

Examples

The apple appears (in the scene)
M_2

The apple disappears (from the scene)
M_2

(v) Finally all the points on the lines in diagram 27 which are not fold points are Morse, i.e. of type A_1 and structurally stable. For M_2 this stability is limited (cf. under (c)) by the fold points.

Examples

Adam exists
M_1

Eve exists
M_3

The apple exists (in the domain of M_2)
M_2

We assume that the relation of dynamic inference can be relevant in the semantics of verbs and in the description of tense, aspect and action modes. An elaboration of this application presupposes, however, a larger empirical and theoretical frame and cannot be given here.

4.2 *Word semantics*

Perhaps the most important advantage of a dynamic model in semantics lies in the fact that the most basic derived structures (the archetypes) are independent of the realizational levels. These are specific to single languages and depend on the economy of language use. The semantic archetypes emerge at different levels, such that the same pattern can appear in word semantics, sentence semantics or text semantics. In word semantics we can profit from the fact that the archetypal structures seem to mirror basic perceptual mechanisms. Whereas logical and algebraic semantics had to consider the level of words as a hidden syntactic level, we can try to fill the gap between lexical structures, structures of classification of reality and perceptual mechanisms on a neurological level. These three sublevels of word semantics have been thoroughly explored in the case of the colour lexicon. We have good physiological models, good anthropological research done in many societies and a highly standardized research on the colour-lexicon of about 450 languages. In Wildgen (1981c) we have described this field and the application of catastrophe theory to it in greater detail. We can summarize our results here (cf. Wildgen 1981c: 239-242, 285-288).

If we start from the opponent-cell theory of colour perception, we obtain two basic dynamic phenomena:

(a) The differentiation between excitation (presence of luminosity) and non-excitation. Dynamically we have an asymmetrical field with only one attractor (luminosity), which can be modelled qualitatively by the fold (A_2), cf. Fig. 39.

(b) The further differentiation into the set of primary colours follows the principle of bipolar differentiation, which can be deduced from the cusp (cf. the higher archetype of bipolar differentiation derived in chapter 3.3.). First the domain specified positively in (a) is further subdivided. After the 'splitting' of light-warm into light (white) and warm (red-yellow), further cuspoid polarizations occur. We can thus reconstruct dynamically the results obtained by Kay and McDaniel (1978). Diagram 28 exhibits the sequence of cuspoid differentiation.

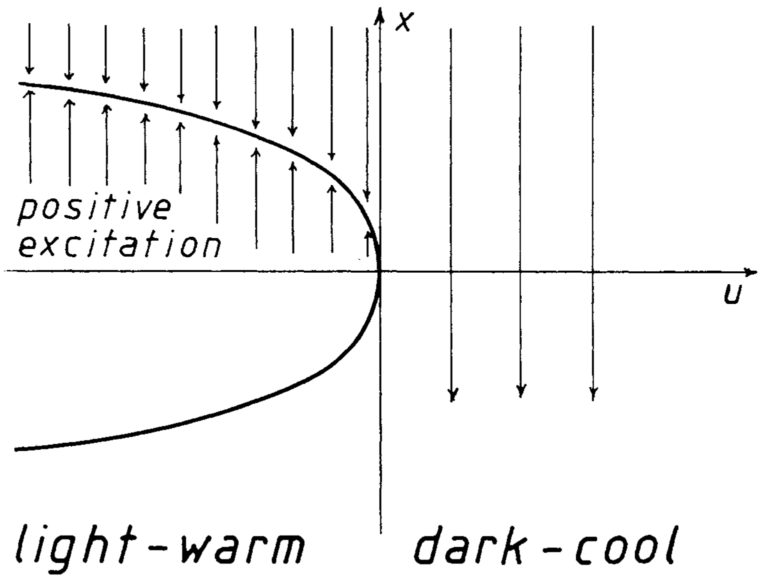


Figure 39.

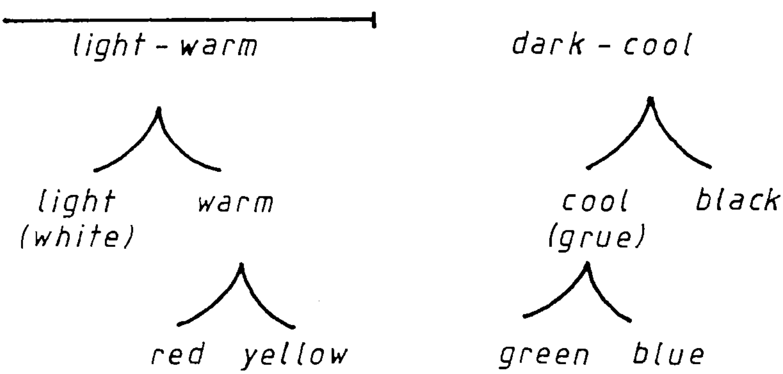


Diagram 28.

These mechanisms reappear in the semantics of other adjectives. We can distinguish

(a) Adjectives dependent on our internal drive system.

In the case of affective adjectives it is clear that this field is governed by primitive and evolutionarily old mechanisms (desire – aversion). The structure of these mechanisms which can be roughly localized in central domains of the brain (hypothalamus, subcortical kernels, parts of the reticular formation, cf. Bruter, 1976: 127-132) serves as a basic organization scheme for the more abstract quality spaces. This leads to the evaluative scales mentioned by Seiler (1978). These phenomena corroborate the basic bipolar distinction proposed by Thom (1978:80) between the object (perceived) and the interpreter (perceiver).

(b) Adjectives dependent on the perception of objects.

Adjectives whose meaning is more or less controlled by perceptual data are assembled in this domain. As the structure of our sensory organs is varied, we must differentiate among visual, acoustic, tactile, olfactory and gustatory qualities. The result of our perceptual analysis is much richer in the visual domain than in the gustatory domain for example.

The exploration of the connection between perceptual schemata and the social selection and enrichment of these structures can use the archetypal structures as organizational schemata which are independent of specific realizational domains and thus constitute a common framework for physiological, psychological, anthropological and linguistic observations.

The immediate consequences of the semantic archetypes for the lexicon of verbs have become clear in the last chapters. We must wait for more specific research in this domain.

4.3 *Linguistic vagueness*

In this section we summarize results described in Wildgen (1982 b). In the last years different models have been proposed to account for linguistic vagueness. We elaborate the list given by Eikmeyer and Rieser (1978). A similar classification was proposed by Wunderlich (1974: 267ff).

(a) The method of *elimination.* Inexact terms are transformed into exact ones. The corresponding operation is called "explication" by Carnap (1950: 3).

(b) The method of *partial interpretation.* A vague sentence is assigned a set of possible ways in which it can be made explicit (cf. Cresswell, 1973: 59f). Other authors (eg. Fine, 1975) consider the truth values that sentences "might receive under different ways of making them more precise" (Fine: 1975: 265).

(c) The *fuzziness* method. It is assumed that the classical concept of a set is not sufficient for the modelling of natural languages. Therefore a modified concept, the fuzzy set, is introduced. Fuzzy sets are defined by membership functions ranging from 0 to 1. They mirror the degree to which an element is a member of a set (a universal set which is not fuzzy being presupposed).

We can add a new method which applies elements of Einstein's theory of relativity.

(d) The model of relativistic vagueness. This approach tries to found the concept of vagueness on subjectivity (cf. Jumarie 1979, 1980). He was the first to notice that the phenomenon of vaguesness call for continuous models (cf. Jumairie 1980: 39).

Our own method is continuous and qualitative. In our perspective words and sentences must be vague in order to be resistant to stochastic deformations in performance. The amount of tolerance of a specific item can differ from situation to situation, from person to person; what is interesting in the theory of vagueness is not the quantitative aspect but the qualitative one. The quantitative characteristics of a particular semantic interpretation (i.e. the set of objects (or other entities) that fall under a concept and the number of those objects) depend on social and contextual factors: the quantitative aspect is governed by social variation. But social variation does not (normally) change the core of the relations between sign and meaning, and it does not destroy the field character of a lexical domain. These qualitative features should therefore be the central issues in a theory of semantic vagueness. If this position contradicts the perspective chosen by logical and set-theoretical semanticists in their treatment of vagueness it is, nevertheless, compatible with traditional structuralist views such as Meillet's conception of the "système où tout se tient", Saussure's theory of 'valeurs' and the theories of linguistic fields (Trier and Weisgerber).

In spite of this shift of perspective, which neglects quantitative descriptions (cf. the empirical foundations of Zadeh's membership function) and tends towards a theory of linguistic fields, the comparability between our model of vagueness and that put forward by Zadeh is preserved by the choice of examples in the next section (compare Zadeh 1971: 163).

The transformed function[12] in Fig. 40 can be shown to be qualitatively similar to a line of minima in the catastrophe set of the fold (A_2). The attractor appears at a singular point (birth) or disappears at a singular point (death). The degree of approximation to these singularities is measured by the unfolding parameter u ($u<0$). If u is near to O, the corresponding membership function must take maximal values; as u becomes smaller the line of minima approaches asymptotically $V = -\infty$. Fig. 41 shows a section in the unfolding of the fold which is defined by:

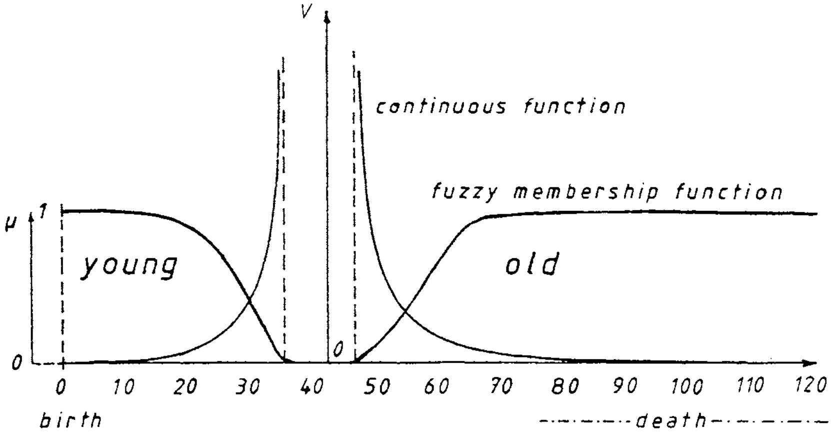


Figure 40.

(1) The unfolding: $V_x = x^3 + ux.$

(2) The catastrophe set: $\frac{\partial V}{\partial x} = 0 = 3x^2 + u.$

The solution of (1) and (2) eliminating the internal variable x gives us a semi-cubic equation:

(3) $27\,V^2 + 8u^3 = 0.$

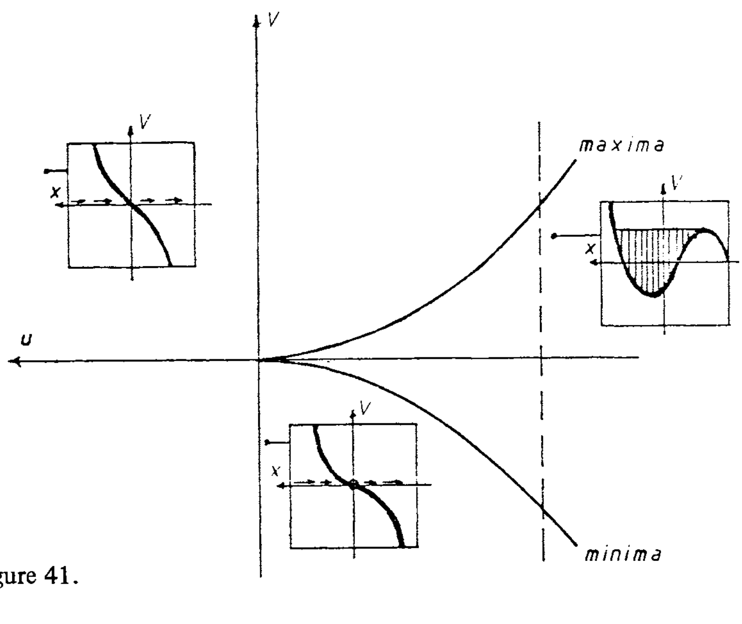


Figure 41.

Fig. 41 shows this curve. The lower branch contains the stable Morse-singularities, the attractor of the field.

If we look at Zadeh's curves we see that they belong qualitatively either to the stable and symmetrical type, which matches the zero-unfolding ($V = x^2$) (cf. Fig. 4 in Wildgen (1982b)), or to the asymmetrical type, corresponding to the fold. Our topological and dynamic treatment seems to be more natural and of greater generality:

(a) It presupposes explicitly that the noun modified by the adjectives *young* or *old* is an animate being or an entity which in a human perspective is seen as being born/created and dying/being destroyed.
(b) No metric is defined for the scale, but it is clear that the scale depends on the "life span" of the entity referred to by the noun.
(c) The relative flatness of Zadeh's curve given for the adjective "old" depends on the imprecise catastrophic point, i.e. a human being probably dies in the domain between 65 and 120. Contrary to the birth catastrophe the exact location of the catastrophe depends on statistical variation.

But our model does not stop here. We can apply the same principles to more complex phenomena.

(a) Vagueness in a field of bipolar conflicts

In chapter 3.3. we have already indicated an interpretation of special paths in the cusp as bipolar quality oppositions. In such a bipolar field we can meet delay phenomena (i.e. the field is not separated at the line of unstable equilibria – the Maxwell line in the middle of the conflict zone). The inertia of the system displaces this line in the direction which preserves a given state of stability. In Fig. 42 we see that two delay lines appear in the conflict zone. These lines mark the points where the *latest* shift occurs, they thus delimit a zone of vagueness.

Bipolar fields such as the examples given in Fig. 42 have a zone of vagueness in the conflict zone, vagueness being zero at the borderlines. If we could specify the feature called 'inertia' of the system we would be able to consider contextual effects on vagueness. Thus it seems clear that the distribution of vagueness values depends on the direction our path takes. If we focus on dark, small, rich, bad the shift towards light, big, poor, good may appear later than in the contrary case (for more details cf. Wildgen 1982b).

(b) Vagueness in a trimodal field with compromise

The unfolding called butterfly (A_5) gave rise to a trimodal field (using the qualitative interpretation). Thus we can model the appearance of a metastable attractor in the field constituted by a symmetrical opposition. We can also predict the rather insecure state of such a 'compromise' which depends on higher archetypes (cf. chapter 3.5.).

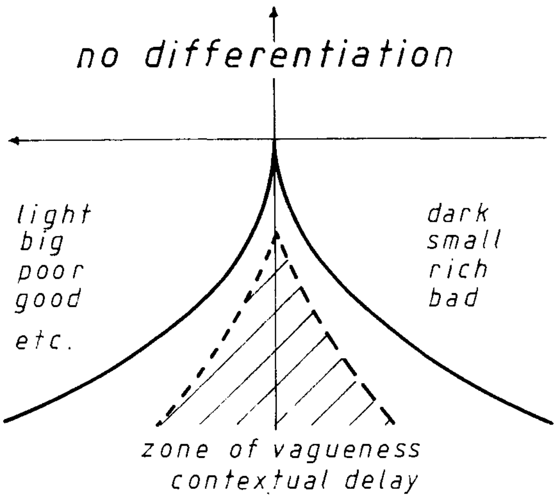


Figure 42

Summarizing the results of this chapter, we can say that catastrophe theoretic semantics is an ideal basis for the treatment of vagueness. In Wildgen (1982b) we have shown that we can easily expand this treatment to syntactic and pragmatic vagueness.

4.4. *Compositional processes*

This application expands the topic of chapter 4.1., where the concept of dynamic inference was introduced. The highly structured system of semantic archetypes together with the hierarchy of interpretative modes achieves a sort of semantic plasticity, which can be used to fill semantic gaps.

Such gaps appear in ellipsis, in pidginized speech (and in normal performance); they are also typical of noun-noun composition in many languages. We refer to Wildgen (1979: 416-467), to Wildgen (1981a) and Wildgen (1982c, 83) for the deatails of this application. The operating principle is very simple. The fact that there exists a small and highly structured set of dynamic primitives is the basis for economical strategies, which in certain situations suppress the realization of the dynamic schemes. This well-known fact calls for a type of semantics such as the one described in this book. All solutions proposed hitherto were arbitrary; they could not explain the fact that a restricted set of dynamic concepts exists, they only vaguely postulated the necessary presence of such a set (cf. Brekle 1976 and Levi 1978).

4.5. *Application in neurolinguistics*

In the framework of biology, very different models can be found: two extremes are the physiological models (aiming finally at physical and chemical laws) and the behavioural models. Physiological models can be called small-scale models as they reorganize physiological, histological and chemical observations into rather restricted mechanisms which simulate the operation of neurons or small neural networks. The behavioural models have a radically different empirical basis, as the whole organism is observed in its natural context. These models aim at an abstract but integrative view of the facts observed under such circumstances. These two paradigms of biological modelling constitute a bipolar field with an empty domain between them; we do not know how to connect our observation at the physiological level with the holistic facts revealed by behavioural studies. Zeeman (1977: 290) proposed filling this gap by introducing a medium-scale model. Both the neurophysiological and the behavioural models are explicit and quantitative. the medium scale model should be implicit and qualitative. It will serve as a preliminary bridge or as a common floor where the extremes can meet. We have seen in chapter 3.5. that such compromise-zones in a three-modal field are metastable. The proposals which will be made in this chapter should therefore be considered rather as a rough synthesis. They cannot replace empirical research in the intermediate domain; they may, however, serve to orientate such enterprises.

In Wildgen (1979a: 468-494) we gave a rather broad description of a set of dynamic-topological models proposed by Zeeman (1962), Zeeman and Buneman (1968), Zeeman (1973 , 1976a), Bruter (1976), Thom (1977:294-334) and of their place in the field of neurolinguistics. We shall only point to some aspects here:

(a) Perception is governed by thresholds imposed on neural firing rates. If this rate attains the threshold, which can be modelled as the edge of a cusp, the behavior of the cell changes abruptly. Thus basic response patterns show catastrophic features.

(b) These local catastrophes can achieve global significance if they appear in those parts of the brain which control global behavioural patterns. Emotional states and their change can be considered as such a basic system. Zeeman locates them physiologically in the limbic system (especially in the hypothalamus). His model for the behaviour of dogs (attack-retreat) under the influence of fear and rage is a good example of the application of catastrophe theory to bridge physiological description and behavioural analysis. Bruter gave a more elaborated version of such a synthesis. Using biological research as a basis, he distinguished three basic functional domains of the brain:

(1) ectopile: S, the environment is perceived
(2) mesopile: M, the body movements are controlled
(3) endopile: I, internal perceptions and movements of the individual are registered.

Functionally I operates like a catastrophic filter, which integrates a body of messages from S and 'decides' afferent signals for M. The endopile, I, can only achieve a constant and coherent control of M if it is able to sum up and to select drastically, the informational flow from S. Catastrophe theory gives a model in which an unlimited range of parameters can be evaluated *and* eliminated, concentrating on the relevant features which govern a stable dynamic scheme.

(c) Communication presupposes a high level of interindividual stability and therefore of transparency of behavioural patterns; i.e, communication presupposes highly self-regulatory and highly similar individuals. This basic stability can be achieved if language activates a very general and very basic cerebral mechanism, elaborating and diversifying only on such a solid base. The hypothesis of a rather deep and central control of language contradicts the local and topographic models of language capacity (compare Broca's and Wernicke's areas). New results, however, support our view that old and basic parts of the brain are involved in the processing of language. Recent results support the view already put forward by Jackson in the nineteenth century, that the basal ganglia are of eminent importance and that lesions in this area lead to irreparable damage in language capacity. These facts converge with Bruter's assumption that the archetypal processes derived from catastrophe theory can be located in the domain of basic ganglia and of the reticular formation (cf. Bruter 1976: 82).

(d) Higher cortical activities involving language seem to be more complicated and seem to call for an elaboration of our dynamic model, as they involve oscillatory dynamic fields. Our applications presupposed, however, gradient dynamic fields, in which the attractors are single points. Different oscillatory systems can be linked. They produce a new stable oscillatory system if resonance takes place. Such phenomena can be dealt with within the framework of catastrophe theory, but they use a type of mathematics which is not introduced in this book and which is not yet fully developed.

In conclusion we can say that catastrophe theoretic semantics fills a gap in the interdisciplinary field. Not only does it give rise to many applications but it is also based on a very rich and well-developed formalism and it opens a way towards a broad synthesis in the sciences dealing with language (including neurobiology).

5. BEYOND CATASTROPHE THEORETIC SEMANTICS

In this final chapter we shall sketch two types of applications lying beyond catastrophe theoretic semantics. In section 5.1. we try to cover three domains which are clearly outside traditional word and sentence semantics but are important levels of a complete language theory:

(a) phonology (as theoretical phonetics),
(b) the organisation of narrative texts,
(c) the organisation of conversations in social encounters.

In section 5.2. we argue that the medium range dynamism of languages, i.e. the conventionality of languages and language change can only partially be modelled using catastrophe theory or cognate theories. These phenomena seem to exhibit rather unstable evolutionary schemata, thus approaching structures treated in the theory of chaos.

5.1. *Beyond semantics: towards a dynamic theory of language*

In his article "La linguistique, discipline morphologique exemplaire", René Thom proposed that catastrophe theory could open a new integrative paradigm of 'morphological' research, unifying the 'reductionist' and the 'structural' paradigm. The structural paradigm is an attempt to overcome the difficulties of reductionism by postulating the existence of:

(a) rather autonomous subdisciplines,
(b) quasi-autonomous descriptive levels.

As the principles of catastrophe theory are independent of specific languages and specific levels (contrary to logics), they can serve as a unifying device bringing together the rather atomistic results furnished by the structural paradigm.

(a) Catastrophe theoretic models in phonology

One of the major problems of phonology is its convergence with articulatory, acoustic and auditory phonetics. Price (1977) argues that only the application of topological and dynamic (continuous) models can fill the gap and thus resolve the inadequacies of present phonology:

> "A dynamic model (in Thom's sense) for a phonemic system includes both kinematics and dynamics. In terms of phonemic systems the kinematics would include: a description of the system in terms of articulation, acoustic output, perception, and the structure of the system as a whole. The dynamics would include: a hierarchical list of forces acting on the system, coarticulation probabilities, perceptual contrast, acoustic stability, and inertia of motion for changes in progress." (Price 1977: 487)

In the quantal theory of speech articulation put forward by Stevens we find an informal concept of structural stability which seems to call for a catastrophe theoretic model.

> "Stevens argued that, for some articulatory configurations even a slight change in a given articulatory property may have a relatively large acoustic consequence. But for other articulatory configurations, large changes in a given articulatory property may have little effect on the acoustic signal. Hence then, the acoustic signal is more sensitive to some articulatory changes than to others, which means that articulatory – acoustic conversions are nonlinear. Given the inherent nonlinearities, a speaker presumably "manipulates his speech generating mechanism to select sounds with well-defined acoustic attributes that are relatively insensitive to small perturbations in articulation. (Stevens 1972b, p. 65)" (Kent 1976: 96)

These hints at a dynamic model of theoretical phonetics/phonology are still programmatic. They show, however, that the application of our methodological tools in this field is very promising.

(b) The dynamic structure of the narrative

As we cannot give a detailed proposal for this very rich field, we shall only demonstrate how basic narrative schemata such as those found by Labov and Waletzky and formally reconstructed in Wildgen (1977a: 227-247) can be related to the archetypal patterns derived in chapter 3.

Three main functional levels of the narrative can be distinguished:

(a) The *orientation phase.* The agents and prominent objects of the situation are introduced. This constitutes a dynamic configuration; a type of start position for the dynamic system.
(b) The *complication phase.* A series of events involving the agents (cf. (a)) are reported. These events contribute to a more global evolution which reaches a climax at the end of the complication phase.
(c) The *result phase.* A second series of events resolves the dramatic situation found at the climax, tending towards a situation of relative rest.

The single narrative steps of a story can be described applying the dynamic model for sentence semantics developed in chapters 3 and 4. Globally we have a cuspoid process with a catastrophe of change. The dynamics fit the description given by Thom (1977: 313) presupposing a cyclical path in the bifurcation set of the cusp. The global catastrophe consists of the transition between phase (b) and phase (c) which constitute a bipolar dynamic field governing the overall evolution of the narrative. The climax of the story, especially the appearance of a set of sentences called *coordinated* by Labov and Waletzky (cf. Wildgen 1977a: 246) corresponds to a slowing down of the process in the environment of the catastrophe. This dynamic feature, which was described in Thom (1977: 311-315), lies beyond elementary catastrophe theory (compare Fig. 13-19 in Thom (1977:313)).

This sketch should be elaborated in a more detailed study. In this context it shows that dynamic features at the level of text semantics fit into our framework.

c) Dynamic models at the level of social interaction

In spite of the behavioural complexity of social encounters, rather simple mechanisms can be found. Following the proposals of Goffmann (1976) we can define three major types of roles in a communicative interaction:

(i) The speaker: S; he has the actual initiative and expends most energy in the encounter.
(ii) The addressee: A; he can immediately take the next turn and his receptive activity is explicitly considered by the speaker.
(iii) The hearer: H; he observes what is taking place in the situation and he is not obliged to respond to the speaker. He can, however, enter the central scene as an addressee or as a speaker; thus he is a latent participant; this fact is explicitly considered by S and A.

The dynamics of the encounter can be described if we consider phases of the interaction such that the allocation of roles to participants is *stable*. Poythress (1976) proposed a model in which these stable phases are called 'snapshots' (he did not notice that 'snapshots' must occur at stable, regular points and not at singular points; thus, the model of Poythress is only implicitly dynamic). The 'dynamics' of the encounter are described by group operations on a transformation matrix. The kernel of the dynamics consist of those transformations in which the allocation of roles is changed. It is natural to reconstruct these 'transformations' by catastrophes, as the basic interactive processes are continuous rather than discrete. We can model a situation in which three persons (or three groups of persons) interact using three attractors. The roles (S,A,H) correspond to stages of relative dominance. If a person has role S (= speaker), he dominates: if he takes role (=addressee), he is not dominant but approaches dominance; if he has role H (= hearer) he is subdominant, a passive agent. These dynamic features are symbolized by:

——————————— : dominance: S= speaker
———.———.——— : near-dominance: A = addressee
—— —— —— —— —— : subdominance: H = hearer.

We can distinguish two types of changes:

(a) Turn-taking; a person becomes speaker (S)
(b) A shift in the audience; a different person is addressed, a particular person becomes passive (H) or a person becomes more active assuming the role of addressee (A).

(a) is a high energy change, i.e. a catastrophic event; (b) is a covered structural change.

If each participant (or group of participants) is associated with a stable attractor in the dynamic system, configurational changes in the conversation correspond to conflicts between attractors. The deepest attractor (relatively to the potential V) has the role S, the highest attractor has the role H and the role A lies between these two. The unstable points of equilibrium between attractors bring about the catastrophes corresponding to the changes (a) and (b) above. In diagram 29 below, a typical encounter which exhibits different types of events is illustrated.[13]

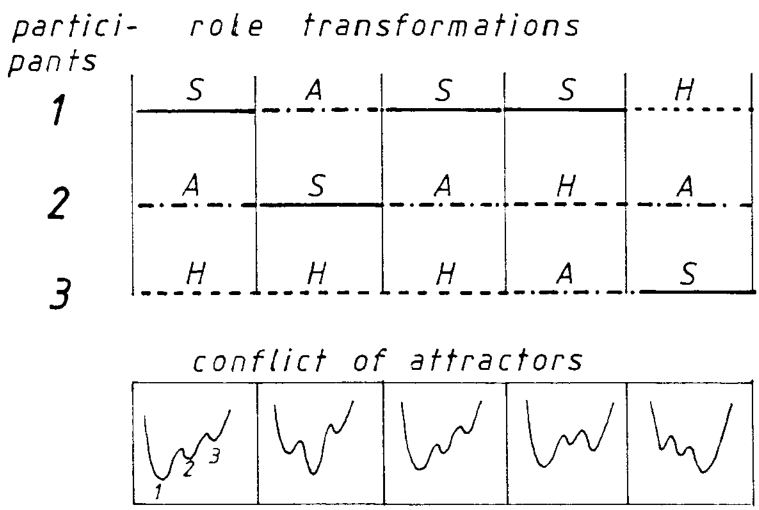


Diagram 29.

This sketch of further applications of catastrophe theory constitutes a kind of framework for an integrative theory of language. We have shown that at every level of such a theory relevant and basic phenomena can be modelled in our paradigm.

5.2. *Beyond Catastrophe Theory*

In this final section we sketch two very important domains of linguistic research which are clearly beyond catastrophe theoretic modelling. They seem to apply similar but more complicated dynamic mechanisms.

(a) The global dynamics of language change.

Language change seems, at first view, to be an excellent field for the application of catastrophe theory. It is governed by principles of optimization (or minimization) (cf. Lüdtke 1980: 5) and displays several qualitative features typical of catastrophes (divergence, modality, instability of equilibria (cf. Zeeman 1976b and Poston 1978). The fact that historical models using catastrophe theory exist (cf. Petitot 1978) could encourage an application of catastrophe theory in the field of historical linguistics. We are, however, inclined to doubt the stability of the patterns of language change. This type of dynamics is rather comparable to economic systems which on the one hand can be reduced to systems with optimization strategies but which on the other hand exhibit features of *chaos*, i.e. minimal perturbations of basic developments which are in fact calculable result in an unstable pattern. The path of development does not return to a stable starting-point of the field, instead it fills a large set with (often) fractional dimension thus creating an overall pattern which approaches randomness (cf. Poston and Stewart, chapter 17.7, *Beyond Elementary Catastrophe Theory*). We presume that, for a good approximation of language change, we must go beyond elementary catastrophe theory. Thus our framework is at least a good starting-point.

(b) The dynamics of language conventions

The conventionality of language is the basic motor of language change. Thus point (b) is related to (a). In principle we could reconstruct the game theoretic foundation of linguistic conventions proposed by David Lewis (1969) in the framework of differential games using catastrophe theory (cf. Smale (1973), Thom (1975b), Ekeland (1975) and Doležal (1978) for dynamic game theory). We discussed these aspects in Wildgen (1979: 512-524), concluding that it is premature to propose concrete systems for this domain; the conventionality of language requires more empirical (experimental) studies and models which organize their results. One of the main results of this book lies in the statement that many areas of language are at a deep, archetypal level iconic (indexical) rather than symbolic. This result contradicts Saussure's concept of arbitrariness and also the theory put forward by Lüdtke (1980: 3), where he says that only very general features of language systems are biologically determined, excluding the concrete form-giving of language. We have shown that there exists a very rich archetypal structure underlying language. In a sense the existence of such a stable and universal basis simplifies the vast problem of conventionality, thus making a solution more feasible.

In conclusion, we can say that our dynamic model opens a larger field of models which are beyond the scope of the present book. In spite of their limitations, catastrophe theoretic models furnish a platform on which an integrative model of language system, language use and language change can be built.

FOOTNOTES

* This is a shortened and revised version of central chapters of my second thesis ("Habilitationsschrift") in General and Theoretical Linguistics accepted by the University of Regensburg (Wildgen 1979). My research was supported by the "Deutsche Forschungsgemeinschaft" from 1976 to 1979. Thanks are due to Herbert E. Brekle and Klaus Matzel for linguistic discussion, to Bruno Kramm and Klaus Jänich for mathematical help. Tim Poston made helpful comments on the manuscript. In this book the more recent developments in Thom's semiotic theory are not discussed as they neither change nor elaborate his proposals for semantics.

1. For the terms 'gestalt' and 'archetype' compare Wildgen (1979: 110-117). The notion of semantic archetypes is adapted to Thom's notion "morphologie archétype". Thom takes his notion of 'archetype' from Plato. Semantic archetypes can in a sense be compared to Chomsky's "innate ideas". By their dynamic nature semantic archetypes need not preexist in the individual, they are rather developed as a consequence of universal mechanisms of form-giving and self-regulation. Thus semantic archetypes transcend the static conception of "innate ideas". Compare the critique of Chomsky's position in Piaget (1972: 68-71).

2. An extremely relativistic perspective is taken by Davies (1978), who says that the laws of our world depend on the existence of an observer. Other worlds, which took a different evolution and did not develop intelligent beings, can have laws of nature different from ours (this would depend on the development of the universe in the first 'moments' after its birth).

3. In Wildgen (1979: 122-130, 140-147) we discuss traditional and modern localistic theories of case, which are in a sense the background of this type of interpretation.

4. We may distinguish two sources for quality scales:
(a) perceptual mechanisms imply certain scales by their physiological properties. This is especially clear in the case of colour perception (cf. Kay and McDaniel 1978; Wattenwyl and Zollinger 1979; Wildgen 1981c). These scales emerge, however, in the language behaviour only if there is a necessity for differentiation.
(b) The social constitution of a universe of semantic distinctions (as it is realized in the lexicon of a linguistic community). Here the quality scales are something we can deduce from language use, they are not pre-existent to language and cannot "explain" semantic structures.

5. Logical negation is in a sense a complex notion. This was the basic motivation for the development of three-valued logics (cf. Blau 1978). In three-valued logics two types of negation are distinguished: *strong* negation (–) which presupposes the existence of an entity and asserts positively that the predicate does not apply to the entity, and *weak* negation which includes vagueness and non-referentiality ($\urcorner$). The concept of weak negation is con-

gruent with the opposition: stable existence vs. nonexistence derived from the *fold* (germ: $V= x^3$), whereas the concept of strong negation and the third value 'neutral' constitute a field which is congruent with dynamic structures contained in the *swallowtail* (germ: $V = x^5$). Compare Wildgen (1979: 315, path a).

6. This intuition becomes even clearer if we note that the first jump in diagram 14 depends also on the height of the maximum. As we apply a local Maxwell convention to avoid the dominance of the global attractor at $-\infty$, we must presuppose moderate fluctuations. In this case the process will only explore the deeper minimum and not really jump to it.

7. Cf. Lakoff and Johnson (1980: chapter 14). In a sense the archetypal level is a stable platform, which serves as a starting point for multiple elaborations. Some of these elaborations make up the core of a social system of attributions, others are spontaneously activated in communication and constitute a creative domain of language use.

8. This type of communication is typically found in termite populations, where the emission of chemical traces 'informs' the other termites, thus leading to a form of cooperative behaviour. Compare Prigogine (1976): L'Ordre par Fluctuation et le Système Social. He shows that ants mark their paths to food by the secretion of chemical substances (pleromones). Other ants tend to follow lines of maximal concentration of these substances when they seek food. Similar mechanisms control the behaviour of termites in the building of pillars for their burrow. Thus very complicated cooperative tasks can be solved at such a basic level of communication.

9. Thom used, however, a different formula for his derivation which contains two quartic terms (cf. Thom 1970: 236). Thus he intuitively conjectured an unfolding like the double cusp. The results of Godwin are based on quantitative computer analyses, whereas Thom proceeded rather by mathematical reasoning.

10. The organizing center $x^3 - 3xy^2$ can be transformed into $x^2y - y^3$ if we change the system of coordinates. We could also write wx^2 instead of $w(x^2 + y^2)$ losing thus certain properties of symmetry. Contrary to the unfolding of corank 1 we do not have unique normal forms (cf. Poston and Stewart 1978: 180).

11. As the semantic archetypes exploit normally maximal paths in the bifurcation set, this principle does not account for archetypes derived from the same unfolding. One could define a similar but more general principle on the basis of the CF's of typical paths (compare section 1.3.).

12. Such a transformation could be: $V = 1/\mu - 1$.

13. In a recent study (Wildgen 1982d) I have shown that these processes in a conversation with three roles can be described by a cyclical path in the bifurcation set of the butterfly. The center of this cycle lies at the point of triple conflict.

REFERENCES

Arnold, V.I.

1972 "Normal Forms for Functions near Degenerate Critical Points, the Weyl Groups of A_k, D_k and E_k, and Lagrangean Singularities". Functional Analysis and its Applications 6. 254-272.

Ballmer, T.T.

1982 "The Interaction between Ontogeny and Phylogeny: A Theoretical Reconstruction of the Evolution of Mind and Language". In A. Koch (ed.) 1982. Semiogenesis. Essays on the Analysis of the Genesis of Language, Art and Literature. Bern: Lang, 481-545.

Blau, U.

1978 Die dreiwertige Logik der Sprache. Berlin: de Gruyter.

Brekle, H.E.

1976 Generative Satzsemantik im System der Englischen Nominalkomposition. München: Fink (2nd edition).

Bröcker, Th. and L. Lander

1972 Differentiable Germs and Catastrophes. Cambridge: Cambridge University Press.

Bruter, C.P.

1974 Topologie et perception. Vol. 1: Bases philosophiques et mathématiques. Paris: Doin & Maloine.

Bruter, C.P.

1976 Topologie et perception. Vol. 2: Aspects neurophysiologiques. Paris: Maloine.

Callahan, J.J.

1974 "Singularities and Plane Maps". American Mathematical Monthly 81. 211-240.

Callahan, J.J.

1977 "Singularities and Plane Maps II: Sketching Catastrophes". American Mathematical Monthly 84. 765-803.

Callahan, J.J.

1978 "The Double Cusp has Five Minima". Math. Proc. Camb. Phil. Soc. 84. 537f.

Callahan, J.J.

1980 "Bifurcation Geometry of E_6". Mathematical Modelling 1, 283-309.

Callahan, J.J.

1982 "A Geometric Model of Anexoria and its Treatment". Behavioural Science 27. 140-154.

Carnap, R.

1950 "Empiricism, Semantics and Ontology". Revue Internatinale de Philosophie 4. 20-40.

Chillingworth, D.R.J.
1976 Differential Topology with a View to Applications. Series: Research Notes in Mathematics 9. London: Pitman.

Cresswell, M.J.
1973 Logics and Languages. London.

Davies, P.
1978 Other Worlds. London: Dent.

Doležal, J.
1978 "A Gradient-Type Algorithm for the Numerical Solution of Two-Player Zero-Sum Differential Game Problems". Kybernetika 146. 429-446.

Eikmeyer, H.J. and H. Rieser
1978 "Vagheitstheorie". Mimeo. Bielefeld.

Ekeland, I.
1974 "Topologie différentielle et théorie des jeux". Topology 13. 375-388.

Fillmore, Ch.J.
1968 "The Case for Case". In: E. Bach and R.T. Harms (eds.) 1968. Universals in Linguistic Theory. New York: Holt, 1-88.

Fillmore, Ch.J.
1976a "Frame Semantics and the Nature of Language". Annuals of the New York Academy of Science 280. 20-32.

Fillmore, Ch.J.
1976b "The Need for a Frame Semantics within Linguistics". Statistical Methods in Linguistics 12. 5-29.

Fillmore, Ch.J.
1977a "The Case for Case Reopened. In: P. Cole and J.M. Sadock (eds.) 1977. Syntax and Semantics, Amsterdam: North Holland, 59-81.

Fillmore, Ch.J.
1977b "Scenes-and-Frames Semantics". In: A. Zampolli, (ed.) 1977. Linguistic Structure Processing. Amsterdam: North Holland. 55-81.

Fine, K.
1975 "Vagueness, Truth and Logic". Synthese 30. 265-300.

Gilmore, R.
1980 Catastrophe Theory for Scientists and Engineers. New York: Wiley.

Godwin, A.N.
1971 "Three Dimensional Pictures for Thom's Parabolic Umbilic". Publications mathématiques de l'Institut des Hautes Etudes Scientifiques 40. 117-138.

Goffman, E.
1976 "Replies and Responses". Language and Society 5. 257-313.

Görlitz D. et al.
1978 Bielefelder Symposium über Attribution. Stuttgart: Klett-Cotta.

Haken, H.
1977 Synergetics. An Introduction. Berlin: Springer.

Heider, F.
1958 The Psychology of Interpersonal Relations. New York: Wiley.

Hjelmslev, L.
1935/37 La catégorie des cas. Etude de grammaire générale I, II. Reprinted: München. 1972: Fink.

Johansson,G.
1976 "Spatio-Temporal Differentiation and Integration in Visual Motion Perception". Psychological Research 38. 379-393.

Johansson, G.
1977 "Spatial Constancy and Motion in Visual Perception". In: W. Epstein (ed.) 1977. Stability and Constancy in Visual Perception. New York: Wiley.

Jumarie, G.
1979 "New Results in Relativistic Information and General Systems. Renyi Entropy, Observed Probability, Relativistic Fuzzy Sets, Generative Semantics". Cybernetica 22:1. 131-158.

Jumarie,G.
1980 "Relativistic Fuzzy Sets. Toward a New Approach to Subjectivity in Human Systems". Mathématique et Sciences Humaines 71. 39-75.

Kay, P. and C.K. McDaniel
1978 "The Linguistic Significance of the Meanings of Basic Color Terms". Language 54. 610-646.

Kent, R.D.
1976 "Models of Speech Production". In: N.J. Lass (ed.) 1976. Contemporary Issues in Experimental Phonetics. New York: Academic Press, 79-104.

Lakoff, G. and M. Johnson
1980 Metaphors We Live By. Chicago: The University of Chicago Press.

Levi, J.
1978 The Syntax and Semantics of Complex Nominals. New York: Academic Press.

Lewis, D.
1969 Convention. A Philosophical Study. Cambridge: C.U.P.

Lüdtke, H.
1980 "Sprachwandel als universales Phänomen". In: Idem (ed.) 1980, Kommunikationstheoretische Grundlagen des Sprachwandels. Berlin: De Gruyter, 1-19.

Michotte, A.
1954 La perception de la causalité. Louvain: Publications de Louvain.

Montague, R.
1970 "Universal Grammar". Theoria 36. 373-398.

Osgood, Ch.
1976 Focus on Meaning. Den Haag: Mouton.

Osgood, Ch., G.J. Suci and P.H. Tannenbaum
1967 The Measurement of Meaning. Chicago.

Peirce, Ch.S.
1965 Collected Papers of Charles Sanders Peirce. Ch. Hartshorne and P. Weiss, Cambridge (Mass.): Belknap Press. (In our citations the first number refers to the volume, the second to the paragraph).

Petitot, J.
1978 "Sur le modèle historique de Thom-Pomian". Mathématiques et Sciences Humaines 64. 43-70.

Piaget, J.
1972 'L'épistémologie génétique', Paris: P.U.F.

Poston, T.
1978 "On Deducing the Presence of Catastrophes". Mathématiques et Sciences Humaines 64.

Poston, T. and I.N. Stewart
1978 Catastrophe Theory and its Applications. London: Pitman.

Pottier, B.
1979 "Sémantique et topologie". In: Höfler et al. (eds) 1979. Festschrift Kurt Baldinger. Tübingen: Niemeyer, 3-10.

Poythress, V.S.
1976 "Mathematical Representations of Sociolinguistic Restraints on Three-Person Conversations". Information and Control 30. 234-246.

Price, P.J.
1977 "Catastrophes in Linguistic Theory?." Chicago Linguistic Society. 480-488.

Prigogine, J.
1976 "L'ordre par fluctuation et le système social". Vorträge der Rheinisch-Westfälischen Akademie der Wissenschaften 260. 7-47.

Prigogine, I., I. Stengers and S. Pahault
1979 "La dynamique de Leibniz à Lucrèce". Critique 360. 35-55.

Saunders, P.J.
1980 An Introduction to Catastrophe Theory. Cambridge: Cambridge University Press.

Seiler, H.
1978 "Determination: A Functional Dimension for Interlanguage Comparison". In: H. Seiler (ed.) 1978, Language Universals. Tübingen: Narr, 301-328.

Smale, S.
1975 "Global Analysis and Economics. Pareto Optimum and a Generalization of Morse Theory". Synthese 31. 345-358.

Stratton, Ch. R.
1971 "The Pathological Case". Working Papers in Linguistics 10. 221-230.

Tesnière, L.
1959 Eléments de syntaxe structurale. Paris: Klincksieck.

Thom, R.
1968 "Topologie et signification". Reprinted in Thom, 1974a: 193-228.

Thom, R.
1970 "Topologie et linguistique". In: A. Haefliger and R. Narasimhan (eds.) 1970. Essays on Topology and Related Topics. Berlin: Springer, 226-248.

Thom, R.
1972 (1977) 'Stabilité structurelle et morphogénèse'. Essai d'une théorie générale des modèles. New York: Benjamin Addison Wesley. Translated into English, 1975. New York: Addison Wesley. Second augmented and revised edition, 1977. Paris: Interéditions.

Thom, R.
1973a "Langage et catastrophes: éléments pour une sémantique topologique". In: M.M. Peixoto (ed.), Dynamical Systems. Proceedings of the Symposium at Salvador, Brazil, 1971. London: Academic Press. 619-654.

Thom, R.
1973b "De l'icone au symbole: esquisse d'une théorie du symbolisme". Reprinted in Thom, 1974a: 229-251.

Thom, R.
1974a 'Modèles mathématiques de la morphogénèse. Recueil de textes sur la théorie des catastrophes et ses applications'. Paris: Union Générale d'Editions.

Thom, R.
1974b "La linguistique, discipline morphologique exemplaire". Critique 30: 1. 235-245.

Thom, R.
1975a "D'un modèle de la science à une science des modèles". In: Synthese 31.359-374.

Thom, R.
1975b "L'optimisation simultanée et la théorie des jeux en topologie différentielle". In: Cahiers Math. de Montpellier 3. 63-70.

Thom, R.
1975c "La Théorie des Catastrophes: état présent et perspectives". Reprinted in: Zeeman, 1977. 615-621.

Thom, R.
1976 "The Two-Fold Way of Catastrophe Theory". In: P.J. Hilton (ed.) 1976. Structural Stability, the Theory of Catastrophes and Applications in the Sciences. Lecture Notes in Mathematics 525. Berlin: Springer. 233-252.

Thom, R.
1978 "La double dimension de la grammaire universelle." In: H. Seiler (ed.) 1978. Language Universals. Tübingen: Narr. 79-87.

Wattenwyl von, A. and H. Zollinger
1979 "Color-Term Salience and Neuro-Physiology of Color Vision". American Anthropologist 81. 279-288.

Wildgen, W.
1977a Differentielle Linguistik. Entwurf eines Modells zur Beschreibung und Messung semantischer und pragmatischer Variation. Tübingen: Niemeyer.

Wildgen, W.
1977b Kommunikativer Stil und Sozialisation. Eine empirische Untersuchung. Tübingen: Niemeyer.

Wildgen, W.
1978a "Rekonstruktion der Sprachbarrierenproblematik im Rahmen einer Sprachverwendungstheorie". Linguistische Berichte 53. 1-20.

Wildgen, W.
1978b "Prolegomena zu einer dynamischen Sprachtheorie.
Vol. 1: Grundlagen einer Theorie der Interkommunikation.
Vol. 2: Grundlagen einer katastrophentheoretischen Semantik". Ms. Regensburg.

Wildgen, W.
1979 "Verständigungsdynamik. Bausteine für ein dynamisches Sprachmodell". Thesis (Habilitationsschrift, Ms.), Regensburg.

Wildgen, W.
1980 "Models of Verbal Planning in the Theory of Catastrophes". In: H.W. Dechert and M. Raupach (ed.) 1980. Temporal Variables in Speech. Den Haag: Mouton. 51-59.

Wildgen, W.
1981a "Makroprozesse bei der Verwendung nominaler *ad hoc* Komposita im Deutschen". Trier: L.A.U.T. Reprints, Series A, Nr. 83; 1982. Deutsche Sprache, 3, 237-257.

Wildgen, W.
1981b "Semantic Description in the Framework of Catastrophe Theory". In: B. Rieger (ed.) 1981. Empirical Semantics. Vol. II. Bochum: Brockmeyer, 792-818.

Wildgen, W.
1981c "Archetypal Dynamics in Word Semantics: An Application of Catastrophe Theory". In: H.-J. Eikmeyer and H. Rieser (eds.) 1981, Words, Worlds and Contexts. New Approaches to Word Semantics. Berlin: De Gruyter. 234-296.

Wildgen, W.
1982a "Gestalt Semantics on the Basis of Catastrophe Theory". To appear in T. Borbé (ed.) 1982. Proceedings of the 2nd. IASS Congress (Vienna, 1979). Den Haag: Mouton.

Wildgen, W.
1982b "Modelling Vagueness in Catastrophe-theoretic Semantics". To appear in T. Ballmer and M. Pinkal (eds.) 1982, Approaching Vagueness. Amsterdam: North Holland.

Wildgen, W.
1982c "Zur Dynamik lokaler Kompositionsprozesse: Am Beispiel nominaler ad-hoc-Komposita im Deutschen." To appear in Folia Linguistica, XIV, 1982.

Wildgen, W.
1982d "Dynamik richterlicher Anhörungen in der psychiatrischen Anstalt". Report given at the Fourth Annual Meeting of the DGfS, Cologne 2.-4. 3.82.

Wildgen, W. (forthcoming)
1983 "The Dynamics of Nominal Composition." In: Th. Ballmer (ed.) 1982/83, Linguistic Dynamics.

Wildgen, W. (forthcoming)
1983 Archetypensemantik. Ein topologisch-dynamisches Modell für ganzheitliche Bedeutungskomplexe. (Augmented and updated version of Wildgen, 1979). Braunschweig: Vieweg.

Woodcock, A. and T. Poston
1974 A Geometrical Study of the Elementary Catastrophes (Lecture Notes in Mathematics 373). New York: Springer.

Woodcock, A. and M. Davis
1978 Catastrophe Theory. New York: Dutton.

Wunderlich, D.
1974 Grundlagen der Linguistik. Reinbek: Rowohlt.

Zadeh, L.
1965 "Fuzzy Sets". Information and Control 8. 338-353.

Zadeh, L.
1971 "Quantitative Fuzzy Semantics". Information Sciences 3. 159-176.

Zeeman, E.C.
1962 "The Topology of the Brain and Visual Perception". In: M.K. Fort, Topology of 3-manifolds. New Jersey: Prentice Hall.

Zeeman, E.C.
1972 "Differential Equations for the Heartbeat and Nerve Impulse". Reprinted in Zeeman, 1977. 81-140.

Zeeman, E.C.
1973 "Catastrophe Theory in Brain Modelling". International Journal of Neuroscience 6. 39-41.

Zeeman, E.C.
1976a "Brain Modelling". Reprinted in Zeeman, 1977. 287-292.

Zeeman, E.C.
1976b "Catastrophe Theory". Scientific American 234: 4. 65-83.

Zeeman, E.C.
1977 Catastrophe Theory. Selected Papers, 1972-1977. Reading (Mass.): Addison-Wesley.

Zeeman, E.C. and O.P. Buneman
1968 "Tolerance Spaces and the Brain". In: C.H. Waddington (ed.). Towards a Theoretical Biology. Vol. 1. Edinburgh: University Press. 140-151.

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