CHAPTER 3
PROCESS AND IMAGE SCHEMATA IN THE LEXICON AND IN BASIC SYNTAX♣

In Chapter 1, Section 4 it was shown that realistic semantics take very general laws found in the description of the world as its base-line. This position is important for the choice of a mathematical background for the semantic model, i.e. for the choice of dynamical systems theory as a formal reference structure. Nevertheless these general laws must first be accommodated to the immediate ecological domain of cognition and language behaviour. The following Chapter goes from very general systemic considerations (basic laws and principles) in Section 1 to a specification and an application of these principles in the semiotic domain (Section 2). The Sections 3 and 4 will apply the dynamic schematizations of Sections 1 and 2 to the description of the meaning of verbs and of basic predication in sentences. Section 5 introduces the topic of syntactic constituency which will be further elaborated in Chapter 4.

1 Order phenomena in the ecology of man

In the ecological niche of man (his physical and biological environment, his domain of bodily interaction with the environment and his mental domain) different types of order vs. disorder can appear.

a. Real systems are in *equilibrium*. This state of a system or this selective view of a system allows us to observe the major components, forces and possibilities of a system. It is the best scenario for the purpose of scientific modelling. Unfortunately systems in perfect equilibrium are rare (the

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planetary system, for example, which is one of the archetypes of human model making) and in order to filter out this equilibrium aspect in systems which are not in equilibrium we must go beyond empirical knowledge and make assumptions about the system which are rather theoretical.

b. Real systems are in *transient equilibrium* (far from thermodynamic equilibrium). For these structures (called "dissipative" by Prigogine and Nicolis, 1989) noise and a constant flow of energy are necessary to preserve or even build up ordered structures. All living systems in equilibrium are at this or a higher level of dynamic organization.

c. Real systems are locally ordered but globally chaotic, i.e. minimal perturbations of the system grow stronger instead of being absorbed and after a number of evolutionary steps they end up in a chaotic mode.

A prototypical example of a *system in equilibrium* and of transitions between different phases in a state-space defined by several equilibria is given by the phases of a physical system with one or more components. The American physicist Josiah Willard Gibbs (1839-1903) formulated a basic law of thermodynamic equilibrium for such systems (in 1876) which is called the phase rule of thermodynamics. I shall explain its main points. If we consider a physical or chemical system, a *phase* is a domain of homogeneity in the system which can be distinguished from other phases.

In a more general way every natural system can have such "phases" or states not altered by small changes in parameters. The phase is a locus of macroscopic *stability*. A physical system (any system) consists of a number of components (e.g. water in Figure 1.3, or a mixture of water and salt in other cases, etc.). These components are assumed to be independent of each other.

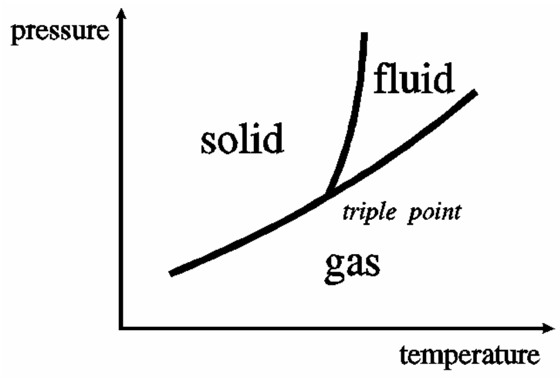

Figure 3.1 *The phase space of water*

Finally, there are a number of parameters which govern the behaviour of the system, e.g. temperature and pressure. These parameters are macroscopic forces. Thus temperature is a macroscopic measure relative to the motion of the atoms and molecules. Figure 3.1 shows the (schematic) phase space of water.

We can abbreviate:

p = phase

c = component

f =degree of freedom (i.e. the number of macroscopic parameters which can change).

Gibbs' law, which is called the *phase rule*, is a very simple equation:

First rule (Gibbs' phase rule): $p\text{-}c+f = 2.$

This law is, however, not a specific rule for chemical analysis. One can show that it is related to the Platonic polyhedrons; as Descartes (1640) and Euler (1752) have shown a similar formula holds for the relation between: P = surfaces; C = edges; F = vertices.

Euler's law states a relationship which corresponds to Gibbs' law: $P - C + F = 2$.

Example: The cube has

6 surfaces (elements of dimension 2): $P = 6$

12 edges (elements of dimension 1) : $C = 12$

8 vertices (elements of dimension 0): $F = 8$

We can check that Euler's law holds for this specific case: $P\text{-}C+F = 6\text{-}12+8 = 2$. It can be proved that it is valid for all regular (convex) polyhedrons. As Wildeboer and Plath (1979: 165) show, the same regularity is found in Pascal's triangle, which serves as the basis for combinatorial analysis and statistics.

All these parallelisms are not due to chance. They show that Gibbs' law, Descartes' and Euler's rules, and Pascal's formula concern not specific systems but regular systems or systems in perfect equilibrium in general. A further extension of Gibbs' law concerns dynamical systems in equilibrium; thus the hierarchy of elementary catastrophes is directly related to regular polyhedrons and Euler's formula (as to Gibbs' law as well). To explain these complicated relations here would take too long (see Slodowy, 1988). The basic result is that this type of law is appropriate for ecological semantics as it is:

- categorical and simple,
- not limited to specific ontological domains (it reappears in the physics of solids, fluids, gases, in chemistry or biology, etc.)

Moreover, it is a macroscopic law which is independent of the specific organization of the systems at the microscopic level. This is just the type of law needed in semantics, where microscopic behaviour (at the level of the brain - the neurones; at the level of the society - the individual speakers/listeners) is not well known or not considered.

A prototypical *system in transient equilibrium* is found in convection (Bénard)-cells. If a fluid is heated from below the flux of energy and the viscosity of the fluid create rotating cells, i.e. out of molecular chaos a specific order is created which can itself jump from one stage to another (different sizes or directions of the 'rolls'). Other examples are magnetization (the spins of the atoms are co-ordinated) and co-ordinated motions (compare the different "phases" in the locomotion of a horse). Again we have phases of stability and transition points. If the energy flux is stopped the initial unordered situation reappears, i.e. order is only present in the flux. Figure 3.2 shows the cycles of a Bénard-cell (cf. Nicolis and Prigogine, 1989: 11). This order can be called a spontaneous order which arises by co-ordination of subsystems and the domination of one or a few "slaving" parameters (cf. Haken, 1983).

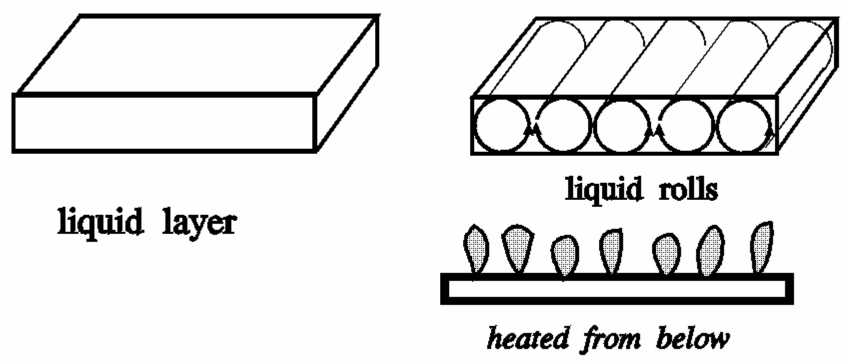

Figure 3.2 *Bénard-cells (cf. Haken, 1990: 5)*

The transient order is imposed on stochastic motion of single molecules and depends on the critical value of the temperatures below and above the liquid, on the geometrical form of the vessel, etc. The patterns obtained are not only transient, normally multistability is observed, i.e. the system chooses between a range of possible states. Haken (1990: 7) extrapolated this situation to cognition:

> "Our results may be interpreted as follows: The fluid possesses a variety of different states because of its internal mechanisms. But which of these states is realized depends on the initial conditions, or, to put things in a different way, a partially given pattern is completed in a unique fashion. But this is at the cognitive level precisely what happens in associative memory. Part of a set of data is completed in a unique fashion. Multistability means that our system can internally store many patterns. Their restoration from initial states appears simultaneously in all volume elements of the fluid, i.e. our fluid acts as a *parallel computer*."

This image of a process based on stochastic dynamics with transient order is relevant for the problems dealt with in Chapters 4 and 7. In general the tools of synergetics (cf. Haken, 1983) are relevant for these applications.

A prototypical *chaotic system* is given by the multiple copying machine (MCM) described by Peitgen, Jürgens and Saupe (1992: 30-35). In general these processes include a type of self-referentiality, in which the product of an operation is taken again and again as input of the operation. If every operation introduces minor changes, especially if non-linear transformations occur, the result of a chain of operations is chaotic. Most real systems have a range of initial conditions under which chaos appears. Chaos is thus a very general behaviour of dynamical systems and order phenomena are particular islands in a landscape dominated by chaos. Specific applications will be treated in Chapter 4. In general we focus on order phenomena because the observational techniques for an exact description of stochastic and chaotic dynamics in language have not yet been developed. I presume that neurolinguistic models on the one hand and sociolinguistic ones on the other will require the application of these conceptual frameworks (cf. Wildgen, 1986 for an application of synergetical methods in sociolinguistics).

If we consider language from the perspective of a system in equilibrium with transitions between different equilibrium phases in a landscape of attractors, the methods of qualitative dynamics, known under the heading "catastrophe theory" impose themselves. "Catastrophes" are transitions between equilibrium states and the astonishing aspect of these transitions is that mathematically a limited and beautifully structured "lexicon" of such transitions can be predicted. We shall give a very informal summary of this "lexicon"; cf. Wildgen, 1982, and for a mathematically explicit description Wildgen, 1985 (in German).

2 Transitions between equilibrium phases and semantic schemata

In the following I shall argue that Gibbs' law and a classification of processes under the conditions of structural stability allow the establishment of a basic list of process- and image-schemata, whose properties can be exploited for semantic description. In Chapter 5 a model of representational spaces will be built on this basis.

The problem of finding the most basic entities underlying a set of complex structures (generated by constructive devices) is very similar to the search for basic figures in geometry, and the analogy between geometry and the psychobiological domain was already evident to Aristotle (in his treatise on psychology "De Anima", line 414b16). The abstract geometrical character of basic representations is not only metaphorically valid; looking at results in neurophysiology (see Orban, 1984) and in the psychology of vision (Kosslyn, 1980) the relevance of spatial and "imaginistic" analyses for cognition, memory and language become evident. The analysis of sensory inputs (I shall primarily consider vision here, but similar methods can be applied to audition) consists of serioparallel mappings from a basically three-dimensional input which enables a very precise control of activity in space and time. The basic problem in the transition between perception - cognition - motor control is the proper mapping from one internal representation (in a realistic sense) to the other. The mapping must conserve basic topological and dynamic characteristics and can forget metrical details, variations of a type of object or event. Therefore, the problem of a *structurally stable mapping* lies at the heart of every theory of representation and of semantics. The crucial result in this field is the theorem of Whitney. Whitney's theorem (for mappings from plane to plane) says that locally (in the environment of a point) we can only find three types of points (all other types become identical to these if perturbed):

a. regular points (Morse-points); they do not qualitatively change under perturbation; we may say that they have a static identity (of self-regulation),
b. fold-points (a frontier line between a stable and an unstable domain appears),
c. cusp-points (two stable attractors are in conflict and one of them may appear or disappear).

Thom and Mather's classification expands this list in the domain of real analysis and Arnold et al. (1986) present a list for the more general case of complex analysis. In the present context it is important to note the basic difference between static stability and process stability.

a. *Static stability* and the unstable points in its neighbourhood. The prototypical (local) systems are the potential functions: $V = x^2$ (one can add a function Q which contains more quadratic terms and constants, e.g. $V = x^2 + Q$; $Q = c_1.y_1^2+c_2.y_2^2+...+c_n.y_n^2$.
The singularity of the unfolding is given by the gradient: $V'=2x=0$.
The stable system $V = x^2$ has a minimum ($V'' = 2 > 0$) as its singularity. The dual of this function is $V = -x^2$; it is the prototype of an unstable singularity, $V' = -2x = 0$; $V = -2 < 0$; it is a maximum. Figure 3.3 shows the two dynamical systems and as analogues two physical systems (pendulums with damping).

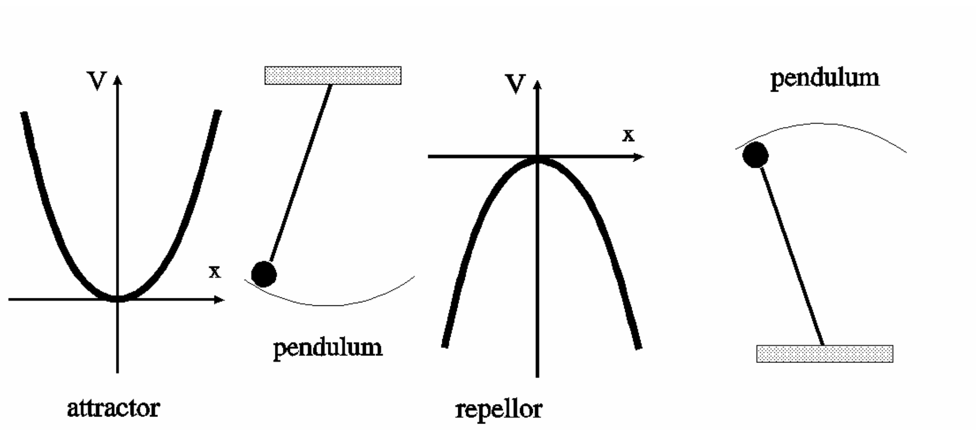

Figure 3.3 *Basic dynamical systems*

b. *Process stability*. Most dynamical systems are not structurally stable, they degenerate under small perturbations. Nevertheless, they can, under specific conditions, have a stable evolution called "unfolding". These special cases can be called highly ordered instabilities or catastrophes. The measure of degeneracy is given by the minimum number of unfolding parameters, it is called the *co-dimension*.

As the theorem of Thom and Mather shows, we have three basic types of dynamical systems: A (cuspoids), D (umbilics) and E (symbolics).

Geometrically, cuspoids correspond to regular polygons, umbilics to dihedra (introduced by Felix Klein) and symbolics to regular polyhedra (Platonic solids). The list of elementary catastrophes is, therefore, a list of ideal, regular dynamic forms or archetypes of processes.

Table 3.1 shows the list of ideal process forms (cf. Arnold, 1972: 254 and Gilmore, 1980: 11).

Table 3.1 *Normal forms of some stable unfoldings*

A_k: $V = \pm x^{k+1} \pm y^2 + Q$; $Q = -z_1^2 - \ldots - z_s^2 + z_{s+1}^2 + \ldots + z_n^2$
Example: $V = + x^3$ (fold); co-dimension = k-1 = 1; unfolding: $V = x^3 + vx$
D_k: $V = x^2y \pm y^{k-1} + Q$ (Q as above)
Example: $V = x^2y - y^3$ (elliptic umbilic); co-dimension = k-1 = 3; unfolding: $x^2y - y^3 + wy^2 + uy + vx$
E_6: $V = x^3 \pm y^4 + Q$; co-dimension = 5 (= tetrahedron)

E_7: V= x^3 +xy^3 +Q; co-dimension = 6 (= octahedron/cube)
E_8: V =x^3 +y^5 +Q; co-dimension=7 (= dodecahedron/icosahedron)

As this book addresses a linguistic audience we must dramatically simplify the mathematical aspects of the theory. This can be done if we consider just the configurations of conflicts in phase (behaviour)-space. Figure 3.4 shows the conflict lines for three (compact) unfoldings of the A_k-family called: the cusp (A_3), the butterfly (A_5) and the star (A_7). Every regime R_i has, locally, the form of a stable attractor (V = x^2), the lines are transitions or conflict lines.

An even simpler (linear) picture is given by a diagrammatic representation of the stable attractors in the unfolding (⊕ = minimum, ○ = maximum, — = vector field).

cusp (A_3): ⊕ — ○ — ⊕

butterfly (A_5): ⊕ — ○ — ⊕ — ○ — ⊕

star (A_7): ⊕ — ○ — ⊕ — ○ — ⊕ — ○ — ⊕

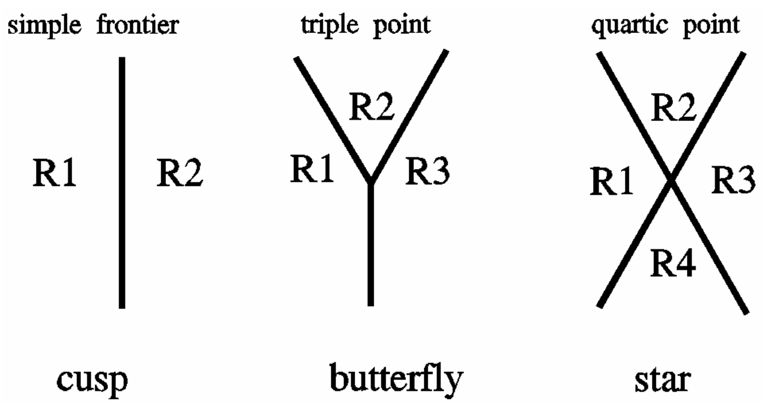

Figure 3.4 *Configurations of conflict*

In the family D_k (umbilics) the notion of a saddle (●) must be introduced (if we add a quadratic function, e.g. y^2 to the members of the A_k-family, maxima become saddles; cf. Gilmore, 1980: 119f).

cusp (A_3) +y^2: ⊕ — ● — ⊕

elliptic umbilic (D_{-4}):

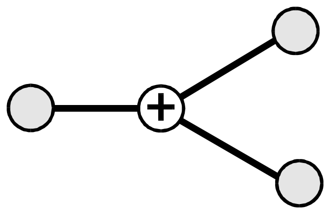

Figure 3.5 *Dynkin diagram of the elliptic umbilic*

If the elliptic umbilic is made compact, i.e. if attractors ⊕ close the saddle connections, we obtain the maximal substructure with four minima:

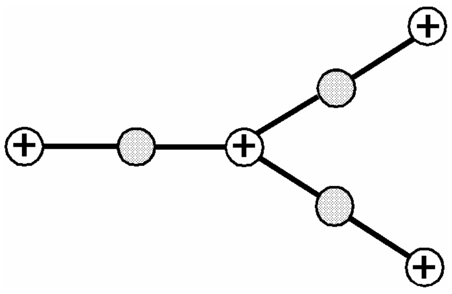

Figure 3.6 *Diagram of the compactified elliptic umbilic*

This is the basic type of a two-dimensional configuration with four attractors (cf. Wildgen, 1985: 204-212).

The configuration with 1, 2, and 3 linearly arranged attractors and the configuration of four attractors in a two-dimensional (x-y) plane will be fundamental concepts in the following sections.

A further notion must be informally introduced: the linear path in an elementary unfolding (this aspect has been elaborated in Wildgen, 1982 and in more detail in Wildgen, 1985). If we consider linear paths in an unfolding, i.e. in the phase spaces sketched in Figure 3.4, we can classify types of processes. In this book only the most basic types will be used; the schemata are abbreviations of explicit dynamical descriptions. In Figure 3.7 the schemata called EMISSION, CAPTURE and (bimodal) CHANGE are derived from the catastrophe set (set of extrema) of the cusp. The diagrammatic simplification eliminates the lines of (unstable) maxima, the circles symbolize the bifurcation points (type 'fold': $V=x^3$).

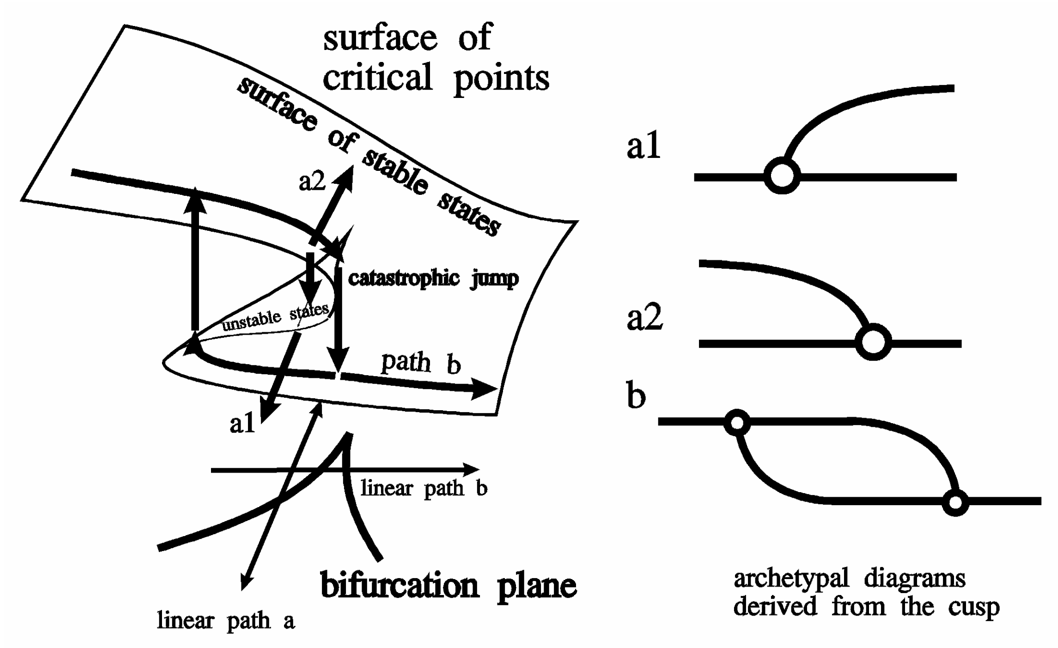

Figure 3.7 *The derivation of archetypal diagrams from the "cusp"*

Thom proposed considering only catastrophes with a co-dimension equal to or lower than the dimensionality of space-time (= 4). With this assumption and if the symmetrical catastrophes (compact, i.e. closed by minima on both sides of the Dynkin diagram; cf. Figures 3.5 and 3.6) are preferred, the basic scenarios of change and process are processes in the cusp (A_3), in the butterfly (A_5) and in the elliptic umbilic (D_{-4}; compacted in the double cusp X_9). We add the very simple fold-catastrophe which appears locally in the cusp (by abutment).

This very regular substructure shows a structure corresponding to Gibbs' law: P (phases) + F (degrees of freedom) = C (components) + 2. In the region of maximal complexity (at the conflict point) F = 0; i.e. P = C + 2. The components correspond to the variables x and y. If C=1 then the maximal number of coexistent phases can be computed: P = 1 + 2 = 3. If C=2, the maximal number of coexistent phases (F = 0) is: P = 2 + 2 = 4.

These theoretical arguments led René Thom to formulate a conjecture (in 1968):

Thom's conjecture

Given a dynamic situation the analysis of structural stability cuts out pieces of the continuous process:

a. in the neighbourhood of singularities (catastrophes),

b. these segments have a maximum complexity of 3 (with one component) or 4 (with two components).

In Thom (1972: translation 1983, p. 211f.) the list of archetypal morphologies is commented on with reference to cognitive processing:

> "Reverting to Zeeman's model [Thom cites Zeeman, 1965] we can assert, for evident functional reasons, that the dynamics of our mental activities admit a fairly large number of first integrals (approximately at least): the representation of external space, sensory qualities [...] We can then form ideas of dynamic attractor structures associated to structurally stable singularities of co-dimension N much higher than 4. But if we wish to 'express' this idea, we are obliged 'to unfold' this singularity, to make it a series of local sections of dimension 4 at most, by a kind of local spatio-temporal realization. This leads to representation of all thoughts by graphs of interaction. [...] We can ask ourselves whence comes so special a structure of formulated thought. We must see in it, probably, a consequence of the three-dimensionality of the space in which we live. In order that a set can be perceived in a global form, a 'Gestalt', it is necessary that the different elements a_i do not cease to exist individually in the global perceptive field. Now, this requires that their dynamic neurophysiological representatives have spatially disjoint supports, but nevertheless having a point in common where the local equilibrium between the systems is manifest. According to Gibbs' law there can be at most four independent systems in equilibrium."

In order to clarify the semiotical relevance of this conjecture, we must look at the traditional semiotic triad, for which Thom conceives a topologico-dynamic invariant.

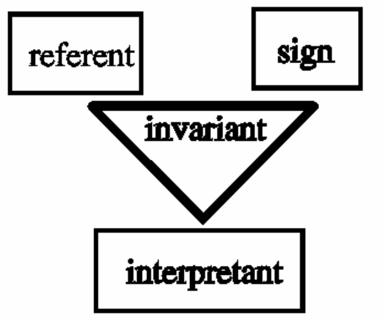

Figure 3.8 *A reinterpretation of Peirce's triad*

Although language is not a mirror, neither of thought nor of the world, there are traces (structural principles) which are conserved at least locally, i.e. in specific juncture points. These invariant principles make linguistic structures ontologically transparent and allow for a basic control of its realistic character (they restrict the possible constructional chaos in linguistic representations, cf. Chapter 4).

If we consider Thom's conjecture (the radical reduction of complexity in basic utterances), the distinction between static and process stability introduced above, and the list of process-schemata derived from elementary catastrophes, we can summarize the underlying assumptions in three principles:

Basic principle 1

A finite (small) list of formal process scenarios is derived by considering states, continuous processes, and transitions/changes along linear paths in elementary catastrophes.

Basic principle 2

The static stable points, lines and surfaces are interpreted cognitively as mental attractors and linguistically as nominal entities, specifically nominal roles in minimal sentences. The stable process types of events are interpreted cognitively as mental scenarios and linguistically as predicative centres of minimal sentences.

Basic principle 3

The control-space of the dynamic model is interpreted in an ordered but multiple manner as: temporal control, spatial control, control of an agent system (cf. Chapter 5, Section 1).

Some general features of the model based on these principles are that:

a. The model exploits a formalism which refers abstractly to processes in space and time; it thus gives rise to a special type of localistic semantics.

b. In principle 3 a minimal ontology is introduced, i.e. a classification of possible interpretations of the mathematical structures in (a). This formal ontology points to a basic ontological commitment of language.

c. Basic linguistic categorizations, mainly in the domain of verb valence and predication structures, must be systematically reassessed (cf. Sections 3, 4 and 5).

In Section 3 I consider the embodiment of these principles in the psychophysical transition between the immediate environment of man (e.g. the floor on which a human is moving forward and the gravitation law which governs human locomotion) and the internal schemata in perception and motor-control. The model starts from the psychophysical "mechanics" and relates them to language. The semiotic triad reduced to body-centred, experiential realism is, therefore, the following (compare Figure 3.8):

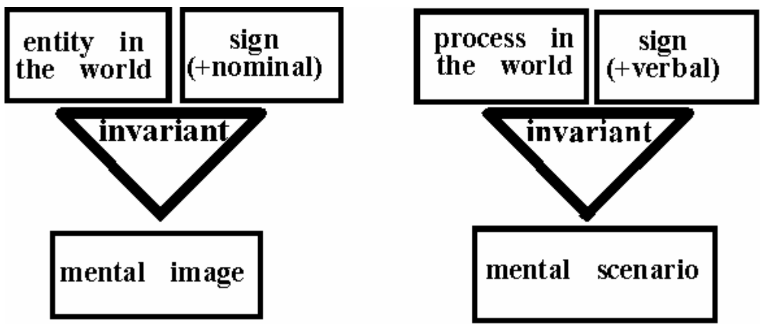

Figure 3.9 *A two-fold interpretation of Peirce's triad*

The specific analyses in Sections 3 and 4 create the observational platform which supports the more general construction of representational spaces in Chapter 5.

3 The meaning of verbs

The logical tradition in the analysis of sentences goes back to Aristotle and holds that the hierarchy of categories is based on the category of *substance*. Aristotle distinguishes between *first* substance, the material of the world and individuals, and *second* substance, the classification of individuals into species and types. In this system the basic task of semantics would be the establishment of a natural and all encompassing classification (mainly based on nominal categories). In the classical Logics of Port Royal (Arnauld and Nicole 1662/1981), verbs are considered to be reducible to the copula (English 'be', Lat. 'essere', French 'être'). All other properties can be analytically separated by the use of adjectives, participles, etc. In Talmy (1975) this tradition is followed insofar as he reduces all verbs to deep predicates, e.g. all verbs of motion have as their common root the deep predicate MOVE. Specific meanings are created by the adjunction of further predicates (adverbial modifiers).

I consider this tradition to be strongly biased. The lexicon of verbs with its valence patterns and selectional restrictions is in many languages a very systematically organized field, and the starting point of every model of the sentence is the main verb of the sentence. If the basic problem of verb valence, i.e. of the gestalt-patterns represented by verbs is solved, then the question of the meaning of sentences can in principle also be solved.

3.1 What is the meaning of verbs?

In Chapter 1 the question was asked "What is meaning?" In the spirit of realistic semantics (ecological or cognitive) this question cannot be answered by simply giving paraphrases in some other language (by translation) or in some quasi-universal language like predicate calculus or intensional logics. One has to look for the basic laws ruling the processes, events (and eventually states) referred to by verbs, and for a basic description of motion and change in the human context (ecosystem). These processes in the human ecosystem can be related to cognitive schemata and to semantic categorization.[1]

A proper starting point is the description of the "perceiving-acting cycle" at a macroscopic level (see Turvey, Carello and Kim, 1990). This macroscopic cycle is on the one hand "slaved" by the basic laws of biomechanics[2] so that the laws of physics can be applied. On the other hand higher cognitive activities such as semantic categorization are built on this cycle and its stable results (cognitive schemata and scenarios). Consequently, the general principles of dynamics (of dynamical systems in equilibrium) are no longer considered sufficient. The bodily enaction of these principles must be taken into account. The results of dynamic semantics (see Wildgen, 1982, 1985) are nevertheless still relevant; they are just given more psychophysical "reality". By integrating the ideas of Turvey, Kelso et al the mathematical basis is enlarged insofar as the more structural models, such as Prigogine's "dynamics far from thermodynamic equilibrium" and Haken's "synergetics", are considered. This results in a tremendous enlargement of the domain of dynamic concepts and devices which can be considered. Nevertheless the theorems of singularity theory and the principles derived from them (see Section 2) maintain their relevance in this enlarged field.

3.2 A cognitive behavioural framework for the analysis of verbs

As a kind of preparatory classification I have used the lexicon of German verbs established by Ballmer and Brennenstuhl (1986) and some of the parameters they introduce. Based on the dimension called "Eingriffsgrad" by Ballmer and Brennenstuhl, i.e. the degree of control (by a human agent), I propose an initial rather coarse subdivision into three domains:

A. Verbs referring to bodily motions occurring in the immediate field of the body, i.e. in the motion of body-parts and limbs relative to a body (see Section 3.3.).

B. Verbs referring to motions, actions controlled by only *one agent*. The difference between motion and action *emerges* at this level depending on the intentionality of the process. I shall try to give an initial approximation to a naturalistic concept of intentionality (see Section 3.4).

C. Verbs referring to the interaction between agents. This "interaction" can be a purely co-ordinated action (i.e. the actions of type B in co-ordination) or it can presuppose very specific scenarios of social and communicative interaction, such as speaking/listening (see Section 3.5).

Section 3.6 elaborates the basic semantic patterns. The complete architecture of representational spaces will be developed in Chapter 5. Section 4 will show how predication and basic syntax follow from the treatment of verb valence.

The interactive schema of sign-using is a general presupposition of all semantic schemata at the levels of A, B and C. It is a higher control schema serving as an orientation for all lower schemata. It can be elaborated and gives rise to the domain traditionally called "speech act theory". In Chapter 5, Section 2.7 I give a short analysis of the verb "promise" in order to illustrate how different levels of analysis interact to form the complex psychosocial schema of linguistic activity in a social setting. This aspect will be further elaborated in Chapter 10.

The strategy of the following analysis is threefold:

a. To seek a very fundamental spatio-temporal system which could underlie the types of motion/action considered. I consider simple mechanical models to be good hypotheses for such basic schemata.

b. To specify the basic perceptual and motor schemata underlying a class of events and actions.

c. To describe the contents of a class of verbs using the schemata found in (a) and (b).

Such a semantic description aims at establishing invariants for interrelating the external world (as a basis of perception and motion), the categories of perception and the schemata of motion, locomotion and action and finally semantic categorizations found in the lexicon. This basic position defines a new paradigm in semantics which I called "realistic/ecological semantics", cf. Section 4 in Chapter 1. As processes and sudden changes are more important than states in this ecological perspective, the semantics can also be called process semantics. This paradigm is opposed to "internal semantics" (exploiting only language-specific features such as distributions, sequential correlations, possible commutations and replacements) and to set-theoretical semantics which interprets sign-forms in relation to set theoretical constructs called "world", "possible world" or "situations" (see Montague, 1970, Cresswell, 1973, and Barwise and Perry, 1984).

3.3 Process semantics of the verbs of bodily motion

Movements of living bodies and body parts are subject to two types of control:

a. The non-linear control of movements, which is largely independent of specific contextual factors and defines the goal of a movement. Non-linear controls involve catastrophes, i.e. sudden changes in the evolution of a process.

b. The linear control adapts the movement in its metrical detail to specific contextual features, it "tunes" the qualitative motion-schema.

If we consider simple movements with one or two limbs and look for analogies in physical mechanics, we find the elastic pendulum and the double pendulum. Figure 3.10 shows the analogy between the motion of an elastic pendulum (left) and the motion of a limb (right) (compare Kugler et al, 1980). The right-hand side of Figure 3.10 shows that the peripheral mechanism of a muscular system controlling the movement of the limb is a damped oscillator of the kind given by the elastic pendulum. This means the higher (e.g. cerebral) controls only specify this peripheral quasi-autonomous system and do not govern it in detail.

Figure 3.10 *The motion of an elastic pendulum and of a limb*

Figure 3.11 shows the analogy between a double pendulum and the movement of a human leg. The right-hand side of Figure 3.11 shows phases in the movement of the human leg while the person is walking (experimental results of Johannson, 1976: 386). The dynamical system of the human leg is comparable to a double pendulum (strongly damped and with restricted domains of freedom).

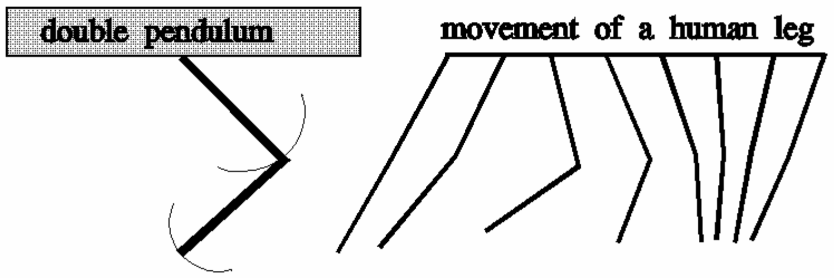

Figure 3.11 *The motion of a double pendulum and of a human leg*

If a person performs a locomotion which is composed of a number of limb-motions two levels can be distinguished:

a. The rhythm of the composed movements, which is a code for the categorical perception of moving agents as Kruse et al (1983) and Wehner and Stadler (1982) have shown.

b. The overall "gestalt" of the movement. In the case of a simple locomotion there is the initial phase which starts the locomotion. It destabilizes the system in its position of rest y_0 and creates a steady evolution until the system is at rest again in y_1.

The coarse topology of locomotion has three phases (see Figure 3.12):

A. Loss of position of rest, beginning of motion

B. Steady motion

C. Gain of a new position of rest, end of locomotion.

The steady motion in phase B is the basic schema, which underlies the semantics of simple verbs of locomotion like *go, run,* or *drive*. These have been traditionally characterized as *durative.*

Figure 3.12 *The basic schema of locomotion*

Instabilities of a simple type can be added to the basic schema using different types of information:

a. *Intrinsic information* contained in the background schema: "A speaks to B", where A=speaker, and B=listener. This schema divides the space into the field of A and B, with a boundary between them. The continuous locomotion can enter the field of A or leave it. The prototypical realizations of this schema are:

C *comes* (towards A = speaker)

C *goes (away)* (away from A = speaker)

b. *Extrinsic information* given in the utterance or by the context of the utterance, as in:

John enters (the house)

John leaves (the house)

In both cases the underlying topological schema contains an instability of the type called birth/death. The basic dynamics are shown in Figure 3.13. The specified domain (intrinsic: the domain of the speaker; extrinsic: any given domain) is a position of rest which is only reached if the boundary of the given zone is crossed. The existence of some larger domain of previous or later rest is given as a background of the process schema (cf. the lower plane in Figure 3.13).

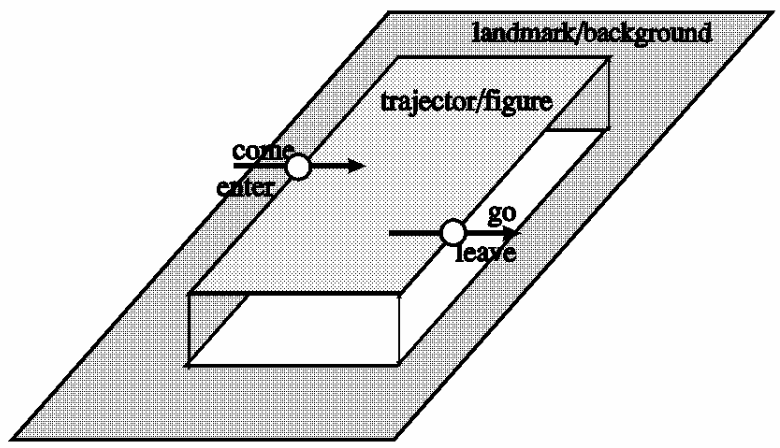

Figure 3.13 *The topological schema of "enter" and "leave"*

The process of locomotion of a body is either continuous (durative) or it involves an implicit or explicit boundary and an orientation of the process relative to this boundary. The introduction of an orientation defines a goal and introduces a kind of *intentionality*.

The path from x_0 to x_1 (x_1 being the goal) can be complicated by the introduction of intermediate forces. We find two fundamental types of intermediate forces in linguistic scenarios.

1. *Instrumental "mediators"*. They modify the mode and the reach of our locomotion. The overall schema remains qualitatively the same; e.g. a traveller going from Berlin to Rome can go by foot, bicycle, car, train, or plane.
2. *Causation*. Causation is a mediation which includes the control of other agents or of natural processes. The attribution of causality (see Heider, 1958) is linked to the perception of certain spatio-temporal correlations and presupposes more complicated mechanisms.

The cognitive schemata that have been classified here are not only relevant for the lexicon of the verb, they also form the cognitive basis for causative constructions (see Talmy, 1976).

3.4 Process semantics of the verbs of action by one agent

In the prototypical situation there is one agent (a more highly organized body with its periphery) who acts on an entity which has a lesser degree of agency (matter, solid objects, living beings dominated by the agent) and which is not an inalienable part of it. We can distinguish three major aspects:

a. The configurational aspect. This aspect only concerns the spatio-temporal relationship, the topologico-dynamic "connectivity" in the scene.
b. The energetic aspect. Here the forces controlling the process, the irreversible path of an effect by an agent, are considered.
c. The intentional aspect. The direction of the energy of an agent towards some global goal is experienced by the (human) agent as an intention which either reaches or fails to reach its goal. In our framework, intentionality is a subjective interpretation of the energetic aspect.

Ballmer and Brennenstuhl (1986) distinguish two main groups of verbs at this level of control:

1. the creation, the destruction and the regeneration of entities (pieces of the environment),
2. the effect of an agent on the state of entities in his environment.

3.4.1 The creation, the destruction and the regeneration of entities

The first group clearly mirrors the fundamental schemata of emission and capture derived in catastrophe theoretic semantics from the cusp (A_{+3}) (see Wildgen, 1982: 42-45 and 1985: 118-136).

Figure 3.14 shows the basic process types: emission and capture. As the examples given by Ballmer and Brennenstuhl (1986: 377-393) show, two subtypes of emission can be distinguished:

a. an agent creates something,

b. something appears (against a background)

The verbal frames can take one or two nominal roles, as the following examples show:

Table 3.1 *Verbal frames with one or two nominal roles*

Alan tells	a story	Charles eats	the soup
M1	M2	M1	M2
Doris sews	(a dress)	Fritz reads	(texts)
M1		M1	

Figure 3.14 *The schemata of creation and destruction (above) and of appearance and disappearance (below)*

The incorporation into the verb of features pertaining to the created/observed object is a very general procedure. A converse strategy chooses a semantically poor verb such as "make" and combines it with a noun specifying the product. The details of the linguistic realization of basic process schemata depend on historical processes of lexicalization and grammaticalization in specific languages or their dialects (see Wildgen and Mottron, 1987: 143-146 and Wildgen, 1990a). They have the effect that the configurational structure on the level of process schemata is not isomorphic with structures of the lexicon or the syntax.

The subtype called "regeneration" by Ballmer and Brennenstuhl (1986) suggests a space of qualities (qualia). The objects involved appear in different qualitative "phases". In many cases the quality space has two (or in rarer cases three) stable phases. The symmetry between the two modes is normally broken and one pole is marked. The process called "regeneration" is given by a path x_0 - x_1 in a control-space with two conflicting states. The general model for this situation is the unfolding of the singularity called cusp ($V = x^3 + ux^2 + vx$). This is illustrated by the analysis of some typical verbs:

Table 3.2 *Analysis of two typical verbs*

(a) to distort, to bend	(German: verbiegen)	scales
	qualitative scale:	+ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ - straight twisted, crooked
(b) to clean	(German: reinigen)	
	qualitative scale:	- _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ + dirty clean, neat

The denomination of the scales depends on the language considered. For the application of his "semantic differential" Osgood has exploited the adjective polarities of many languages and has (statistically) constructed a low dimensional space of basic semantic dimensions (E-P-A: Evaluation-Potency-Activity). The organization of the space of qualities in a minimal semantic space could be similar to his proposals. We would have to add other less connotational dimensions (e.g. material, colour, size, etc.).

If we assume a linear space with two poles we can describe the process contained in the two verbs above in the way shown in Figure 3.15. The curved surface above describes the states of stability and instability (the attractors and the repellors of the system). Only the stable states (on the main surface) can be observed and denominated. The process makes a catastrophic jump from one partial surface to another (e.g. from 'dirty' to 'clean'). The contours of the different surfaces are projected beneath on a plane called the bifurcation plane. These surfaces and curves can be calculated; the corresponding equations are:

- the equation of the set of critical points in the cusp (= the set of maxima and minima): $4x^3 + 2ux + v = 0$

- the equation of the bifurcation set of the cusp: $27 v^2 + 8u^3 = 0$

This model shows that regeneration and degeneration/deterioration must be considered as two distinct subtypes. The invariant schema is the topological schema of (bipolar) change.

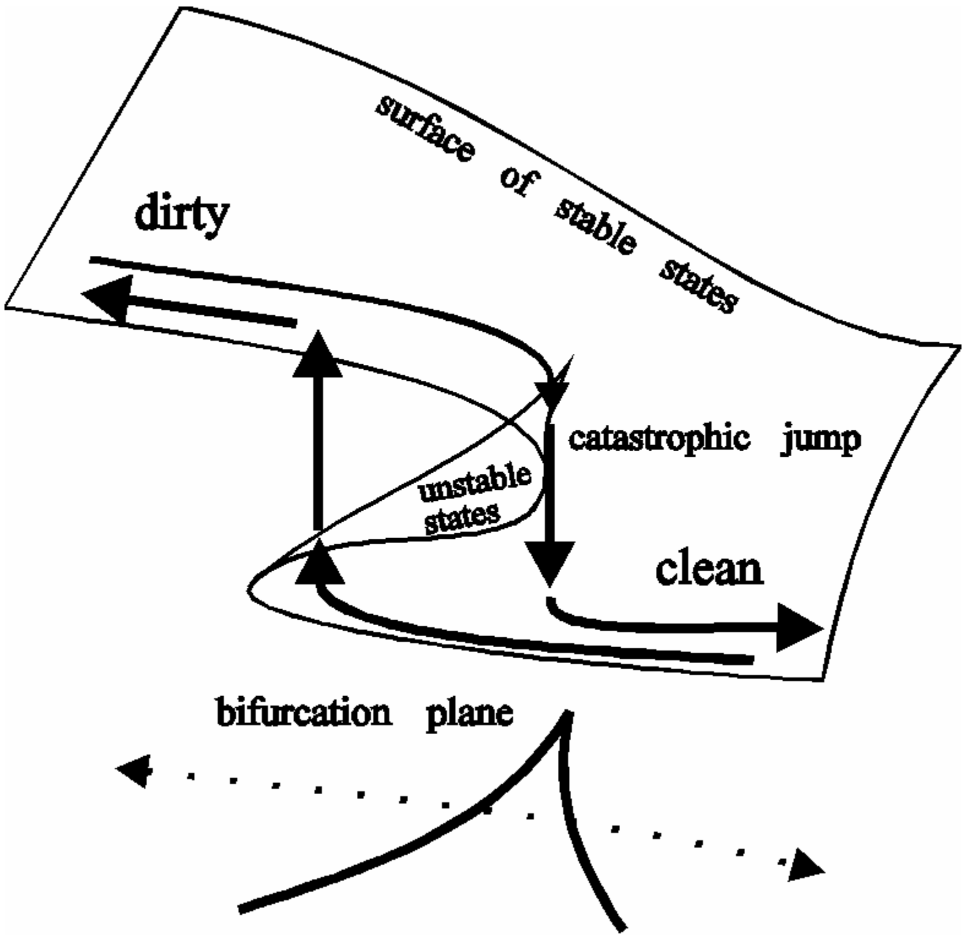

Figure 3.15 *A catastrophe model of regeneration and deterioration*

3.4.2 The effect of an agent on the state of entities in its environment.

The asymmetry between agent and non-agent becomes more pronounced in this group of verbs and the energetic/intentional aspect is dominant (in the foreground).

Following the same strategy I would like to start with the description of a mechanical analogue. Two systems of pendulums are shown in Figure 3.16:

a. Two pendulums A and B. A gives its impulse to B (punctual transfer).
b. Two pendulums dynamically coupled. The coupling can be either rigid or elastic.

The mechanical analogue can be interpreted as a model of basic causality (by contact of rigid bodies), such that (a) stands for a chain of causes and (b) for a system of coupled causes.

Figure 3.16 *Two basic types of dynamic coupling*

The following sentences exemplify processes of type (a) and (b) in linguistic category formation. Many types of complex propulsion use a series of mechanical couplings whereby an initial force giver can cause the final locomotion. Thus, in the case of a bicycle the vertical motion of the legs is transformed into the circular motion of different wheels and finally into the horizontal locomotion of the person on the bicycle:

Table 3.3 *Sentences expressing punctual transfer vs. rhythmic coupling*

(a) punctual transfer	*(b) rhythmic coupling*
The player kicks the ball	The sexton tolls the bell
The man pushes the chair	The man pushes the rocking-chair
The girl throws the ball	

The general configurational schema is a modified schema of emission. Two systems (the agent and the object) are co-present. The agent is in motion and the object begins to move under the control of the agent (emission of momentum). In the complementary case the momentum of an object is absorbed by the agent who stops the motion. In all cases the existence and stability of the agent and the object are not changed by the action. Figure 3.17 shows the modified schema. Due to the fact that the agent (M1) is energetically superior to the object, the energy of M1 is not absorbed totally by M2 (this would correspond to the physical example (a) in Figure 3.16). In Figure 3.17 every point on the lines of the diagram is an entity in movement.

The transfer of energy/intentional direction from M1 to M2 (via some mediator) can be either isolated (as in "kick"), repeated or continuous (as a sum of rhythmic actions).

Figure 3.17 *Emission and capture of motion/energy*

In the case of movement, the object changes from rest to movement under the effect of the agent. In a similar way the object can change its shape and even its qualities. Thus if we introduce a quality space we obtain a very rich field of actions on objects which can be labelled and organized in the verbal lexicon.

3.5 Process semantics of the verbs referring to the interaction of agents

The level of interaction between human agents cannot be strictly separated from the level of movement or manipulation of objects. Expanding these domains results in a higher level of organization with specific controls on the co-ordination of several (free) agents. The kinematic principles and the energetic/intentional orientation discussed in Sections 3.3 and 3.4 remain the same. What calls for explanation is the almost "unlikely" stability and constancy of patterns of interaction in a domain which has so many degrees of freedom.

An initial clue as to the basis for such patterns can be found in animal behaviour. Fentress (1982) and Golani (1982) show that very specific paths exist for the contact behaviour of mammals. The paths and their attractors can be lines of contact (between the tip of the mouth and the body of the partner) or lines followed in the bodily orientation of one animal (the direction of its head and its eyes). These lines follow stable paths and stabilize in very specific regions. Thus a very small sub-field of the body surface is selected for allowing contacts. Furthermore in the course of repeated contacts very specific symmetries and asymmetries in the relative behaviour appear in the interaction so that a highly ritualized pattern is created (cf. the analysis of the behaviour of wolves by Fentress, 1982). The punctual attraction in the relative movement of

two agents plays a similar role to the body-joints in Section 3.3. Thus even the patterns of interaction reproduce basic mechanical processes.
Different types of social contacts make use of different "joints":

- the eyes of the mother are an attractor for the baby and are essential for the first contacts with the mother (humans attract humans specifically by the white parts of the eyeball and the movements of the eyes);
- the bodily contact zone (at short distance) using the lips (compare the suckling activity of the baby); in the same way the breast of the mother is an attractor for the baby;
- the contact at a certain distance using the hands (grasping, petting);
- the contact of exchange (using the hands, controlled by the limbs and the eyes);
- the communicative contact (using the mouth and the ears as instruments).

The co-ordination of the interactive processes exploits these kinematic and energetic sources and elaborates them. Linguistic activity itself is simultaneously such an interactive process and the product of it (it is therefore self-referential). One specific process in this field will be more closely analyzed: the process of giving (receiving/exchanging).

3.5.1 The configurational structure of "giving"

The basic schema or prototype of "giving" can be configurationally described using a model proposed by Zeeman (1975). The scenario is defined by a sequence of snapshots: t1 to t5. Each snapshot represents an instantaneous three-dimensional configuration in which the specific positions of sender, receiver and object define a plane. The third dimension is a density (or relevance) function. This density is a correlate of the subjective focus in the perception or the motoric control of a specific region of the scene. At the beginning and at the end of the series density has two attractors (maxima of attention, relevance), in the middle of the series (t2 to t4) a third attractor appears, grows and finally disappears (the participants focus on the exchanged entity).[3]

The intermediate, symmetric scene at t3 is the most unstable one. Both agents concentrate their control on one target, and their control must be co-ordinated in order to secure the smooth exchange. Thus, if A releases his control before B takes the object, or if A holds the object tight, although B seizes it, the character of the process is dramatically changed and degenerates to "A loses, drops the object" or "A and B compete for the object C". Thus the unstable state of exchange is the "junction" of the process, the point of maximum co-ordination of the controls. It can be a metastable state, if the object gains some autonomy, for example if it lies on a table between A and B such that it is within the reach of both but is not strictly controlled by either of them. This configuration corresponds to the topological schema of transfer (see Wildgen, 1985: 185). The process of exchange, transfer, or change of possession is highly differentiated in the lexicon of German verbs.[4]

Figure 3.18 *Zeeman's model of the transfer schema*

In Figure 3.19 we distinguish five major phases separated by the catastrophes called "EMISSION", "CAPTURE" and "TRANSFER" (transition) between HAVE1 and HAVE2. The phases can be further subdivided by the dominant perspective (M1 or M2). The line of TRANSFER separates HAVE and HAVE NOT.

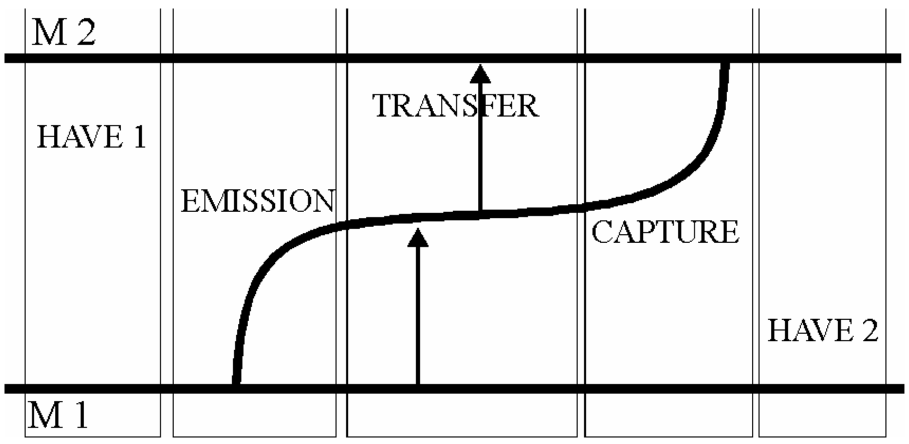

Figure 3.19 *The phases of the TRANSFER schema*

3.5.2 The energetic (intentional) structure of "giving"

The two concepts of control and intentionality allow the construction of a scale with four steps:

a. a simple control is a function inside the agent and its immediate parts (limbs),
b. a second type of control is created if the agent takes into consideration an entity which is not part of himself and has its own dynamics (own forces),
c. the control necessitates a recognition of the "intention", the goal of another agent,
d. a complex scenario with objects and other agents is integrated into a higher "gestalt". It creates a social schema which is the presupposition for the evolution of communicative routines and of language.

In relation to the basic intentions of the participants in the transfer scenario the schema of giving is in disequilibrium as agent A finishes "poorer", agent B "richer". A symmetric configuration is found in the schema of mutual exchange, which corresponds to a closed loop in the underlying control-space of the catastrophe called "butterfly "(A_{+5}). Figure 3.20 shows this structure.

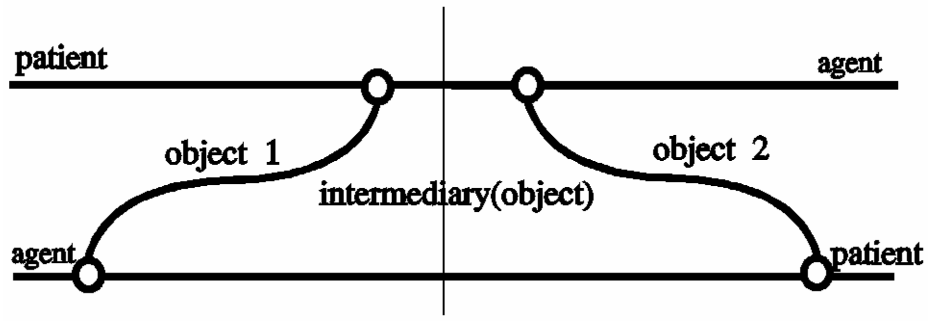

Figure 3.20 *The energetic cycle of transfer*

In the first phase the patient gets object 1 and "wins", thus creating an asymmetry of possession; in the second phase the former agent gets object 2 and "wins". The general figure represents two basic movements of a simple game (compare the theory of game-theoretic equilibria and the application of game theory in Chapter 7, Section 2.2).

In Figure 3.19 the line of TRANSFER is defined by a shift of dominance (from M1 to M2). The concept of dominance of a force[5] allows the definition of a perspective; the different dynamic perspectives are the basis for a semantic subclassification of verbs. In German we find the following subclasses of GIVE:

- geben, schenken (give, donate),
- erhalten, nehmen, abnehmen, rauben, stehlen (receive, take, take off, rob, steal): CAPTURE,
- austauschen (exchange): TRANSFER,
- kaufen, abkaufen, ankaufen, einkaufen (buy, buy from, purchase, shop): TRANSFER + CAPTURE,
- verkaufen, ausleihen, zurückgeben (sell, lend/borrow, return): TRANSFER + EMISSION.

The concept of dominance in a dynamical system can also be used for the modelling of topicalization and passive transformation (see Wildgen, 1988).

3.6 Elaboration of the basic ecological patterns in the semantics of verbs

The basic patterns of verbal semantics under the headings: bodily motion, actions controlled by one agent, and interaction between different agents, can be elaborated by multi-modularity, evaluation, and onomatopoeic "meanings".

3.6.1 Multi-modularity

The motion verbs in Section 3.3 can be classified relative to their auditory patterns (in addition to motor patterns).

Table 3.4 *The auditory aspects in verbs of motion*

hopsen	(to hop)	*stapfen*	(to plod)
humpeln	(to hobble)	*tappen*	(to grope about)
latschen	(to shuffle)	*tippeln*	(to tiptoe)
schlurfen	(to scuffle)	*trampeln*	(to trample)
staken	(to punt)	*trippeln*	(to trip)

The meaning of these verbs refers not only to motor schemata (and corresponding visual controls), it also mirrors an auditory classification which becomes prominent when visual cues are absent. In some examples visual and auditory classification are closely related; thus the specific rhythmic features of *hopsen, humpeln, tippeln, trampeln, trippeln* are apparent both visually and auditorily. Other verbs like *latschen, schlurfen, staken, stapfen, tappen* refer more directly to auditory impressions.

Visual memory and visual imagination of larger settings can be utilized to achieve a richer content of verbal meanings.

Table 3.5 *Effects of visual aspects on German verbs' contexts*

German	*English*	*Context*
pirschen	to stalk;	cf. the *huntsman*
preschen	to race;	cf. the racing *car*
stelzen	to walk (as)	on *stilts*
stiefeln	to march (as)	in (heavy) *boots (=Stiefel)*
tigern	to walk	like a *tiger*

3.6.2 Evaluation

In a paraphrase of specific verbs (as in componential analysis) adverbs of manner can be used to distinguish the specialized meanings from a more general component: quickly, slowly, fast, clumsily, etc. In a more theoretical style one can use Osgood's connotative space and associate every verb with a positive or negative weight of one or several of the dimensions which Osgood (1976) calls Evaluation (E), Potency (P), and Activity (A). The list below is given as an illustration of such an elaboration.

Many verbs have an evaluative connotation. Starting from Osgood's connotative space (see Osgood, 1976) with the axes *Evaluation* (E), *Potency* (P), and *Activity* (A), the following list of verbs can be assigned weights (+ vs. -) :

+A, -A correspond prototypically to [active, passive]
+P, -P correspond prototypically to [strong, weak]
+E, -E correspond prototypically to [good, bad]

Table 3.6 *Evaluative meanings of verbs (*examples)

to run	(+A)	to stroll	(-A)
to chase, to race	(+P)	to hobble, to limp	(-P)
to pace, to stride	(+E)	to trample, to waddle	(-E)

3.6.3 Onomatopoeic "meaning" of verbs

A kind of dynamic resonance between the conceptual level and the acoustic form of the word can be observed when looking at the auditory classification underlying the meaning of verbs. This kind of phonetic iconism in the lexicon is called onomatopoeia. Some of the examples listed above under A and B show a similarity between phonetic features (front vs. back vowels, long vs. short vowels) and auditory characteristics of the real world process they express.

Table 3.6 *Onomatopoeic features of motion verbs*

English	German	phonetic features	content
trip, tiptoe	trippeln, tippeln	the vowel [i] has high values of the formant F_2	quick rhythm of the movement referred to by the verb
shuffle, scuffle	latschen, schlurfen	the vowel [a] has lower values of the formant F_2	slow rhythm of the movement

Evaluation and multi-modularity produce a very rich and very stable inventory of cognitive "entities". The specific mixture of these different layers, and the way in which features of the preferred fillers of semantic roles and typical manner modifications are coded in the verb, create a huge field of interlanguage variation in the lexicon and in basic syntax. What is universal is rather the underlying schematism and the underlying semantic space. In Chapter 5 I shall try to enumerate possible universal traits which make up the skeleton of our universe of discourse.

4 Predication and basic syntax

Although dynamic principles govern the organization of the lexicon, this domain is rather static when compared to syntax. It can be described as a *field* (i.e. as a multiplicity of possible choices which fit together). In the act of predicating and of uttering (or hearing) a sentence, this field structure is exploited, used in a concrete act (involving real bodies, minds, situations). Thus the transition from lexical units to sentences is a dramatic one. This transition has four aspects:

a. The speaker of a sentence makes a specific choice in a lexical field; the remaining field, especially that surrounding the chosen item, constitutes an important background for the utterance and may be used in understanding it.

b. The tension between static vs. dynamic entities in the lexicon is the germ of *predication.* The utterance of the sentence is driven by the instability of the basic configuration and its restabilization. It is therefore comparable to the motion schema described in Section 3.3 (cf. Figure 3.12).

c. The basic choices made in the first predicative step are elaborated, still exploiting the lexicon (specific selection rules, lexical incorporations, etc.) but also making use of the context (anaphora, cataphora). Further specifications are added using additional devices (adjectival and adverbial constructions, relative clauses, prepositional phrases, etc.).

d. Some parts of the sentence (especially the main nominal roles) may be further specified (by the use of proper names, definite descriptions, demonstratives, deictic pronouns and by modality indicators).

I shall deal only with the dynamically central aspect (b) and try to develop a new concept of predication. Two basic types exist:

A: Strong coupling in predication. The predicate e.g. the finite, main verb has a central position by which it organizes the coupling of valence-bound noun phrases.

B: Weak coupling in predication. The subject is linked by only a semantically weak element, or none at all, to something which itself has a predicative character (but is not verbal, rather nominal or adjectival). The predicative centre is said to be split into one (semantically) weak and one strong centre. The coupling is done by the weak centre.[6]

In addition to the cases falling clearly into these two types, there exists an intermediate zone containing serial verbs and verbal compounds. In the case of serial verbs two finite verbs together describe a complex event. The following Twi-sentence is from Sebba (1987: 1):

Kofi	de	pono	no	baae
Kofi	*take*-Past	table	the	*come*-Past
Kofi	*brought*	*the table*	(=took the table and came with the table)	

The first verb 'take' has the basic process type CAPTURE (see Section 3.4), the second verb the more basic process type ENTER (see Section 3.3). This gives an indication of the possible applications of the dynamic model in the areas of verbal composition and serial verbs which are outside the scope of this book. I shall concentrate on the basic polar fields A and B.

4.1 Strong coupling in predication

In this case the verb is really the organizing centre of the sentence. It corresponds roughly to the picture of basic syntax given by dependency or valence models (cf. Tesnière or others). However, this type is neither the only one, nor does it expand to cover the whole sentence structure, e.g. to phrasal syntax. In this sense the dependency models are overgeneralizations.

Here is an example of how the strong predication of the verb constitutes a sentence frame. It also shows the projection of the dynamic schema into a dependency tree.

Example:	Eve	gives	Adam	the apple
	-----	====	------	-----------
	1	dyn. centre	2	3

This sentence falls under the schema of 'GIVE' and is described by the diagram in Figure 3.21. Its configurational information can be projected horizontally on a static plane (nominal roles) and vertically on a process plane (dynamic centre, verb).

Figure 3.21 *Selective projection of the schema of 'GIVE'*

The following rules allow the construction of a conceptual dependency tree:

Rule 1 : The most complex (degenerate) singularity of the process type defines the root of the tree, the basic node.

Rule 2 : The regular points (attractors) define the arcs originating from the root (with unit length). The end-points of the arcs define the nodes for nominal fillers.

The kind of dependency tree that can be derived is shown in Figure 3.22.

When considering the production process, the typological rules of sentence ordering valid for a specific language must firstly be determined. The specific grammatical terminology (subject of, direct or indirect object of, instrument, etc.) can be defined at this level.

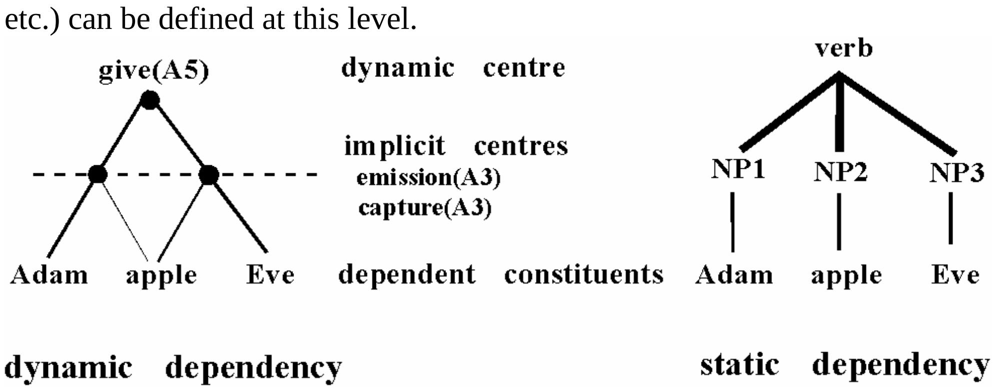

Figure 3.22 *Two dependency trees derived from the schema*

A theoretical model of the production process involves, however, a psycholinguistic or even a neurolinguistic level which is not dealt with in this book.

4.2 Weak coupling in predication

The prototypical example of weak coupled predication is the use of the copula (e.g. "be" in English); it has been the historical starting point of all traditional models of predication.

The general characteristics of weak coupled predication are:

a. The underlying process referred to is dynamically weak (static or without change/transition).

b. The type of process has a compound nature, the second (coupled) predication adds some aspect of the process.

In the first case the copula construction (or a copula-less predicative construction) is the natural outcome. In the second case adverbial modifiers, verb prefixes or constructions with auxiliaries may represent the underlying dynamism.

In coupled predication the conceptual input is distributed to several (normally two) sequentially ordered predications. Dangelmayer and Stewart (1982) represent such systems by a block-diagram as shown in Figure 3.23. The input can be interpreted as some holistic "Gedankengestalt" (thought-schema) underlying the sentence; predication 1 forms/selects a first predicative component, predication 2 (weakly coupled to 1) forms/selects a second more important component, which is semantically dependent on/prepared by the first one.[7]

Figure 3.23 *Sequentially ordered bifurcations (Dangelmayer and Stewart, 1982)*

The examples (i) to (vi) below follow the predicate hierarchy proposed by Hengeveld (1992: 138): Verb > Adverb Loc > Adjective > Noun > Possessive phrases. He associates the scale with a measure of "time stability". In the domain of non-verbal predicates, the adverb is less time-stable than the adjective, noun or possessive phrase (in their predicative uses). This fits well with our analysis of verbs as maximally unstable centres (germs) of simple dynamical systems in the last sections.

If we compare the examples, we observe that in (i) the copula still has a dynamic character, it describes the stable or metastable position of the ball; the basket is a spatial attractor and the ball is at rest in this attractor. This dynamic character gets looser and more abstract in the examples (ii) to (vi).

Table 3.7 *Predications with copula*

(i) The ball is	p.1	in the basket	p.2
(ii) The sky is	p.1	blue	p.2
(iii) The dog is	p.1	big	p.2
(iv) Mary is	p.1	(a) teacher	p.2
(v) This book is	p.1	by Shakespeare	p.2
(vi) This book is	p.1	mine	p.2

In (ii) a space form (the sky) intersects with a domain of the colour space. The colour space is, however, not considered independently of the first predication, as possible colours of the sky restrict the meaningful fillers in p.2:

colour of the sky:

blue, blue with clouds, grey, dark, (rarer) red.

The restrictive power of p.1 on p.2 is even more prominent in example (iii), where the measure-adjective "big" can only be specified knowing some proto-typical size of dogs. The first predication p.1 sets the conditions for the second one. In example (iv) the copula links two nominal entities with different specificity; the first is denominative ("Mary"), the second is descriptive ("teacher"), (cf. the scale: descriptive - versus - denominative established in Seiler, 1975: 25). This difference has as a consequence that "Mary" is included as a member in the descriptive domain of "teacher". Some of the features of "Mary" restrict the domain of "teacher" (e.g. to female teachers). The fact that we may infer from (iii) the paraphrase: Mary is a member of the (social) group of teachers, or: Mary has some properties common to the group of teachers, exploits the semantic asymmetry between the proper name "Mary" and the common noun "teacher".

In the case of semantic "lightness" the copula can still be used to indicate grammatical person, member and aspect. In some languages these grammatical markers are added to the non-verbal predicates (e.g. to the adjective).

The use of the copula with a possessive construction, which ranked lowest on Hengeveld's scale of time stability (highest on the scale of abstractness (ibid.: 136)), can be related to the phase of stable possession in the transfer-archetype in Section 3.5:

This book is mine.

I won this book.

In some languages locative predications are preferred. Instead of "I have a house", "a house is at me" (example from Banbara, cf. Hengeveld, 1992: 162).

Spanish has two verbs which translate into the English "be" and German "sein": *ser* and *estar*. It is interesting that in many translations of Spanish sentences into German and English, changes in the Spanish copula are expressed by changing the adjective in German and English sentences.

Table 3.8 *Comparison between Spanish, German and English*

Spanish	*German*	*English*
el nino *es* bueno	das Kind ist brav	the child is nice
el nino *esta* bueno	das Kind ist gesund	the child is healthy
Pablo *es* listo	Paul ist schlau	Paul is clever
Pablo *esta* listo	Paul ist bereit	Paul is ready

It seems that if the first predication (with the choice between *ser* and *estar)* is more differentiated, then the second (with the adjective) can be less differentiated; the effect is the same. A coupled predication thus creates a domain of semantic variability.

The second major type of coupled predication distinguishes between one basic predication and the addition of an aspect, a specification of the manner (cf. (b) above). Talmy (1991) has described the distribution of predicative content on the verb and on adverbial phrases. He distinguishes between "framing verb" and "supporting verb":

> "Languages with a framing satellite regularly map the supporting event into the main verb, which can thus be called a *supporting verb*. On the other hand, languages with a framing verb map the supporting event either onto a satellite or into an adjunct, typically an adpositional phrase or gerundive like constituent -- terms which in this usage can now also have the word "supporting" placed before them." (Talmy, 1991:6)

Table 3.9 *Talmy's comparison of Spanish and English*

English:			*Spanish:*		
I *blew*	*out*	the candle	*Apagué*	la vela	*desoplido/soplándola*
			I extinguished the candle with a blow / blowing it		
supporting verb	framing satellite		framing verb		supporting satellite

In English the manner of the process is given by the verb stem "blow", in Spanish it is given by an adverbial "with a blow" (de soplido). The type of process is coded in English by the preposition "out" and in Spanish by the verb "apagué". By iteration of this process, a language could generate a complex verb whose morphemic structure codes the basic types of construction in the sentence. This is typically done by certain American Indian languages.

The basic assumption that there is one centre of the sentence (cf. basic principle 2 in Chapter 5) is relativized by the existence of a scale of predication types. In the borderline cases the verb is almost empty (this is the case with the copula and its zeroing) or it is so differentiated that all other parts of the sentence can be left unspecified (the listener may fill them in on the basis of his knowledge of the context). The concept of a central predicative verb must therefore be replaced by the concept of a "scale of predication".

5. Syntactic constituency and stable dynamic schemata

My starting point is Fillmore's distinction between *external syntax* and *internal syntax.* The lexical items which govern specific syntactic groups are the proper domain of internal syntax. Complementary to this bottom-up organization in linguistic structures is a domain which is functionally related to discourse structure, namely to the distribution of information in sentences and texts. This domain is called the domain of *constructions* by Fillmore and Kay (1987). Fillmore (1987) presents a preliminary list of the major types of constructions (see Fillmore, 1987: chap. 2 and for a summary Wildgen, 1990b). In Chapter 9 more will be said about the information structure of sentences and texts.

a. Subject-predicate constructions

The child torments the horse
subject predicate

The constituents can be characterized as maximal nominal and maximal verbal (in the X-bar hierarchy): N, [max+]; V, [max+].

b. Complementation structures

These are made up of a lexical predicator and its local complements (i.e. the non-subject arguments)
put the money in the jar
predicator complement complement

c. Determiner-head constructions

the child (torments the horse)
det head
The constituents are a determiner (det) and a non-maximal nominal phrase N[max-]. The whole construction is, however, maximal: N[max+]
Examples with other determiners:
our baby; det = possessive; every baby; det = quantifier
this baby; det = demonstrative

d. Modification constructions

These constructions produces a phrase with the same category as that of the head.
green box; category of the construction N[max-]
Mod N[max-]
very green; category of the construction A (adjective)
Mod A
eat noisily; category of the construction V[max-]
V[max-] Mod

e. Conjunction constructions

These combine categories of a similar type into one construction.

John and Mary sleep and dream.

Big or tall, slowly or quickly, etc.

These constructions are rather pervasive in human languages.[8] If the notion of an "attractor" and an "attracting field" is introduced in order to reorganize Fillmore's proposals in a dynamic context, then the result is a nested hierarchy of attractors (centripetal fields). Thus the predicate as a whole (V[max+]) is an attractor in the bistable configuration of the subject-predicate construction. The available information is either drawn towards the attractor [subject] or towards the attractor [predicate]. The second field can be further analyzed as a field with local (minor) attractors, the predicator and its complement, where the complement has a certain multiplicity (no complement, one or two complements in Fillmore's analysis). Below this level all constituents are controlled by the dynamics of the determiner-head construction and all the remaining and resulting sub-constructions are controlled by modifier-head constructions.

From this new perspective the complementation construction is deviant as it does not have a bi-polar structure. It is clear that the specificity of the complementation construction has its sources in the dominant valence patterns which are stronger than the external constructional forces. If a more radical separation is made between external syntax (functionally related to discourse laws) and internal syntax (functionally related to cognitive laws) fewer basic constructional types result. The first type contains two subtypes of constructions:

A. The subject - complementary part of the sentence - construction (for sentences)

B. The determiner - head - construction (for noun phrases)

These constructions create specific asymmetries in the sentence and in the noun phrase (they are linked to pragmatic motivations like topicality).

A second type of construction is accumulative insofar as a plurality of information is bound together by co-ordination.

C. The modifier-head construction.

D. The conjunction construction.

Both provide the means for the clustering of information under a purely organizational head (conjunction construction) or a semantically specified head (modification construction). In Figure 3.24 the relation between the three basic types of construction A, B, C is illustrated for the case of the NP (on the left). On the right-hand side the splitting of the predicate, which is also a bimodal bifurcation, is added (cf. Section 4). The VP can contain a NP, and the processes B and C can be reapplied.

The dynamic schemata of A, B and C together with the gestalt-like valence patterns analyzed in Section 3 form a system of basic constituent structure (in an abstract sense). A more elaborate version would have to consider the functional space in which the forces which drive these bifurcations can be labelled and empirically assessed.

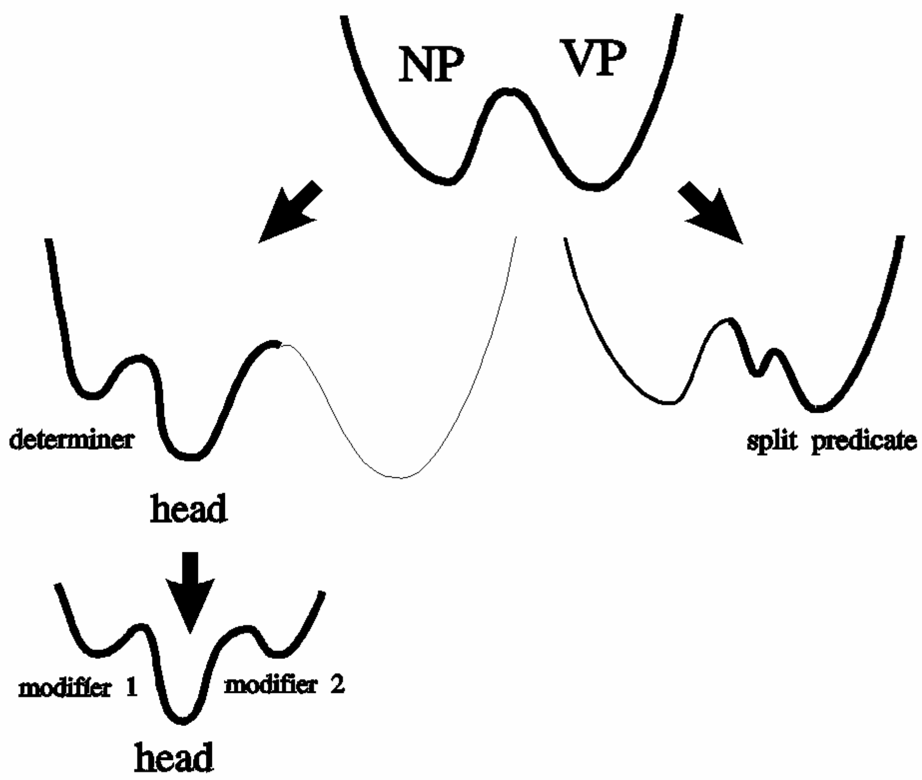

Figure 3.24 *Three basic types of construction*

In Figure 3.24 the VP shows only the basic bifurcation characteristic of sentences with a copula (cf. Section 4.2). It could contain a direct object, an indirect object, a prepositional phrase, etc. Adverbials or adverbs could further elaborate the verb, the modifiers and the whole sentence.

The basic bifurcations are very frequently of the bipolar type (cf. the catastrophe called "cusp"). The richness of stable process-scenarios is only unfolded in the case of valences, which therefore constitutes an island of dynamic complexity in the sentence. This analysis is able to catch the basic heterogeneity in syntactic structures. We presume that the force fields which cause/enable the separations mentioned above are different for valences on the one hand (their foundation is a psychophysical one) and for the bifurcations A, B and C. In the case of the bifurcation "determiner (nominal) head" we presume that two basic functions show up: the deictic, demonstrative, topicalizing function in the determiner, and the descriptive, classifying, and evaluative function in the nominal head and its further bifurcations (cf. the head-modifier construction). Together these mechanisms constitute the stable backbone of all complex utterances.

A third type of construction has the function of a sequential binding of information. Binding phenomena are examples for this construction; they will be dealt with in Chapter 7, Section 6.3.

1 This line of research has a long tradition. A treatise by Aristotle on the motion of animals has been lost; the first modern treatise on biomechanics was written by a pupil of Galileo, G. Borelli (in 1679). This tradition was taken up under a system-theoretic perspective by the Russian psychologist N.A. Bernstein and the American psychologist J.J. Gibson. I pick up the thread from ecological psychology (cf. Stadler and Kruse, 1990).

2 Cf. Donskoi, 1975 for an introduction to biomechanics.

3 At a conference in Urbino (in 1992) Jean Petitot showed that the technique of neural net dynamics can be used to simulate the cognitive process of finding such stable patterns in the perception of three-dimensional scenes.

4 Ballmer and Brennenstuhl (1986) distinguish 130 specific lexical subgroups in the large group called *haben* (to have). The phases, which are empirically identified in their description, map into the set of distinct phases one finds by a topologico-dynamic analysis of the schema of

transfer. Their analysis of valence is, however, linear, which is why the different perspectives of the giver or the receiver (goal) are not clearly distinguished. Their descriptions incorporate many aspects of the manner of possession and transfer and the kind of objects possessed or transferred.

5 The dominance of an attractor is defined by the relative depth of the attractor (if we start with a negative gradient dynamics).

6 In Hengeveld (1992), this basic difference is called verbal vs. non-verbal predication. In the domain of non-verbal predication a further distinction between copula, semi-copula (e.g. become), and pseudo-copula (e.g. seem) is made. The copula can be "predicativizing" or "discriminating". The latter "function as a sign of (non-verbal) predication rather than as an element creating the main predicate of the sentence in which they occur. Both (original) pronouns and particles may be used in this way" (Hengeveld, 1992: 190).

7 Inanimate processes showing sequential bifurcations may be found in chemical reactions and non-linear electrical circuits.

8 Idiomatic constructions specific to single languages are discussed in Fillmore, Kay and O'Connor (1988). They describe for instance an idiomatic construction called the "Let alone-construction." Example: He wouldn't give a nickel to his mother *let alone* ten dollars to a complete stranger (ibid.: 514).