SYSTEMS

New Paradigms for the Human Sciences

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Chaos, fractals and dissipative structures in language

Or the end of linguistic structuralism

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Structuralism, which had been fundamental to chemistry in the 19th century, became dominant in linguistics and also in specific areas of philosophy at the beginning of the 20th century. It was further pushed by the rapid growth of the computational 'ideology' in the sciences, but its limits became apparent when in sociolinguistics (cf. Labov 1966), psycholinguistics and later in the cognitive sciences this paradigm lost its attractiveness or was replaced by a series of new models, like grammar with variable rules, logical grammars, space grammars and different variants of computational models like schema theory, principle-governed grammars and unification grammars. All these proposals were variants of the old structuralist models with some new sophistication. Now at the end of this century, after so many decades of theoretical quarrels and divergences, it is necessary to come to a conclusion. In the meantime many of our neighbouring disciplines have been successful in elucidating aspects of language behaviour and language capacity and could easily dispense with the specific theoretical developments in linguistic theory. Beginning in the seventies, a new paradigm, called the dynamic, non-linear paradigm, was proposed first by René Thom, later by Petitot, Wildgen, Brandt and others. In the eighties this paradigm was elaborated and now includes aspects of non-linear neural nets, chaos theory and synergetics. In this article I shall outline the different theoretical options and their possible applications in order to introduce the new paradigm and to show its merits and possible limits. The mathematical and philosophical contexts which motivated the generative movement in the fifties and sixties have also evolved and it is now time to rethink the common presuppositions of classical structuralism; I will, however, only give some hints for such a reform of the foundations of linguistic theory.

In the first chapter I characterise the major subfields of the new, the dynamic paradigm (cf. also for a general review of this paradigm Wildgen and

Mottron 1987 and Wildgen 1994). The following chapters will discuss major applications to linguistics.

1. A short characterisation of three subfields of the dynamic paradigm

1.1. Chaotic dynamics

The general idea of *chaotic* dynamics can be understood if we imagine a human character who never forgets any trouble which occurred to him; as more troubles occur, which is natural in a situation where one is in rage, the poor guy loses control and may do anything. The opposite of this character is the phlegmatic one. Anything may happen, good or bad, he does not change his mood. A conservative system, which always goes straight to its attractor, its point of rest, may still be dangerous because anger may still accumulate and in a sudden outburst, he/she makes a radical move and shifts to a new field of attraction. The transition may have aspects of a *catastrophic* change.

Since chaotic systems are deterministic, their future behaviour may in principle be calculated if one has total information about the initial condition.

In the framework of language behaviour we may consider a grammar as a deterministic dynamical system (e.g. a generative grammar). Now, if at some point from which we start the production, e.g., of a sentence or a noun-phrase, there lies some insecurity about the type of category or rule to apply, and if the system reacts strongly at this insecurity, the deterministic system may become incalculable. This can happen under two conditions:

(1) The generative process is not only a rewriting of symbol-chains, it also has to rewrite or copy the cognitive content attached to the labels; i.e. the syntactic device is also a semantic one, syntax is *not* autonomous in relation to semantics; in this case one must consider the fact that the contours of semantic units and processes are always vague, i.e. basically insecure.

(2) There is a transfer of syntactic processes from one system to the other, thus we must introduce a secondary copying-process involving different systems. This is the case in the dialogue where the listener must reconstruct the structure of the utterance of a speaker.

In both cases perturbations and insecurities are unavoidable. However, the chaotic outcome only becomes apparent if several such processes which introduce insecurities are added, i.e. if iteration occurs.

One interesting result of chaos theory is that under specific control the final outcome is independent from the input, but may correspond to some universal fractal pattern, i.e. the specific information of the input is lost, but the system constructs a pattern which is an autonomous result of the structure of the system itself and therefore independent of the input. One may call such a system informationally closed and self-referential (or 'autopoetic'). In relation to a language, these conditions impose severe restrictions on complexity, which could be a major characteristic of human languages as compared with animal languages (e.g. that of gorillas). One possible reason why other species that have developed communicative techniques do not show the complex constructive language behaviour of humans may be due to the fact that they cannot control the chaotic outcomes. We may ask, therefore, how human language overcomes this restriction. It must have a technique of chaos *control* which allows it to go beyond simple utterances, like those of a child in its two-word stage. My hypothesis is that semantic space and semantic scales allow the control of the iterated constructions in complex sentences; without this low-dimensional representational background, the formal syntactic devices would be lost in chaos.

Large language communities (just 30 speakers establish a net of 435 pairs of speakers and listeners and twice as many possible pathways of communication) must control another source of chaos, the disturbed mapping from one cognitive system to the other and the iteration of this mapping. In a language community with millions of speakers, hundreds of dialect- and sociolect-areas, a diversity of styles, registers, and topic-specific domains the mapping of individual communicative acts into different minds and memories should destroy all those patterns which do not have self-regulatory power. In current theories of language the enigma of 'language', 'collective competence', 'inter-individual meaning' is hidden behind a vague concept of 'abstraction'. In reality we do not know how these collective phenomena are possible. The chaotic dynamics of language remains a hidden background, as long as we presuppose such entities as 'language systems' and do not ask how it can be the stable product of billions of (basically insecure) interactions, of probabilistic memory-traces and variable co-operative processes. Without the help of a very specific dynamics the addition of insecurities in the mapping from one mind to the other would strictly exclude the intuitively felt[1] unity of

[1] This 'feeling' is in many cases itself a social construct which only appears under specific historical and political conditions.

language.

1.2. Diffusive and synergetic processes

The fundamental problem of a thermodynamic field is its universal trend towards a loss of information, given by the second law of thermodynamics. Not only language but all biological systems and many chemical and physical systems may, however, under specific ecological conditions, increase information. They are in an equilibrium state far from thermodynamic equilibrium.

In languages we may observe losses, e.g. a loss of vocabulary, a loss of unstressed syllables, etc. The interesting fact is that these losses are compensated for by lexical and grammatical innovations. In critical situations, e.g. in pidgins, but also in first-language acquisition, a tremendous amount of information gain is observed. The balance of a general process of loss of information (augmentation of disorder) and a specific process of information gain under well-defined ecological conditions is the main topic of the theory of dissipative structures and synergetics. The key notions are:

- a flow of information (and energy related to it) between the system and its environment,
- a catalytic component which can transform input information into output information without being affected/changed by this transformation,
- a process of self-organisation by which certain modes (slaving modes) win and many others are eliminated. This can be called stabilisation by selection. The synergetic processes described by H. Haken are paradigmatic examples of such processes.

In language, synergetic processes occur on several levels:

- In the brain we observe dissipative patterns of neural activation. The neural net models exploit the propagation of inputs in a network.
- In the domain of face-to-face communication we acknowledge the dissipation of content (e.g. opinions) and language patterns (words, styles).
- In the linguistic community the diffusion of language change and the effects of language contact may be interpreted as dissipative processes.

Later, I shall give an example of metaphorical dissipation as a basic device of semantic organisation, thus remodelling proposals made by Lakoff and Johnson (1981).

1.3. Fractal patterns and basic categories in language

The dominating view of categories in linguistics presupposes that the boundaries of a category are either clear-cut and smooth, as in lexical field theory, or centred with vague borderlines as in prototype-theory. In Lakoff's book about categories (Lakoff 1987) the dominant metaphor for a category is the container. A container may be represented in three dimensions as a cylinder with an opening above or in two dimensions by a circle which separates inside and outside. Figure 1 shows these two 'metaphors'.

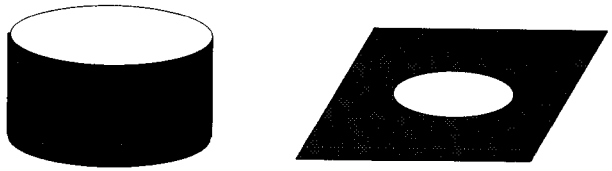

Figure 1. The container metaphor

Now the bounding cannot only be weak, e.g. if a critical value of the distance to the centre defines the boundary, but it can also change its dimension. Instead of being a limiting line (with the ends joined), it can have a fractal character, i.e. the dimension may vary between dim. 1 (line) and dim. 2 (surface).

A typical case has been analysed by Mandelbrot (1977). A medieval town typically has an external delimitation which is similar to a circle. This form is the optimal frontier if a maximum of houses (citizens) has to be concentrated inside the city walls. The length of the wall is critical for defence, as the density of defenders decreases if the wall becomes longer. The city is under these specific criteria a typical and optimal container. If defence becomes less important or may be guaranteed by the control of a larger territory, the growth of the city destroys the delimiting line (goes beyond, 'eats it up') and a fractal frontier appears. This was observed, e.g., in Paris in the 17th century. After a period of steady growth without external constraints, the fringes of the city mixed with surrounding green areas. Public and private parks appeared in the city and finally the dividing line between buildings (city) and rural environment (green) was totally disrupted and was in contact with virtually every inhabited place in the whole area, its dimension took a value between dim = 1 and dim. = 2 (it became a fractal, i.e. a

fraction like 1/2, 1.23456 etc.). I shall be concerned with the basic question of whether linguistic boundaries may be fractal. If the answer is yes, what are the consequences for linguistic theory?

In the following chapters the intuitive notions outlined above are elaborated in relation to linguistic description.

2. Chaotic attractors in nominal composition and in the semantic organisation of non-phrases

A first dynamic model of nominal composition based on catastrophe theory was proposed in Wildgen (1982). The hypothesis that nominal composition shows a type of 'ordered chaos' was also put forward by M.E. Ryder (1994), where 'ordered chaos' is opposed to 'rule-governed systems' (ibid.: 1). The term 'chaos' in her book is, however, only a metaphor for systems with 'incompletely definable input' and 'apparently unpredictable output' (ibid.: 1, 5). In the conclusion of the analysis which dispenses totally with the techniques of chaos-theory Ryder writes: "It [this work] demonstrates that language users are constrained to a kind of ordered chaos, and that it is possible to define what the bounds of that chaos are" (ibid.: 199). In my book from 1994, *Process, Image, and Meaning,* I proposed a more specific cognitive interpretation of chaotic attractors and their control in nominal composition (Wildgen 1994: 115-117). Some of these ideas will be taken up in this chapter.

A major fact in noun + noun compounds is the deletion of underlying predicates or relational schemata. Levi (1978) calls them 'recoverable deleted predicates'. But the situation is more complicated than her transformational account makes us believe. If we consider the two lists of examples below (cf. ibid.: 52), we can, for every compound, imagine a sentence or a noun phrase which is a paraphrase of the compound and in which a predicate (a verb, a preposition) appears.

A concrete empirical test would immediately show that for every compound different 'predicates' (verbs, prepositions) may be 'recovered'. The recoverability, and even the existence of recoverable predicates is a methodological construct. In reality a huge indeterminacy, vaguely limited by selections inherent in the nominal constituents, is given.

The first constituent in the nominal compound, N_1, allows for a certain class of verbs (such that N_1 is the subject, object, indirect object or adverbial

Table 1
Different underlying relations in similar compounds (Levi 1978)

tree nursery	FOR	bedclothes	FOR
tree house	IN	bedpan	IN
tree spraying	OF	bedpost	OF
tree branches	ON	bedsore	FROM
		bedroom	AROUND

complement to the verb), and N_2 also has such a class of possible predicates. Thus, the morphological construction $N_1 + N_2$ can activate a huge number of possible predicates. The search for *one* stable reading could be described as a chaotic orbit in the space of possible predicates (e.g. verbs). If these are arranged on a plane, the orbit of the 'search attractor' goes through almost all points of the plane as Figure 2 shows.

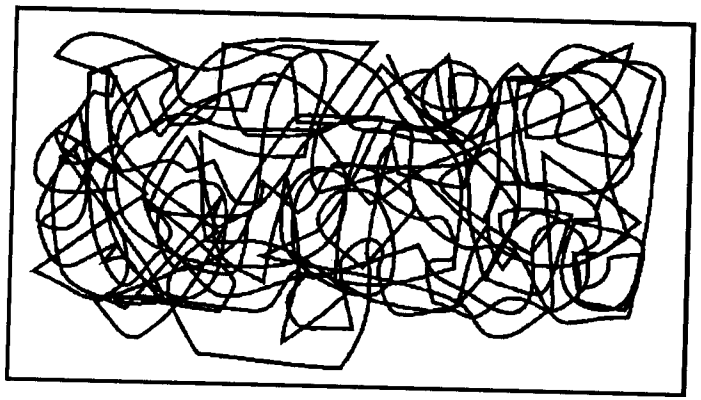

Figure 2. The product of the possible links of N_1 and N_2 and a chaotic itinerary in this plane

In a neurolinguistic context we could say that the brain has simultaneously access to almost all of the possible predicates, it is in a state of 'predicate alert'. Freeman (1991) has shown that the olfactory bulb is in such a state just before the recognition of a smell.

On the other hand, there are very basic types of predicates which have a high probability of selection due to the structural stability of the process

which they conceptualise. These are called 'semantic archetypes' in Wildgen (1982 and 1985). These highly ordered and stable types of predicates can function as chaos-controllers (cf. Ditto and Pecora, 1993), they allow the very rapid selection of one or several 'recoverable' predicates and reduce the initial indeterminacy of a noun + noun compound.

The above-mentioned compounds are lexicalised, i.e. one or few specific meanings have been fixed in the history of the compound, it functions almost like a simplex noun (its compositionality is 'frozen'). In nonce compounds the context of use and pragmatic principles disambiguate the readings left by the reduction of the chaotic field of alternative readings. In general we can distinguish three phases in the determination of meaning of an unknown noun + noun compound.

First level: The possible predicates fitting N_1 and N_2 are *activated.*

Second level: A chaotic orbit explores all the possible links between the sets of predicates triggered by N_1 and N_2 and a generalised frame for adjacent elements.

Third level: The chaotic attractor is reduced to a stable one and selects one or several archetypal schemata (the universally recoverable predicates).

Fourth level: Lexicalisation or contextual processing reduces the alternatives left to one reading (or very few). The amount of cognitive analysis (see above) and rule-governed, language-specific processing varies from one language to another. In a similar way the relevance of composition itself as a basic means of vocabulary growth and contextual adaptation is variable.

These processes are not limited to nominal composition, possessives show a similar indeterminacy.

Example: The President's table.

a. the table the President owns,

b. the table at which the President dines,

c. many other interpretations which link 'table' and 'President'.

Another domain of similar indeterminacy are the so-called non-predicate noun phrases. The following list of examples is taken from Levi (1978: 3).

the rural policeman,
the logical fallacy,
the electrical engineer,
the solar generator.

These noun phrases cannot be considered as paraphrases of simple sentences like:

- the policeman is rural

- the engineer is electrical[2], etc.

If the head noun changes, the interpretation of the 'deleted predicate' changes too:

- musical clock = clock that *produces* music
- musical criticism = criticism of music / *referring* to music.
- musical talent = talent *in the domain* of music.

From these short overviews it follows that the semanticist has to explain both the basic indeterminacy of these constructions and the very fast reduction to one reading in specific utterance situations.

3. A basic challenge: does recursiveness in the noun phrase have a chaotic attractor?

3.1. A linear network analysis of the noun phrase

In the following I shall first investigate the fundamental nature of syntactic recursiveness in noun phrases, and then seek to identify the type of dynamic system that corresponds to recursive syntactic (and morphological) structures. My strategy will be to choose a descriptive device which is as linear as possible, otherwise the underlying problem becomes obscured.

The most linear device is a simple transition network (a finite state automaton, or a generative grammar of type 3 in the Chomsky hierarchy). For the purpose of empirically more adequate modelling the augmented transition networks (ATN) have been developed which link different partial linear networks together. Since we shall only consider the sub-network for nominal phrases, the difference between augmented and non-augmented transition networks does not affect our present argument. We start from a specific network proposed by Winograd (1983: chapter 5). A version of his network has several (recursive) loops on the node which precedes the noun (cf. Figure 3) and several loops on the node (c) for modifiers standing after the noun.

Examples: The **big** (Adj.) **three** (Number) universities (Noun),
The **stone** (Noun) **supporting** (Verb) pillar (Noun),
The **hatch** (Noun) **cover** (Noun) **support** (Noun) **strut** (Noun) holder (Noun).

[2] If a metaphorical use is made of 'electrical engineer', as in 'electrically charged engineer', the paraphrase is possible.

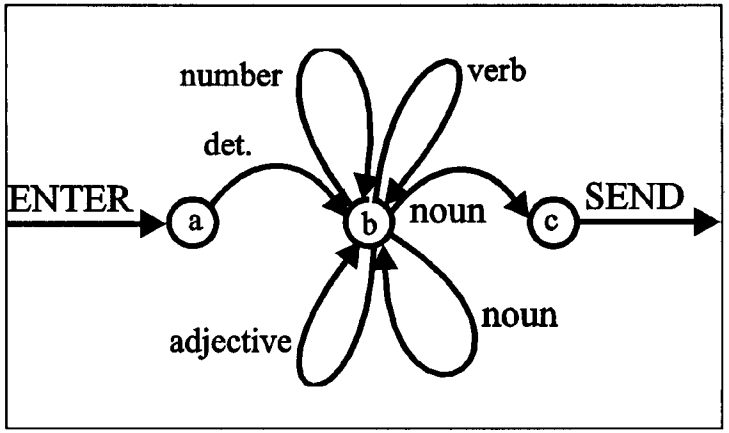

Figure 3. The network of modifiers standing before the noun

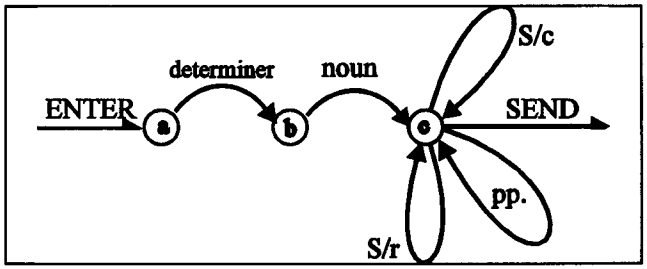

Figure 4. Elaboration of the postnominal network *(S/c* = subordinate construction with participle; *S/r* = relative clause)

Examples: S/c: The architect **having lunch** in the portico.
S/r: The answer **that they were looking for.**

In general we have two positions in which recursive transitions can occur. In the first position, our simplified model distinguishes four different loops, in the second position three loops.

If the syntactic parsing of the noun phrase makes use of loops, we must ask what the semantic correlate of such loops is. The principle of linearity does not apply to content forms, and even if different modifiers have the same category, e.g. Adjective, Verb, Noun, Number, etc., their impact on the

content of the noun phrase is nevertheless different with every new item. In order to make the argument more concrete I shall discuss the case of adjectives modifying the noun in a prenominal position. This discussion only explains the underlying problem; in order to solve it we need new empirical techniques which are able to analyse the semantic effects of consecutive modifications of a noun.

3.2. Recursive application of nominal modifiers

Three basic cases may be distinguished:
- application of the same modifier,
- application of different modifiers of the same category,
- application of different modifiers of different categories.

3.2.1. Recursive application of the same modifier

This case is rather marginal. We can say:
A big, big hamburger,
A beautiful, beautiful painting,
A nice, nice girl.
In these examples, we can observe how almost independently of the content of the modifier a general meaning like augmentation is approximated. This observation fits well with a general theory of feedback dynamics in two-dimensional systems. Peitgen et al. (1992: 30ff.) show how a multiple Xerox-machine with linear transformations and a collage of its products loses the initial information and approaches a common (fractal) attractor which only mirrors the feedback function. We can say that the multiple iteration of the same content loses this content and reveals an underlying (universal) mechanism. Thus a specific feedback copying machine uniformly produces the Sierpinski triangle (cf. Peitgen et al. 1992: 98-102).

3.2.2. Recursive application of different modifiers of the same category

Insofar as the category which is preserved in the feedback loop has some well-defined content (is a semantic category), the results of our analysis above will also apply in the case of different modifiers. This means that if a series of adjectives of the same type (e.g. evaluative adjectives, substance adjectives, etc.) are applied, a kind of uniform semantic effect is obtained in

which the specific contribution of the single adjectives is lost. If this result is not intended, the modifiers must be ordered on a scale which controls their successive application. A scale which is immediately evident is the iconic interpretation of the linear order (in terms of linear distance). The basic rule would be that those adjectives which are semantically very close to the noun (to the apprehension of its content) stand at a smaller distance. If the noun refers to a concrete object, the order established by Seiler (1975: 25) obtains:

Die herrlichen(wonderful) grünen(green) hölzernen(wooden) Kugeln(balls)
affective/evaluative > colour > material (adjective) noun

The linear distance corresponds to a kind of epistemic distance. The material adjectives contribute to objective knowledge, the colour adjectives are halfway between subjective and objective, and affective adjectives are clearly subjective.

As an initial result, one can say that the effect of recursive modification, the loss of input information, is balanced by an iconic order imposed on the successive applications of the feedback process.

3.2.3. Recursive application of different modifiers of different categories

One can go beyond this iconic ordering and define a theoretical scale like the one called 'determination' by Seiler, on which all pre- (and eventually all post-) nominal categories are ordered. The reason why prenominal and post-nominal modifiers could be ordered on *one* scale is that the order relative to the head is variable across languages. A less radical solution would be to classify the modifiers into:
- determiners,
- non-restrictive modifiers,
- restrictive modifiers,
- (valence bound) complements.

Similar solutions are proposed in the X-bar schema used in different types of generative grammar. The major point is, however, not the specific mode of classification of modifiers or determiners in the prenominal or postnominal position. The central point is the semantic interpretation of recursiveness. Either the syntactic recursiveness does *not* map into semantic recursiveness (if iconic or semantic scales control the process) or the chaotic attractor must be systematically analysed.

3.3. Some general considerations concerning endocentric constructions and the X-bar principle

In this section I will bring together the X-bar hypothesis (which is a generalisation of Bloomfield's analysis of endocentric constructions) and the concept of a generalised copying apparatus discussed in Peitgen et al. (1992). Our major concern is the possibility or even the probability of a chaotic result with this type of mechanism.

Noun phrases are a domain in which the constituent structure is highly branched. Starting with the so-called *X-bar*-hypothesis, the following assumptions can be made:

a. The basic *noun* is the head of the endocentric noun phrase.
b. Further specifiers can occur to the left and to the right of the noun phrase. Their number is (theoretically) not restricted but their order is subjected to semantic and combinatorial constraints.
c. A specific type which often occupies an extreme position in the sequential array is called the *determiner*.
d. It is possible for more than one constituent to occupy the same step, i.e. some constituents do not affect the index. Thus even if the index is normally finite and small, say three (3), an infinite number of constituents could appear on this scale.

If the typologically determined ante- and postposition of adjuncts is ignored, three basic questions must be answered:

- What are the dynamics of the underlying recursiveness?
- What principles could govern the appearance of singularities on this scale, cf. (d) ? Why do some of the adjuncts have *no* effect on the X-bar level?
- What does syntactic recursiveness mean in semantic terms?

The current arguments developed in generative linguistics offer no answer to these questions; they only show that the X-bar hypothesis could fit the data; but many hypotheses have fitted the data since Bloomfield formally introduced the notion of an endocentric construction.

If we assume, as cognitive semantics does, that semantic representations have some spatial or topological character, endocentric constructions must be interpreted as a type of feedback dynamics. A copying apparatus (or a system of video feedback), which at every turn reproduces the input and possibly adds some modification to it, is a good approximation of such a device. It can, for example, simply enlarge or reduce the picture. But the feedback

mechanism can also rotate or skew the original. If non-linear transformations are allowed for, complicated results are obtained which in most cases have chaos as the final outcome (see Peitgen et al. 1992: chapter 1). Since recursive processes in sentence formation are quantitatively restricted and are not an important feature of everyday language, the chaotic outcome is more of a theoretical possibility which has to be taken into account. Nevertheless, I assume that the probability of multiple ambiguity increases rapidly if recursive patterns are generated. Remembering the process of making copies, one can imagine that every step of the feedback machine introduces linear and possibly non-linear changes. The domains of semantic space which represent a meaning shrink, grow, are deformed and interact with one another. If Chomsky admired the wonderful creativity of recursive, self-similar processes, he did not imagine the effect such processes have on the underlying semantics, and their semantic spaces. Parallel to the chaos which appears in other natural feedback systems, the following deformations can be assumed:

- the possibility of ambiguous patterns grows rapidly,
- the feedback mechanism deforms the meaning of single constituents,
- the semantic space becomes extremely heterogeneous as every operation adds or modifies semantic parameters.

It is typical of noun phrases that a specific choice is made from the possible expansions, i.e. the structural density of constituent trees is low and becomes lower from step to step (as the theoretical possibilities grow very rapidly). This basic observation shows that the growth of noun phrases follows a chaotic rather than a crystalline pattern.[3]

The chaotic structure is due to three major features:

1. Density decays with the radius of the structure; the pattern accumulates more and more lacunas (see Mandelbrot 1991: 151).
2. The structure is basically self-similar and scale invariant (this is the central idea of the X-bar schema).
3. The repetition of the branching operation introduces changes, so that the interpretative result of the operation becomes more and more

[3] The contrast between general productivity and a very selective use of possible patterns is the basis of the hypothesis which assumes that the loss of many innate patterns is the source of the observed asymmetries. This is a misconception. A much more general process of local self-organisation can explain the lack of crystalline regularity (the parallelism to regularity in nature forbids the reference to genetic controls).

insecure and stochastic. It can finally become totally independent of the input; i.e. the receiver builds his interpretation of the received utterance only on the basis of his internal devices.

The analysis of endocentric constructions presented in this section sheds some light on irregularity in syntax based on very general laws, i.e. on mechanisms of deterministic chaos. If we consider syntactic creativity to be a basic feature of human languages, as Chomsky does, we must also consider the consequences of this creativity and look for the conditions of stability or the criteria of tolerance of the chaotic outcomes of such creativity.

Further empirical and experimental research must test these predictions. If we consider current syntactic models, it seems like a miracle that the linguistic system should not show chaos and that the actual restrictions on recursive structures should be a pure phenomenon of 'performance'. If syntax shows order, this is not because there are some God-given rules, principles etc. The basic problem is more one of how a system like language can avoid or at least restrain the chaos which is the normal outcome in self-referential dynamic systems.

4. Metaphors on their journey into chaos

'Love is a journey' is one of Lakoff's favourite metaphors and metaphors have been his love since 1980. But where does the journey of metaphor-semantics end - in chaos?

Metaphors, in the sense of Lakoff and Johnson (1981), are basically mappings from one semantic domain to the other, from a source to a target, and the basic formula: A is B shows clearly the nature of this process. As Lakoff does not subscribe to Chomsky's axiom of autonomy of a syntactic (linear) component, he has to acknowledge that this mapping is one between spatial (multidimensional) entities: moreover, the metaphorical mapping is by definition partial and it is not even clear what the partial basis of the mapping is. In terms of a copying machine this means that there are strong factors of deformation involved in every mapping. One can, therefore, foresee that the metaphorical process reaches chaos after a few steps (two or three). In fact the metaphors enumerated by Lakoff and his co-workers are not recursive and have an extremely low degree of compositionality.

Now, if the chaotic outcome which should be the case given the explanation of metaphors as a mapping does not occur, this shows that the fundamental explication of metaphors is perhaps mistaken. I would like to propose another theoretical account in terms of diffusion and synergetic self-organisation. Instead of a mapping we assume a process of diffusion by similarity (metaphor) or contiguity (metonymy). For this purpose we presuppose that meaning in the adult behaves similarly to meaning in children who learn their first words; it has a natural tendency to infect all neighbouring percepts and experiences (neighbours in terms of the mind = metaphorical neighbours, neighbours in terms of perceived/experienced world = metonymical neighbours). This 'natural', non-caused process is then channelled by specific conditions of the growth of metaphorical and metonymical meanings and by conditions of their stability (repeatability, learnability).

4.1. Semantic vagueness and variability

In semantics two types of structure and variability can be observed.

a. If k independent semantic features are assumed, a semantic space with k dimensions and k weights w_i on these dimensions can be constructed. These weights, which have values between 1 and 0, can fluctuate. If a weight is zero, the feature (the dimension of the semantic space) is irrelevant for the item which is analysed.

Example 1: The semantic description of containers by Labov (1978). Let us assume the following description for the meaning of 'bowl':

- dimension 1: diameter; weight w_1,
- dimension 2: height; weight w_2,
- dimension 3: existence of a handle; weight w_3,
- dimension 4: use (food - non-food); weight w_4,
- dimension 5: material; weight w_5.

In a given context of utterance, dimension 5 could be irrelevant and the weight of dimension 4 could be dominant.

b. A centre (attractor) and a periphery (tending towards this centre) can be defined for every space. The centre is called prototype, the periphery has a radial structure (cf. Lakoff 1987: 83ff. and chapter 6). We can distinguish three scenarios of fluctuation:

- The variance is extremely damped, and motion goes almost immediately to the centre; this would correspond to a categorical behaviour.
- The fluctuations have some strength and it takes some time until the centre is reached.

- The motion is chaotic, it almost fills the field which is surrounded by a line of saddles.

The fluctuations in the second domain can be called *micro semantic*; they are normally too small to be even remarked upon in descriptive semantics, but for a brain-model of word semantics they are probably the basic phenomenon (see Freeman 1991). The fluctuations in the first domain are either immediately damped and therefore unobservable or they are stronger than the force of the attractor and produce ambiguities and changes in meaning.

In the set of dimensions, there are many clusters of dimensions related to each other. Two basic types of clusters can be observed:

a. Clustering by similarity. The similarity can be measured if we relate the different dimensions to an underlying low-dimensional space on which they have different weights. Osgood proposed such a model for connotational meaning and called the underlying (deep) dimensions:
   E = evaluation (good - bad)
   P = potency (strong - weak)
   A = activity (active - passive)

b. Clusters due to spatial relatedness (in a general sense including social and imagined spaces). The parts of an organic whole are strongly interrelated as specific topological and functional relations hold. Examples:
   - geometrical objects and corners, lines, surfaces of these objects,
   - the body and body parts (cf. partinomies),
   - groups and members of the group,
   - organisations, specific institutions, their employees, etc.

Clusters of type (a) can be called analogical (or metaphorical) and clusters of type (b) metonymical. In such a system of semantically interlaced items the processes of dissipation are channelled, i.e. we can foresee (at a short distance) how a meaning will evolve if changes of type (b) or type (a) become sufficiently large. As the general dynamics are high-dimensional and normally chaotic, the channelling under the conditions (a) and (b) can only achieve a low degree of order, i.e. the dissipative processes allow a stable control only for a very few steps. In the next section I shall show that this qualitative prediction holds for the domains described by Lakoff and others.

4.2. Metaphors and metonymies as diffusive processes of meaning

In standard semantics a linguistic expression is directly mapped onto one or more semantic representations. However, Lakoff and Johnson's analyses (1981) showed that the interpretation may be indirect via metaphor or metonymy. Thus the sentences:

1. argument is war (metaphor)
2. the part stands for the whole (metonymy)

define a type of semantic transition which can be applied to many words and utterances which fit (by analogy) both arguments of the metaphorical/ metonymical relation (cf. ibid.: 4):

metaphor: *argument is war*
- a. John's *claims* are *indefensible*
- b. His *criticisms* were right on *target*
- c. He *shot down* all my *arguments*

metonymy: *the part* for *the whole*
- d. We don't hire *longhairs*
- e. The Giants need a *stronger arm* in the right field

Examples (a)-(c) are from Lakoff and Johnson (1981: 4); (d)-(e) from (ibid.: 38). In (d) the literal meaning can be inferred from A (part) and from the metonymical expression 'A for B'. The implicit constituent in B could be 'men' (with long hair) in (d) and 'a football player' in (e). If one considers the list of all metaphors mentioned in Lakoff and Johnson, one sees that their relational networks are very shallow. Almost all metaphors have relational length 1; examples for a relational net of length 2 are (3) and (4):

3. field ← war ← love
   war is a field / love is war
4. path ← journey ← argument
   a journey defines a path / an argument is a journey

In some cases the relation is transitive; thus in (3) one could deduce (by transitivity) 'love is a field' and in (4) 'argument is a path'. If we inspect the single networks which appear in Lakoff and Johnson's analysis, we can formally distinguish two basic types:

a. Those metaphors (A, B) where *more* fillers for B are mapped on *one* filler of A. Examples:

Table 2
Shape of a metaphorical network (A is dominant)

A	B	
ideas	[- objects	[- commodities
are	[- organisms (people, plants]	[- resources
	[- products	[- fashions
		[- light sources
N(A) = 1	N(B) = 7	
love	[- force	[- madness
is (a)	[- patient	[- magic
		[- war
N(A) = 1	N(B) = 5	

b. Those metaphors (A, B) where more fillers of A are mapped onto *one* filler of B:

Table 3
Shape of a metaphorical network (B is dominant)

A	B
vision	is a **field**
action	
event	
activity	
state	
N(A) = 5	N(B) = 1

These metaphors are called 'orientational' and they also include spatial adverbs like: *up, behind, ahead, down* as fillers of A and rather abstract terms as fillers of B: *control, consciousness, life, health, happy/sad, status, good/bad, rational/emotional.*

These two cases of rich networks can be interpreted as the poles of a scale where abstract entities are on the left-hand side (they are rather few) and very general spatial categories are on the right-hand side. In the middle we find basic level terms (relative to the scale of metaphorical relations).

Table 4 shows this restructured scale of metaphorical transitions.

Table 4
Scale of metaphorical transitions

abstract terms (A)	*basic level terms (B)*	*spatial category (C)*
idea	building, light-source, organism	field
love	commodity, limb, patient	up/down
argument	container, machine, product	behind/ahead
discourse	fashion, madness, resource	
mind	force, magic, seeing	
time	game, money, sending	
understanding	light-medium, object, war	

My interpretation of this result is that there is an underlying topology of the semantic space which is rooted in general space-categories (C). These are, however, perceived through concrete objects and qualities (B). The interpretation of abstract notions is only secondarily related to spatial categories. One remarkable result of the research by Lakoff and Johnson is that semantic space has as its immediate basis a body-centred and body-orientated experience of ambient space. This also explains the non-basic character of purely spatial distinctions (C).

Some of Lakoff and Johnson's results have been, however, basic knowledge in gestalt psychology, especially in 'attribution theory', since the fifties.[4] The body-periphery topology, which was already a constitutive part of Lewin's topological psychology in the thirties, could be elaborated by further subdivisions such as: grasp-distance, shout-distance, and locomotion- distance, which stratify the body-centred space. What is new in Lakoff and Johnson (1981) is the role played by locutions and proverbs like: *time is money, argument is war.* Since only a small number of the examples for metaphors in Lakoff and Johnson refer to such frequent and very convincing

[4] In Wildgen (1982, 1985) the level of topological semantics was projected onto a field called 'attribution dynamics' (see Wildgen, 1982: 25ff. and 1985: 104ff., 117ff.).

locutions I presume that the phenomenon of metaphorical interpretation has different sources:

a. The orientational metaphors are rooted in non-linguistic cognition (complex perception and action programmes).
b. Metonymical processes apply general inductive procedures in perception, action and reasoning.
c. Further metaphorical relations (in the domain A-B in Table 4) exploit differences in semantic density in the sense of Thom (1978). The general rule says that expressions which are more concrete (have more semantic density) may replace less concrete ones if some basic similarities are given.

Finally there remains a subclass of metaphorical processes which have a symbolic character and have a regulative power in a specific society. The locutions 'time is money', 'argument is war' describe, in a quasi-symbolic manner, specific Western societies in which the economy plays a prominent role (individual performance, professional achievement, and social status based on wealth are valued), which have democratic institutions, and where the force of the body and violence are (partially) substituted by argument and communicative skills. The metaphorical power of these locutions is therefore taken from the fact that they stand for basic structures of a specific society and does not stem from a general cognitive capacity.[5]

5. The fractal nature of language

The fractal character of language is most obvious in its geographical and social distribution. Based on morphological considerations, Goethe had the basic intuition that "language is noise and smoke" (*Faust I*, verse 3457) and that "nobody understands the other, nobody thinks the same thing as others if he utters a word and a conversation, a reading triggers different sequences of thoughts in different persons" (translated from: Goethe, *Dichtung und Wahrheit*, book 16, p. 11).

[5] Cognitive semantics in the style of Lakoff follows the tradition of Chomsky's generative grammar, which assumes that language is the central cognitive skill and that it is in a certain sense self-contained. Although Lakoff criticizes the hypothesis of an independent syntax and language capacity, he goes even further and tries to explain cognition by the analysis of language.

In a contribution from 1983 (Wildgen 1983) I have already shown that the geographical distribution of words for 'ant' shows a fractal diversity of dialect-words (in the 'Wortatlas') and that the personal pronoun 'sich' (for oneself) in the "Deutscher Sprachatlas" has isoglosses (frontiers) which are fractal and areas which are almost filled by islands of special forms. The myth of a national language (and a competent native speaker) has obscured these insights which were patent at the end of the 19th century when the results of dialect-geography became known.[6]

Modern sociolinguistics, e.g. Labov's analysis of variation in an area of New York City, have given an even more fractal picture. Thus, the different floors of a department store show a social distribution of language and one can imagine that in the streets, in the subway and in many places the sociolects intersect and form a fractal pattern. Moreover, in simple face-to-face communication the rules of language behaviour may be the object of a kind of bargaining (this was shown by conversational analysis). In the case of the Puerto-Rican community in New York a systematic code-switching has been observed in which the sentence is built up in English and finished in Spanish (or, more precisely, in specific variants of these two types). The language community defined by a common language is no more a simply bordered container, it has a fractal borderline, which may change very quickly in time. Thus, Labov has shown that in juvenile groups dramatic changes in semiotic patterns (including language) can take place in the range of a few weeks or months. The 'language' as a whole is thus a fractal entity and the different languages can, therefore, contact along an almost infinite borderline. Some consequences for language contact and language change have been drawn in Bechert and Wildgen (1991).

Another domain of fractality concerns the basic linguistic categories themselves, such as categories in phonology, morphology, and syntax. Typological research shows that as the number of well-analysed languages increases, the traditionally accepted grammatical labels tend to disappear and a huge variety of different, although in a general sense similar, categories appear. If we assume for simplicity's sake a scale, e.g. of nouns, then the further comparison of languages tends to show many different intervals on this scale (as centres of a prototypical category). In the sense of Cantor the

[6] The philologists of this time were as disappointed by these facts as Chomskians today are 'disappointed' by sociolinguistic and psycholinguistic results which destroy their pet ideas.

line is cut in many different ways, such that intermediate holes appear. In Table 5 we give a simplified picture of a categorical scale and its fractions in different languages.

As the categories, e.g., of object-type/gender/animateness, etc. and case, person, number are not independent and are parts of a larger multi-dimensional field of grammatical specifications, one can imagine the amount of fractality which is present. This fractality is far from being dangerous, on the contrary it allows many contacts and transfers and thus explains the albeit imperfect but nevertheless effective mutual understanding between human beings.

Table 5
The 'Cantorisation' of a categorical scale like Noun in different langugaes

language	Noun	Adj.	Participle	Verb
L 1				
L 2				
L 3				
L 4				
L 5				

As a final provocation addressed to structuralism we may say that the fractal nature of language (which makes it independent of input information) is the real universal character of language and not some Cartesian blue-print, like universal grammar.

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VII. Literature