Dynamic semiotics (to appear in Semiotica)

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Introduction

In this paper I shall make a case for a dynamic semiotics. I list a set of phenomena that are difficult to understand in standard theories, and suggest a model borrowed from theories of complex dynamic systems. Since such theories rely on processes of self-organization that often defy analytical treatment, I use small computational models for assessing the empirical consequences of the theories.

Dynamic Models

The past decades have witnessed a growing interest in developing dynamic semiotic models.

Rene Thom's work (1983, 1989, 1990) on catastrophe theory was an inspiration for e.g. Jean Petitot (Petitot 1985, 1989, Petitot and Thom 1983), Per Aage Brandt (Brandt 1989) and Wolfgang Wildgen (Wildgen 1982, 1985, Wildgen and Mottron 1987), but a decade before Winfried Nöth had begun to explore dynamic systems models in several papers (Nöth 1975, 1983, 1989). Diachronic applications are hinted at in Lightfoot 1979 .

Another trend took inspiration from the new ideas flowing from studies of self-organizing and self-reproducing dynamic systems. The models included von Neumann's classical cellular automata (von Neumann 1966), neural nets (McClelland et al 1986), Lindenmayer grammars (Lindenmayer 1968) and ideas from artificial life (Langton 1989). In Langton and Shimohara 1997 one can find papers about self-organizing vocabularies and emergence of communication patterns. Altmann and Koch(1998) contains short introductions to some of the relevant theories.

Empirical work on language acquisition from a dynamic systems perspective can be found in Smith and Thelen (1993), the collection of papers in Hawkins and Gell-Mann (1992) discuss various linguistic issues from this point of view, and Duncker 1999 combines a dynamic systems methodology with computer aided corpus linguistics.

I have myself from time to time experimented with these new models: syntax and conversation structure (1994, catastrophe theory), communication processes (1996, learning cellular automata), logic (1995b, catastrophe theory), and genre formation (2000, genetic algorithms).

Enigmas

This section motivates the dynamic framework. I list four main questions that are difficult to answer in non-dynamic terms.

1. Stability and change: How can language maintain its complexity in view of the fact that this must be accomplished by millions of autonomous language users that neither have the power to control language nor the knowledge to plan non-destructive changes.
2. Truth and reality: Why does language contain circular definitions and paradoxes that are considered detrimental from a logical point of view?
3. Morphology and function: Why are utterances subject to several, concurrently working, principles of construction (e.g. pragmatic and syntactic)?
4. Efficiency of communication: Why does language contain ambiguities and support double-meanings if the purpose of communication is to transmit information from one place to another?

Stability and change

The worst problem is simply how language is possible at all! On the one hand, language is an extremely complex system as any linguist will attest to. On the other hand, the maintenance of language is distributed over millions of independent language users, and although language advisory committees exist for most languages, they have no power to control and plan language development. Why does language not fall apart in the absence of an efficient management?

A century ago Saussure introduced the concept of language system (langue) to capture the invariant complexity of language. Unfortunately, Saussure simultaneously defined it as a social phenomenon in opposition to the individual language usage. This created a conceptual gap between the global invariant features of language, and the local individual usage. Simultaneously, he introduced the opposition between diachrony and synchrony, where again only synchrony could be treated scientifically.

> Thus diachronic facts are individual facts. The alteration of a system takes place through events which not only lie outside it, but are isolated events and form no system among themselves. (Saussure 1993: 93)

These two gaps prevented linguistics from conceptualizing influences from usage to system, and from diachrony to synchrony, a very unfortunate situation since the synchronous language system seems to emerge from diachronic fluctuations of usage!

> [...]variation and fuzziness which so many linguists tried to ignore are quite often indications that changes are in progress. This insight is not, of course, entirely new, and the observation that changes involve periods of fluctuation occurs in several places in the literature[...]. (Aitchison 1995: 38)

This mode of development is unbelievable! To see this, imagine that users of Microsoft Word were allowed to switch a couple of bits in the code every time they used the system. After a couple of days of this treatment, the system would crash and become utterly useless. But not so with language. In fact, language even seems to thrive from these continuous small changes.

As Aitchison argues, this problem is not unique to Saussurean structuralism but is a general problem in most contemporary theory, including the generative tradition (competence versus performance).

If the system is a social invariant and usage covers individual variations, then what agency is responsible for maintaining and changing the language system? The question was posed by Winifried Nöth in an early paper (Nöth 1975) where language is seen as an open self-maintaining system that is not merely able to maintain the same steady state, but, faced with new demands, is also able to change its own rules and thereby create new steady states.

> This postulates a kind of feedback mechanism by which a grammar is, as it were, constantly catching up with its own output [...]. Former errors in linguistic performance have then to be accepted as part of the linguistic norm. The repeated revision of grammar according to the actual speech behavior corresponds to an open feedback control system with a variable desired state. (Nöth 1975: 228)

Nöth hypothesizes a 'linguistic consciousness of a speech community' that exerts a corrective force if the structural oppositions between the linguistic units are no longer maintained: the consciousness compares a desired state to the actual state of language usage ('speech acts'); and if there is a lack of intelligibility, a 'mechanism of language change' adds features to the language system. The language system itself can be disturbed by language contact or by the principle of economy (language users choose the easiest methods, e.g. drop endings) which again effects intelligibility, etc.

The problem is the nature of the agent of stability, the 'linguistic consciousness'? What is it? How can it perform measurements on such a complex and distributed phenomenon as human language? How can it efficiently execute changes of an object it is not able to control and whose rules it does not know?

The generative tradition addressed the problem of the stability of language and the physical existence of rules by postulating that most rule schemata are innate and that only certain parameter-settings are learned.

> Inside-out (IO) theories tend to rely on the maturation of innate structure, describing the adult form in great detail. The maturation of innately given rules or forms is primarily responsible for adult linguistic competence in the IO theories [...]; thus, these theories argue that the innate component of language is of primary importance, and the environment represents raw material which triggers the development of these innate forms. (Tucker and Hirsch-Pasek 1993: 360)

But this explanation runs into two major problems:

- It has not been possible to prove the physical existence of linguistic 'rules' in the brain or in the genome (although centers of language have been documented).
- Even if this were possible, the burden of explanation would just be shifted, because then we would need to explain how the linguistic genes were able to develop and become stable in the first place.

<u>Question:</u> How is it possible for an extremely complex system like language to come into being, to maintain its stability, and to change without falling apart, in view of the fact that it is distributed over millions of independent language users that ostensibly have neither the knowledge nor the practical means for controlling it?

<u>Truth and reality</u>

In some influential linguistic theories, language is assumed to have direct hooks into reality. Although the meaning of complex sentences may be calculated on the basis of simple sentences, young Wittgenstein believed that the simple sentences must correspond to the facts of the world by sharing the same logical form. Others, like Greimas, have assumed that certain elements of meaning correspond particularly closely to our senses (Greimas and Courtes 1979).

Common to these ideas is the notion that language must contain a set of basic elements which can be brought in correspondence with non-linguistic entities. Language must so to speak 'have a bottom', a set of lowest elements to which all meanings can be reduced, and which form an interface to the real knock-knock reality.

These ideas are very sensible if we view language as our means to communicate about the real world and to coordinate our actions there.

The problem is that the elements of such an interface have turned out to be very difficult to find (see e.g. Goddard 1998 for an ambitious attempt), and that very simple and commonplace manipulation of language, such as a lexical look-up, indicates that language is circular. We seem to never get out of language into reality. To see this, consider the sentence

(1) Phone the plumber!

If we repeat looking up the dictionary definition of a word, and selecting a word from the definition and looking that up, we often end in a cycle where a word recurs in its own definition.

If we lookup <u>Phone</u> we get (Concise Oxford Dictionary 1964) 'Phone: <u>telephone', </u>and, via <u>send</u> and <u>conveyance,</u> repeated lookups send us into a cycle where <u>convey</u> and <u>transport</u> keep defining each other:

(2) Convey: <u>transport</u>, carry; transmit (sound, smell, etc.)
(3) Transport: <u>convey</u> (person, goods, troops, baggage, etc.) from one place to another

How can a system with such vicious circles be useful for anything? But it grows worse: language contains paradoxes that philosophers like Bertrand Russell and Alfred Tarski considered so fatal that they wanted to forbid them.

Russell, for example, launched his theory of types in order to avoid the paradox implied in 'The class of classes that are not members of themselves', and another famous example is Tarski's analysis (Tarski 1944) of an equivalent of the paradoxical

(4) This sentence is false.

which is true if it is false, and conversely. Like Russell, Tarski prevents the paradox by postulating an opposition between (scientific) meta- and object languages and preventing meta-languages from describing themselves. 'This sentence is false' is written in a meta-language, and its subject 'this sentence' is a name of a sentence in an object-language, which just happens not to be there. If we violate these laws, we are caught in a cycle where the truth of a sentence entails its falsehood, which shortly afterwards entails it truth, etc. We see that some types of self-reference create unstable truth values: p ¬p p ¬p...

The occurrence of vicious circles and paradoxes in the semantics of natural languages is not predicted by standard theories of language. In fact, they falsify the predictions of logical conceptions of language, but being an empirical science, semiotics cannot follow in the foot-steps of Russell and Tarski and forbid facts that goes against theory. On the contrary, we have to invent a theory that predicts these phenomena.

This is the strategy followed by Gupta and Belnap (1993) for the case of paradoxes. What they do is to define a more general concept of truth than the standard one, a concept that covers the ‘normal’ cases as well as the ‘deviant’ ones. Their main point is that truth should be seen as a recursive process of continual revision. This process can have attractors, i.e. sets of states towards which truth moves given sufficiently long time. The attractor may consist of exactly one state (a fixed point) but may also consist of an oscillation between a set of states. Non-deviant sentences have truth-values that move towards a fixed point, deviant sentences have no fix point, but end in a limit-cycle.

Question: If language is our means to describe the world, to reason logically about it, and to coordinate our actions therein in a rational way, then why has it developed circular definitions and paradoxes?

Morphology and function

Many linguistic theories use more than one representation of sentence structure. For example, Valin and Lapolla (1997) uses two main representations, a predicate-argument tree-like structure plus an operator-projection, and Halliday 1994 lists three main organizing principles, the ideational, the interpersonal and the textual metafunctions.

The problem is not so much that there exist concurrently working constraints on utterance structure, but rather that it is difficult to judge whether this is a symptom of bad representations or whether it reflects real concurrency.

Consider for example a rewrite rule like

(1) $A \rightarrow B_1 \ldots B_n$

The rule states that the section of text categorized as ‘A’ can be divided into smaller contiguous pieces of text, each categorized as ‘B_i’.

However, this way of analyzing text does not predict the phenomenon of cohesion (Halliday and Hasan 1976). It may make precise predictions about the part-whole architecture of texts, but not about dependencies between previous and later pieces of text (anaphoric and thematic relations). Accounts of these phenomena must be added to the part-whole description. Typically, syntactic structures are used to define the way co-referential noun phrases are manifested, as in Chomsky’s work on government and binding (Chomsky 1993). However, in order to make these rules work, the grammar has to add indices to the noun phrases that represent their references. These indices are add-ons and do not follow from the part-whole analysis.

Question: why must utterances and texts be described by several, often unrelated, principles covering different aspects? Is it possible to have a theory that predicts the different aspects, and explains their interrelations?

Communication as signal transmission

According to Fiske 1990, two main communication models have been influential in the century, namely the conveyor tube model, and the interpretative model.

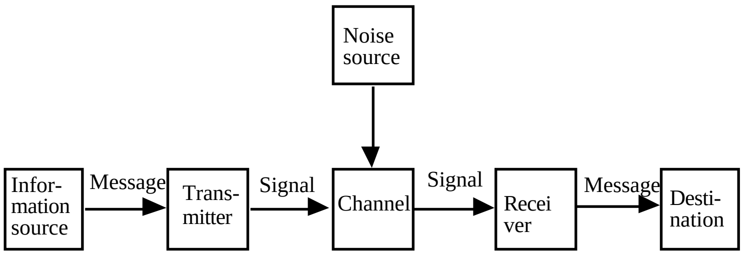


Fig. 3.1. The conveyor tube model

The conveyor tube variants (Fig. 3.1) originated in the works of Shannon and Weaver and are characterized by the following features:

- It is possible for an observer to compare the transmitted and received messages according to correctness and incorrectness.
- The source is active and defines the purpose of the message which is to effect changes in the destination and constructs the message with this purpose in mind.
- The channel is passive and unstructured.
- Communication means: new information is embedded into old information structures.

Componential semantics is associated with this model of communication. It sees complex meanings as being built out of simpler parts, the linking process in some way being controlled by some version of sentence structure (see e.g. Van Valin and LaPolla 1997). The speaker is in principle in control of the individual utterance and decides from scratch what to say and how to say it.

A basic problem of this model is the everyday experience that one is not always in control of what one says and that speakers often borrow the wordings of others to produce allusions, irony and double meanings (intertextuality). In addition, misunderstandings are the rule rather than the exception, in the sense that the addressee understands the signal in a different way than intended by the speaker and that meaning often has to be negotiated. Considered as a transmission channel, language is bad engineering.

Intertextuality means that utterances do <u>not</u> basically belong to the individual actor. They are 'rented':

> In Bakhtin's approach, we find an underlying claim that in some ways appears to be an intermediate one between the position that individuals own meaning and the position that no one owns meaning. ... In Bakhtin's view, users of language 'rent' meaning (...). In other words, 'I can mean what I say, but only indirectly, at a second remove, in the words I take and give back to the community according to the protocols it establishes (...)'. (Wertsch 1991: 85)

Utterances color one other and because of the interaction between spoken and non-spoken, (but present) utterances, communication is in principle multivoiced (Wertsch 1991: 55). In fact, most languages have developed special constructions, reported speech, indirect and hidden reported speech, for enabling speakers to 'infiltrate' each other's utterances.

In addition, language has developed other figures of speech, such as metaphors, litotes and hyperbels, that enable the same phenomenon, namely saying something else than is meant. This is indeed strange if the purpose of communication is to ensure that the message received is the same as the message sent!

Another problem is that the conveyor tube model does not predict the psychological effects of verbalizing thoughts or emotion. Thus, it does not predict the emotional effects of confessing a crime or a lie, nor can it account for the fact that conversational therapy works. Why on earth should the source experience relief from sending a signal to some destination?

<u>Question:</u> if communication has developed as a means for one person to influence another person, then why did language not develop efficient ways of transferring the message so that negotiations were the exception rather than the rule? Also, why does language offer so many ways of saying something else than is meant? The selection pressures ought to have eradicated these anomalies long ago. Finally, why can sending a signal to at destination cause emotional reactions in the source?

<u>3.5. Communication as cultural negotiation</u>

Whereas the conveyor tube model has been popular in the social and engineering sciences, the interpretative model flourishes in the human sciences. It is characterized by the following features:

- The observer cannot decide whether interpretations are correct or incorrect. He analyzes text and culture and discovers structural agreements.

- Every interpretation is receiver- and culture-dependent. There are no correct or incorrect transmissions, only different types of readings. We do not have direct access to reality.
- The destination is the active part, the source is less important.
- Communication means: production of meaning and interchange of meanings between text and culture. The emphasis is on structural influences.

The model is often used to analyze ‘hidden’ ideological meanings of texts, as in the works of Barthes, Levi Strauss and Fiske himself. The syntagmatic patterns of a text are interpreted as signifying paradigmatic, deep-seated oppositions in the culture. Because of the assumption that experience is always mediated by culture and signs, it has often constructivistic overtones to the effect that we have never any direct assess to reality.

Since interpretations are per definition biased by culture it makes no sense to argue which interpretation is the correct one, and therefore there is a tendency to value the activity of the interpreter higher than the intention of the source of the message.

However, it is not capable of accounting for the millions of mundane conversations about what to buy for dinner, where to put the piano, and who is going to do the dishes. Such interchanges cannot be explained as attempts to negotiate meanings with the surrounding culture or mediate its basic contradictions. They are there to get things done. Also, in many cases the intention of the sender is important and misunderstandings of this intention can have grave consequences. Some registers have developed systematic countermeasures against misunderstandings; for example, it is a convention of the maritime register that one should repeat messages received via VHF-radio in order to avoid misunderstandings. Furthermore, the model’s constructivist flavor that questions our access to reality is unable to explain why ship officers are taught to always verify instrument readings from independent sources. On the one hand, if there is no objective reality, then why take so much pains to get at it? On the other hand, if the officer forgets reality and trusts a faulty instrument, he and his crew may drown.

<u>Questions:</u> If the conveyor tube model is correct, why is communication not more efficient and unambiguous? Similarly, if the interpretative model is correct, then how can communication be of help in handling everyday affairs, and if there is no correct reading of a text, then why have registers developed countermeasures against misunderstandings?

Possible solutions

In this section I shall present a simple model that can account for some of the enigmas listed in the previous section but — naturally — has a new set of problems of its own.

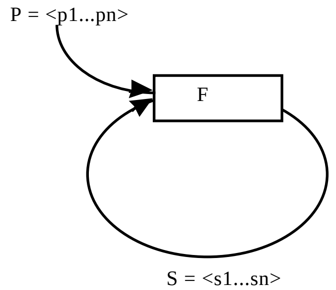


Fig. 4.1. $S_t = F(S_{t+1,} P)$. The basic model.

The model (Fig. 4.1) consists of a parameterized recursive function F that transforms a state S_t into a new state S_{t+1}, taking a set of parameters P = $p_1..p_n$. The states are themselves composed of a set of components $s_1 \ldots s_n$,

The model distinguishes between a <u>system</u>, represented by the S-state plus the next-state function F, and its <u>environment</u> represented by the P-parameters. I shall use the term <u>iterator</u> to denote at state that is recursively produced. Recursive models like Fig. 4.1 are very popular for describing the behavior of complex systems. It turns out that one can produce extremely complex S-states by means of very simple F's and P's. The most impressive example is the Mandelbrot set that is generated by a very simple recursive equation, namely

(1) $z = z^2 + c$

where c is a complex number. S consists of one component, z, P of one parameter c, and F of the simple operations of squaring and adding.

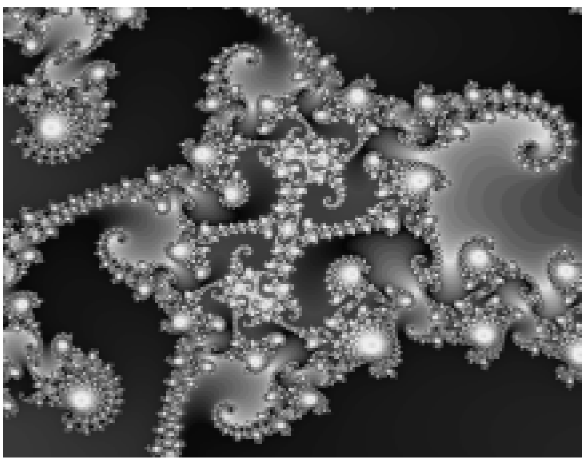


Fig. 4.2. Fraction of the Mandelbrot set.

How does the picture in Fig. 4.2 emerge? The explanation is the following: complex numbers consist of two components, the real and the imaginary component. Therefore they can be displayed as a point in a two-dimensional coordinate system, where the real component corresponds to the x-axis and the imaginary components is plotted along the y-axis.

We now keep z-values constant and vary c. As initial z-values we use the values 0 or c. We begin varying the c-values and recording the c-values for which the formula does not go towards infinity, i.e. whose trajectory stays within a finite space. Each c-value that does not cause the process to go towards infinity is plotted on our two dimensional grid, and the set of these points is the Mandelbrot set.

I have described the Mandelbrot set in some detail because it convincingly demonstrates that an incredible complexity can be generated by recursive use of an extremely simple formula. However, the Mandelbrot set is not unique in accomplishing this feat. Many other complicated fractals have simple recursive descriptions (e.g. the Rössler attractor), and specifications of self-organizing systems often follow the same pattern.

For example, recursive chemical reactions are called autocatalytic and crosscatalytic processes (Prigogine and Stenger 1984: 134). An autocatalytic process

> is one in which the presence of a product is required for its own synthesis. In other words, in order to produce the molecule X we must begin with a system already containing X. (Prigogine and Stenger 1984: 134)

An example is $A + 2X \rightarrow 3X$: in the presence of two molecules X, a molecule A is converted into a new molecule X. In the other type, crosscatalysis, an element X is produced from Y, and an element Y is produced from X.

Recursive reactions are interesting because they are the only ones that can produce chemical instability (Prigogine and Stenger 1984: 145), and in Prigogine’s theory, instability in its turn is a necessary prerequisite for self-organizing processes in systems far from equilibrium. Under the far-from-equilibrium condition, small fluctuations can create a new and more complex order in an unstable system.

In terms of the model Fig. 4.1, we can say that instability can be caused by changing the parameter set P that represents the boundary conditions. As a simple example, consider for example the so-called quadratic equation

(2) $x_t = ax_{t-1}(1-x_{t-1})$.

The equation behaves differently for different values of the a-parameter. For some value, its attractor is a limit-cycle with 2 values (Fig. 4.3). If a is increased, the limit-cycle doubles to 4, 8, 16 etc (Fig. 4.4 – 4.5). For a = 3.6

(Fig. 4.6) it has acquired a chaotic attractor (this actually happens at a = 3.5699456, the Feigenbaum point). This means that it keeps taking on new values that lie inside a confined space. Systems behaving in this way is said to bifurcate. It means that change of their parameters — their boundary conditions — change the attractor of the system.

One often says that the system bifurcates when it is perturbed, and I shall call the model in Fig. 4.1 for the perturbed recursion model.

Models of biological growth, like L-grammars (Lindenmayer 1968), and the biological theory of autopoiesis (Maturana and Varela 1980, 1992) are perturbed recursion models.

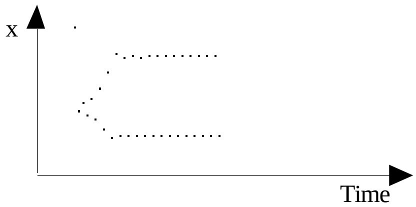


Fig. 4.3. Two periods, 3.4x(1-x)

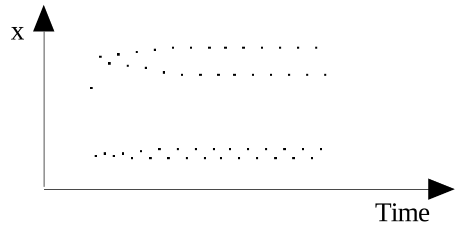


Fig. 4.4. Four periods. 3.5x(1-x)

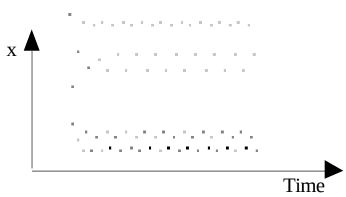


Fig. 4.5. Eight periods, 3.56x(1-x)

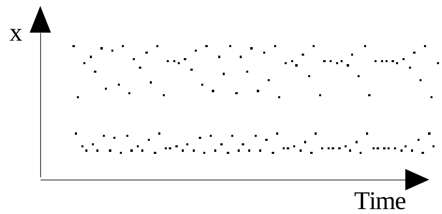


Fig. 4.6. Chaotic, 3.6x(1-x).

The theory of autopoiesis specifies the model further: it not only requires the new state to be manufactured from the old state, but in addition that the system maintains a physical boundary against the environment and itself makes the distinction between the parameters (the environment) and its own state. The argument is that since there is no a priori way to distinguish S and P, the system has to construct the difference itself. Furthermore, the biological system has to be closed to the environment. It forbids access to external agents lest its recursive loop should disintegrate; instead it lets the internal processes be perturbed by the environment in a controlled fashion. Finally, it must also itself evolve and reproduce the next-state function F. This means that F must be able to develop and repair itself.

The social sciences have also produced recursive models (Peters 1991 that discusses chaotic properties of economic recursion, Luhmann (1984, 86, 88, 90) advancing the notion of autopoiesis, and Giddens (1995) with his notion of structuration).

Luhmann in particular adds new conditions to the models: social and psychic systems need to be self-referential in order to maintain their complexity, and particularly stresses the process of reflexion that thematises the distinction between system and environment (but note the criticism in Mingers 1995). For a recursive account of communication processes, see Krippendorff 1994.

The actual existence of formal and physical systems of this kind opens a new avenue for dealing with the problems in Section “Stability and change”: how the complicated language system can develop, maintain its stability, and evolve, even if it is manifested by millions of concurrent and distributed acts of language usage. We know now by analysis and experiments that this is indeed possible with recursive systems with special properties. In fact, we know that we need not stipulate a large complex set of rule for generating a complex object. On the contrary, simple rules applied many times on their own output can create and maintain complexity.

Let us now review the questions with this knowledge.

Stability and change.

Question: How can distributed systems develop, maintain themselves, and change, although no single actor can control it?

Answer: as mentioned above, it is a fact that some perturbed recursion systems with simple rules can have very complicated attractors. It is also a fact that simple operations can maintain these attractors, and that small perturbations can change them. Such systems are called non-linear systems, since there is no linear proportion between the action and reaction. If language belongs to this type of system, it means that the rules of grammar books describe the attractors, but not necessarily the operations that ultimately produce the attractors — the order parameters in the sense of Haken (1998).

In such systems, no omnipotent management manipulating a complex rule set is necessary for developing, maintaining and changing the system. On the contrary, the basic reality of such systems is the millions concurrent simple processes using their own output as input. This is language usage.

The attractors are the invariant patterns that emerge from these uncountable interchanges when performed for sufficiently long time. Attractors thus formalize the notion of the language system.

Small changes of parameters can cause bifurcations that represent language change. Like in chemistry, language change is often heralded by fluctuations, i.e. variations (Labov 1972). This explains how variations can be the source of new invariants (= a new attractor).

Since language change is a change of attractors, and, as we shall see in the “Syntax” section, language usage can also be seen as a series of bifurcations, language change and language usage are not qualitatively different processes, but only differ in their rate and in the dimensions they influence. Even within language change, different rates can be observed: for example, vocabulary changes faster than phonology.

Truth and reality.

Question: Why does language contain vicious circles and paradoxes, and how can it still be useful for handling daily affairs in a rational way?

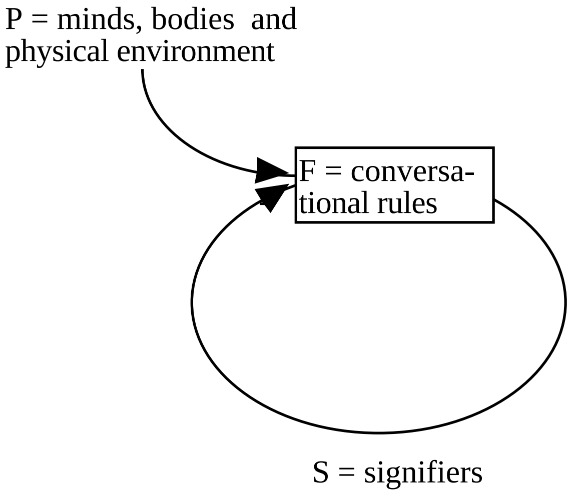


Fig. 4.7. Semiosis as perturbed recursion

Answer: in order to maintain complexity and avoid being invaded by the environment, many complex systems (such as biological ones) must maintain a boundary and themselves decide what is allowed to go through and how it is to interpreted. This means that the system must maintain a certain closure. In addition, if the system itself is responsible for its own maintenance and development, it needs to be able to refer to itself. However, the environment works as a control parameter and determines the actual choice of one of the options opened by the communicative system. Thus, circularity and paradoxes are the prices we have to pay for maintaining our own complexity.

According to Fig. 4.7, the basic mode of operation of language is a recursive loop where previous utterances give rise to new utterances. The environment does not enter into the communicative loop, only signs can do that. Like biological cells, communication is closed to its environment: the dishes themselves cannot take part of the conversation as to who is doing the dishes, only the word 'dish' (or pointing gestures to the dishes) can do that. Similarly, only the word 'piano', not the piano itself, enters the coordinating communication of two piano movers. Therefore only signs can be directly and systematically related to other signs. The environment acts as a control parameter for the perpetual production of signs out of new signs, and in this way can change the trajectory of sign-production. Thus, the influence of the environment upon semiosis is always indirect (cf. Posner 1993).

The activity of defining new signs is a part of the maintenance and development of semiotic systems, and since such systems are closed, signs can only be defined by means of other signs. This explains the necessity of vicious circles. But because there is an, albeit indirect, perturbation of semiosis, these circles do not impede the practical usefulness of language, and does not place us in a semiotic limbo. We just have to realize that interaction and communication does not consist in one system injecting items into another system, but rather in a mutual induction of bifurcations.

The occurrence of paradoxes is also predicted by the model. If semiosis is a closed system, then only semiosis can maintain and repair semiosis. And since, if something needs to be changed it is necessary to refer to it, language must contain the self-referential expressions that cause the paradoxes.

The treatment of paradoxes developed by Gupta and Belnap is in agreement with the model. Their idea was to replace the notion of truth by the notion of attractors, and this concept is well-defined in the model. The theory of truth embedded in their model is not a correspondence theory where 'images' or 'propositions' are said to correspond to reality. It resembles more a Peircean view where truth is a convergence of interpretants: it is a stability concept, a (set of) state(s) coupled systems keep returning to, given sufficiently long time.

Note that in this view, 'truth' can consist of an oscillation between two or more values. Is the 'truth' of the historical oscillations between rationality and feeling, between idealism and realism, and between static and dynamic world-views of this type? Can truth be a limit-cycle?

It is worth stressing again that semiosis is not only a closed circuit where signs beget signs, but is continually perturbed by its surroundings: the communicator's minds, bodies, and physical environment. Although communication protocols require an answer to follow a question, and an accept or rejection a proposal, the reasoning, emotions, and strategic preferences influence the choice of the concrete member of the available linguistic paradigms.

Although a basic requirement of the social syntactic system is that it must keep producing new signifiers out of old ones (cf. Luhmann 1984), a syntactic system running in isolation will not be able to describe actual conversations. It needs perturbations from psychic systems that can invest the empty signifiers with desires, emotions, and purpose, and prevent the signifiers from entering repetitive loops.

Formally this means that the next-state function cannot be fully determined. Its rules must have the form of alternatives — paradigms — whose members are selected based on the psychic perturbations (cf. systemic nets in Halliday (1978, 1994), and the concept of selection in Luhmann (1984)).

Coherence.

Question: Why do texts display thematic and anaphoric cohesion?

Answer: the reason follows immediately from Fig. 4.7. New utterances are produced out of old ones. If the new utterance is a modification of the old one (which it very often is: parts of the old utterance are taken as the known theme, and new items, the rheme, are added), then thematic and anaphoric cohesion is predicted.

As already suggested, it is tempting to see this recursion as the basic process of communication — pragmatics has primacy — and view the stable morphological patterns of the produced utterances as an emergent property of the resulting attractors, i.e. grammar describes only ephemeral structures, supervening on more basic pragmatic processes. Thus, the different syntactic and pragmatic representations of utterances are predicted by the theory in terms of the distinction between the local, causally active, processes and the structure of their resultant emergent attractors. In this view, Levi-Strauss's old dictum is simply reversed: structures no longer 'think us', we 'think the structures'.

However, I am not sure that this is all there is to say about the matter. It is hard to avoid assuming that syntax rules have some kind of causal effect on the production of utterances, i.e. that some kind of 'downwards causation' (Campbell 1975) or 'enslavement' (Haken 1998) exist. I shall take the matter up again in the last section.

Communication.

Question 1: If interpretation is always biased and relative to the receiver and cultural context, how come that are we still able to use language to coordinate our activities in a rational way?

Question 2: if the purpose of communication is a safe and univocal transmission of messages, why does language offer so many methods for saying something else than what is meant, and why can the mere uttering of sentences have profound psychic effects?

Answer: the proposed model incorporates both the conveyor tube model and the interpretative model. They simply describe different aspects of the proposed model.

To see this we need to indicate how communication takes place in Fig. 4.7. The basic form of semiosis is shown in Fig. 4.8.

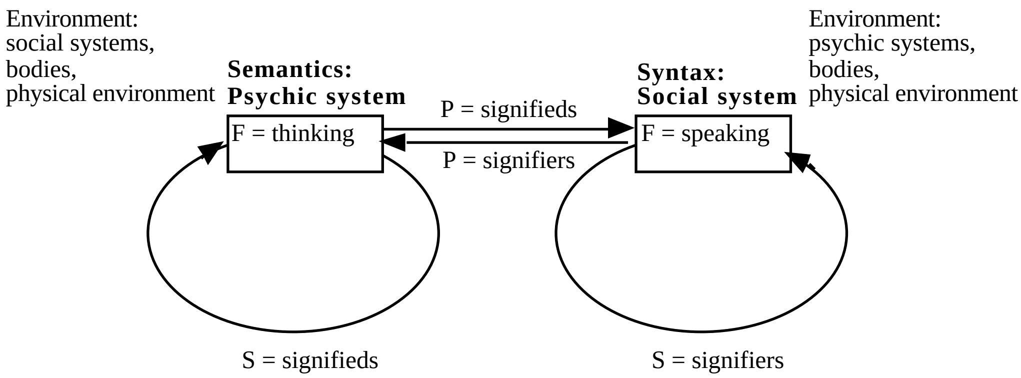


Fig. 4.8. Semiosis

Fig. 4.8 claims that there is a social syntactic system concerned with generating new signifiers out of old ones. This system is perturbed by, and itself perturbs, a psychic semantic system that produces and reproduces signifieds. As a result of the interaction between the two systems, signs emerge. They are not fixed entities, like entries in a lexicon, but resemble more the ones proposed in Eco 1977

> a sign is not a fixed semiotic entity but rather the meeting ground for independent elements (coming from two different systems of two different planes and meeting on the basis of a coding correlation). (Eco 1977: 49)

(here is some psychological evidence of the autonomy proposed by Eco. For example, the numerous empirical experiments reported in Engelkamp and Zimmer (1994) indicate that memory consists of many cooperating and functionally specialized subsystems (Engelkamp and Zimmer 1994: 6)).

Note that each system is perturbed by its environment as a whole. For example, the psychic system does not only interact with its syntactic environment. Its next state depends not only upon what we hear, but also by what we sense and what we do (cf. below).

The material circulating in the syntactic system is the stock-in-trade of linguistics: words, fixed phrases, intonation, stress, etc. In section "Syntax" I shall suggest dynamic variants of traditional grammar rules.

The material circulating in the semantic system is meanings. In this paper I assume at least two different systems of meanings: a visually based filmic system, possibly organized in image schemata (Johnson 1992: 2, 21, 24), and a logical system for reasoning. In section "Semantics" I shall discuss a logical meaning system.

Fig. 4.8 predicts two kinds of processes, interpretation and verbalization. The general process format is shown in (1).

(1) $State_t = F(State_{t-1}, Parameter_{t-1})$

Interpretation and verbalization are specializations of this general format, as shown in (2) - (3).

(2) $Signified_t = Thinking\ (Signified_{t-1}, Signifier_{t-1})$
(3) $Signifier_t = Speaking(Signifier_{t-1}, Signified_{t-1})$

Fig. 4.9 and 4.10 displays the two processes graphically.

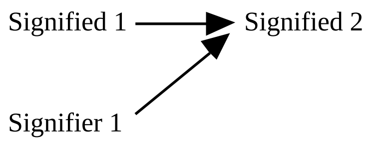


Fig. 4.9. Interpretation

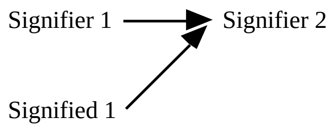


Fig. 4.10. Verbalization

In interpretation, a thought generates a new thought (signified), perturbed by an utterance (signifier), whereas in verbalization an utterance (signifier) generates a new utterance, perturbed by a thought (signified).

(2) and (3) possibly have variants that are insensitive to parameters:

(2’) $Signified_t = Thinking\ (Signified_{t-1})$
(3’) $Signifier_t = Speaking(Signifier_{t-1})$

(3’) can be used for textual operations that have no semantic contents, if such exists. At least in early transformational grammar, some transformations, e.g. morphological ones, were assumed to be devoid of meaning, but this has later been questioned. In Halliday’s theory (Halliday 1976) meaning is assumed in all syntactic processes. My own position is that non-semantic syntactic operations do exist.

Correspondingly, (2) and (3) can have non-recursive variants:

(2’’) $Signified_t = Thinking\ (Signifier_{t-1})$
(3’’) $Signifier_t = Speaking(Signified_{t-1})$

They cover possible instances where thoughts and utterances lack cohesion with the previous state. (3’’) could be used to account for beginnings of texts and for introduction of new items in a text.

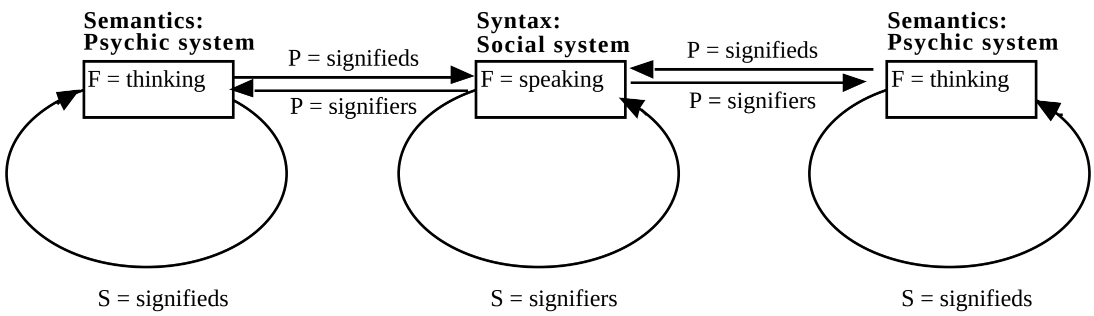


Fig. 4.11. Communication

Let us now turn to communication. Communication takes place whenever two or more psychic systems interact with a shared communicative system (Fig. 4.11).

The model can generate a variety communication patterns, including the prototypical dialogue where communicators take turns. See Fig. 4.12.

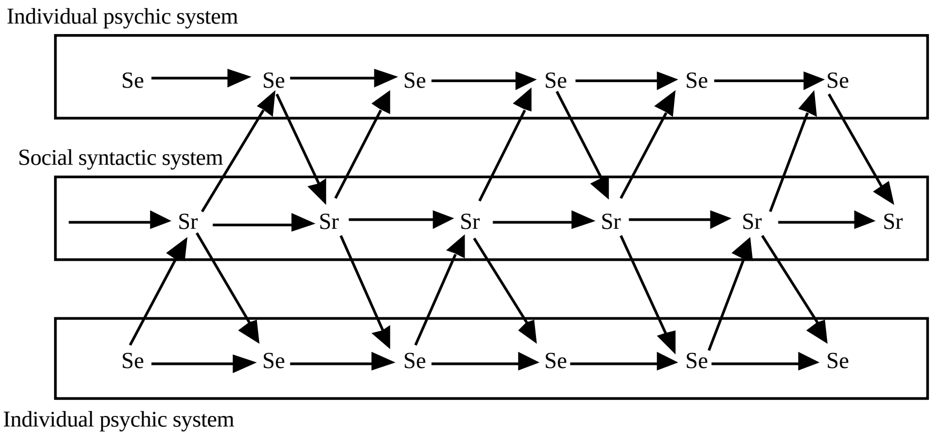


Fig. 4.12. Standard turn-taking communication (Se = signified, Sr = signifier)

Note that the arrows have two different meanings: arrows within a system box describes the recursive process of the system, whereas arrows crossing system boxes denote the perturbation of a system by its environment.

Fig. 4.13 shows how authentic conversations can be analyzed. My examples are the rudder and course-order issued on ship-bridge. The master determines the rudder angle or course, and the helmsman executes them:

Course commands:

1. Master: 'Støtte på to hundrede og firs' [steady on two hundred and eighty]
2. Helmsman: 'Støtte på to hundrede og firs' [steady on two hundred and eighty])
3. Helmsman: turns the wheel and waits until the new course has been achieved.

[4. Helmsman: 'To hundrede og firs', [two hundred and eighty]
5. Master: 'Tak', [thanks]]

This event can have an analysis as shown in Fig. 4.13 that displays the thoughts and utterances of the two interlocutors. The thoughts do not determine the actual utterances, but rather fills out a few parameters ('steady' and '282') in an already existing fixed protocol for course-commands. It also shows that the thoughts of the two persons maintain their own coherence, determined by the different tasks they are assigned. Finally, the example illustrates the point above, that systems react to their environment as a whole:

neither Helmsman nor Master react exclusively to what the other says, but also what he and the other sees and does: the Helmsman turns the wheel, and monitors the rate of turn and course indicators.

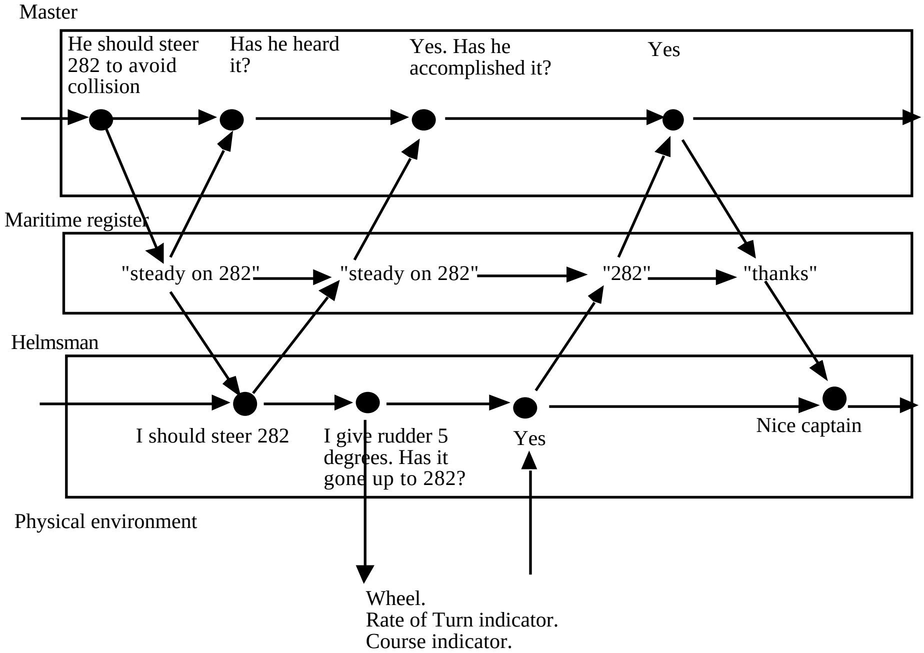


Fig. 4.13. Standard course-order protocol from the maritime domain.

The sequences in Figs. 4.11 and 4.13 are composed of units of interpretation and verbalization.

Verbalization (Fig. 4.14, compare Fig. 4.9): A signifier is produced from an old signifier, perturbed by the old signified (psychic state) of the speaker, and giving rise to a new signified (psychic state) of the speaker. Thus, the speaker hears and interprets what he is saying himself, and this self-interpretation produces a new psychic state.

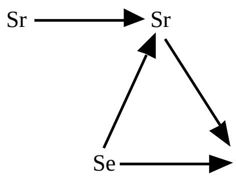


Fig. 4.14. Verbalization followed by interpretation

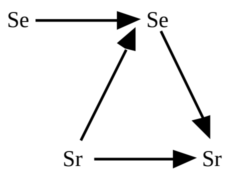


Fig. 4.15. Interpretation followed by verbalization

Interpretation (Fig. 4.15, compare Fig. 4.10): The addressee in his turn produces a new signified (psychic state) out of an old one, perturbed by the signifier, and responds by converting this signifier into a new one, perturbed by the psychic state created by the first signifier.

Monologues are in principle the same, except that the two psychic systems are collapsed into one (Fig. 4.16).

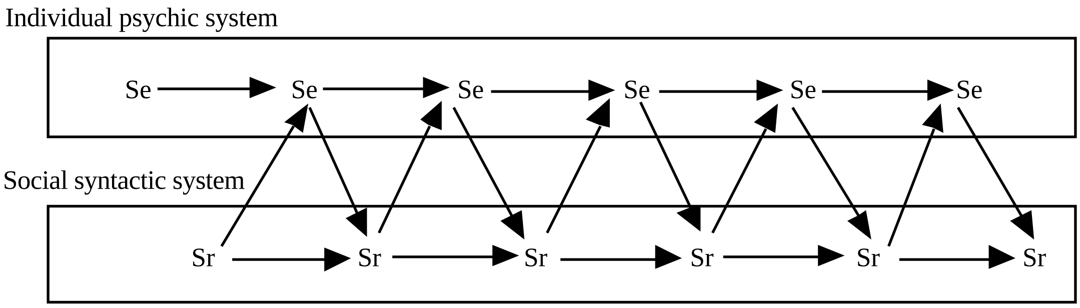
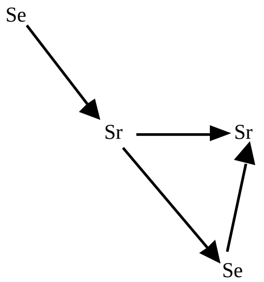


Fig. 4.16. Monologue

Fig. 4.16 could for example model the writing process: the writer perturbs the genre system he is using, generating new sentences out of an old ones. He reads the new sentence, this perturbs his mind, and a new psychic state results. This explains why the process of writing can generate new ideas that would not have came forth by merely thinking.

All kinds of blendings between the two are possible, e.g. a dialogue mainly controlled by one speaker and only commented upon by the other.

Halliday's three metafunctions (Halliday 1994) can be defined in the model. The ideational metafunction describes perturbations between two systems (i.e. signifier-signified relations), the textual metafunctions describe the recursive processes inside the social syntactic system (i.e. signifier - signifier relations) and the interpersonal metafunctions describe conventions as to who is going to produce the next signifier (compare Fig. 4.17 and 4.18).



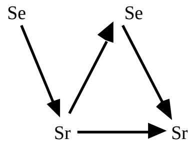


Fig. 4.17. Turntaking in dialogue

Fig. 4.18. 'Turntaking' in monologue

Since the model is symmetric, it predicts that we not only say what we see, but also that we see what we have been told to see, by ourselves or others. As shown in Fig. 4.16, signs stabilize thoughts, not merely express them. Therefore, the model predicts eye-witness phenomena as described in Greene 1992: 157.

Structures corresponding to the Saussurean, as well as the Peircean sign concepts, can be abstracted from the model. The Saussurean signifier and signified are perturbators, signifiers perturbing the semantic psychic system, signifieds the social syntactic system.

Whereas the Saussurean sign thematizes the system/environment aspect of the model, the Peircean concept addresses its recursive properties. In verbalization, a signified, acting as the object, generates a signifier (representamen) which again creates a new signified (a psychic interpretant) out of an old one, (Fig. 4.14). In Interpretation, a signifier, acting as a representamen, generates a signified (an object), which in its turn produces a new signifier (a verbal interpretant) out of an old one (Fig. 4.15).

Thus, both signs concepts are abstractions from the basic flow depicted in Fig. 4.12. Similarly, the conveyor tube and the interpretative models are included in the model in the sense that they too are different abstractions from the same basic flow.

The conveyor tube model is included, since the perturbation of one system by another is a physical process where a physical signal must travel from the environment and impinge upon the system. The interpretative model is included since this physical signal does not enter the target system, but only perturbs it. It is the perturbed system, not the environment, that decides whether the perturbation would be noticed and how the reaction should be.

The model is similar to the interpretative model in that communication is indirect: it does not consist in shoveling bits of information from one container to another; rather, communicators interact with a shared social system of signifiers. The metaphor is not a conduit, but rather a blackboard that all can see and which interlocutors take turns to write on.

Misunderstandings and corrections must be explained in terms of stability of communication. Misunderstandings are discovered when an interlocutor hears an answer he cannot react to and which therefore jeopardizes the recursion; the danger creates a repairing utterance. Thus, like truth, understanding and misunderstanding are stability concepts that characterize the interaction between two interlocutors, not their individual minds.

From this point of view, conversations end when an attractor has been reached. If the attractor is a fixed point, the conversation has a conclusion, whereas a limit cycle where arguments begin to repeat themselves signalizes failure.

The occurrence of intertextuality — the multivoicedness of communication — is predicted from the model when we add memory to the systems. In the syntactic system, the ‘old signifier’ includes durable forms of utterances: books, newspapers, manuals, inscriptions, etc. Since the syntactic system is a social system, the signifiers flowing in the model are not necessarily those produced by the speakers in the actual conversation. In the model, individuals are only allowed to perturb the social system, not to take full control. Referring back to Bakhtin’s ideas, they can literally be said to rent, not own, utterances.

The occurrence of double-meanings like irony, parody, allusions, metaphor, litotes, etc., can be accommodated if the state of the model has at least two dimensions, the well-known paradigmatic and syntagmatic dimensions: S = <syntagmatics, paradigmatics>. This implies that formation of utterances involves a two-dimensional trajectory that moves in time (syntagmatics) as well as in modality (paradigmatics: impossible, possible, actual). This allows sentences to be possible, although not actual at a certain point of time. The alluding sentence is actual, the sentence alluded to possible. I shall later show how this can turned into a grammar that can actually generate sentences.

The model allows the relationship between psychic and social system to be non-linear, predicting cases where there is no proportion between the length of the utterance we hear and the magnitude of our response. A single word can have a large effect. In addition, the model allows for chaotic behavior, in the mathematical sense. This means that the next state of the coupled system can be unpredictable for all practical purposes, although still falling within a confined part of thematic space. This accounts for aesthetic experiences: since the systems cannot directly determine each other, playful exploration of the syntactic system can create surprising and novel semantic effects.

This unpredictability finally accounts for the fact that the mere verbalization of a thought or emotion can cause deep mental changes in the speaker himself. This is predicted because verbalization is analyzed as the psychic system interacting with the social system, not just as emitting signals. The verbalizer perturbs the social system — he utters a sentence. But the social system re-perturbs the verbalizer — he hears what he just said (cf. Fig. 4.12). The perturbation of the psychic system is the same, no matter whether it was created by one self or another person, and this means that bifurcations have equal chance of appearing in both cases. One can be just as surprised over one's own sayings as over somebody else's, because in both cases one interacts with a foreign system that can give unpredictable reactions.

In addition to this, it is the perturbed system, not the perturbing one, that inserts boundaries into perturbations. It is language, not me, that articulates my emotions, and it is me, not language, that determines the meaning of utterances (the commutation test).

For example, because of the commutation test (meet means something else than moot), it is the semantic system that decides that /i:/ and /u:/ are different phonemes, and, similarly, it is the syntactic system that determines the way the semantic field of age is articulated (increasing the age of a male causes the expression boy to be replaced by man).

Dynamic syntax and semantics

In this section I shall give short examples of application of the model in the two key semiotic domains: syntax and semantics. I want to explore Hjelmslev's early suggestion, that the 'content' and 'expression' planes of language are structured in similar ways. Hjelmslev's suggestion has been re-actualized by cognitive semantics that claims that the same biologically motivated image-schemata underlie our patterns of thinking as well as our way of acting.

In both cases I built small computer models as "prostheses of thought" to help me explore the properties of the model. In order to explore to what degree syntax and semantics are structured in a similar way, I used a dynamic phase-space as a model in both cases. A dynamic phase-space is simply a phase-space with forces defined on it that can effect changes in the space. In the next sections I use potential fields for simplicity's sake.

Phase-spaces, also called property-spaces, was early suggested as a semantic representation in Gärdenfors (1992). A force dynamic as a semantic representation was advocated by Talmy (1988). The limitations of phase-spaces as a representation are discussed in Fontana and Buss (no year).

I shall not touch upon empirical and practical issues in this paper. The model is currently being used in a project on maritime work and instrumentation, and preliminary results can be found in Andersen 1998b, 1999 and forthcoming, plus in the website of Center for Human-Machine Interaction, http://www.chmi.dk.

Syntax

This section sketches how a dynamic syntax can be constructed. The example shows how one can build a syntax with a smooth transition between usage and system, how the system emerges as an attractor of use-processes, and how the same conceptual apparatus predicts system features and features of usage, as e.g. speech errors.

I shall mostly discuss rules of the form (1).

(1) $\text{Signifier}_t = \text{Speaking}(\text{Signified}_{t-1})$

(2) $\text{Signifier}_t = \text{Speaking}(\text{Signifier}_{t-1}, \text{Signified}_{t-1})$

The semantic system is assumed to be some kind of a visual filmic system.

In order to stay as close as possible to existing grammar, I use dynamic versions of the three traditional relations as my dynamic building blocks. They are interdependence (Jespersen's nexus), determination (head modifier constructions, hypotaxis) and constellation (coordinative constructions, parataxis) (cf. Hjelmslev 1963: 132).

Interdependence describes a construction whose parts establish a new unity with qualities that are not the sum of the two parts (e.g. Subject + Finite Verb and *Preposition* + *Object*). Determination describes a construction where only the head contract external relations, whereas the modifier is wholly dependent upon the head in its relations to the environment (Adjective Noun and Adverb Adjective). Finally, constellation consists of two independent parts that contract relation to the environment independently of the unity they enter into (Noun and Noun).

A possible dynamic interpretation of these relations is the following:

- A unit that relates to a head owns a force that attracts it to the head[1]. Interdependencies consisting of two heads thus involve two forces. Their members attract each other mutually.

Each word thus generates a potential field influencing other words. The total field influencing the individual word is the sum of the individual fields influencing it. A word is influenced by a field by moving along its gradient.

This idea of using potential fields for specifying purposeful behavior is not unique to verbal behavior, but can also be found in robot research (see e.g. Latombe 1991), and neuropsychology concerned with the neurological basis of movement planning and execution (see Morasso and Sanguinetti 1997).

Thus, the recursive process simply consists in the rule

(3) $X_t = X_{t-1} - \partial F(X_{t-1}, P)$

where X is the location in the syntactic space, $\partial F(X)$ is the gradient working at location X, and P is the perturbation.

In order to determine the descriptive power of these concepts I ran a simple computer simulation with the following syntagmatic attractors:

Interdependencies, i.e. mutual attraction between members of classes:

- Nominative Nouns + Finite Verbs: verbs attract nouns to their left sides, nouns attract verbs to their right sides, so that the stable configuration is Nominative Noun + Finite Verb (The stone rolled).
- Aspectual Verbs + Infinite Verbs. Stable configuration: Aspectual Verb + Infinite Verb (begins rolling).
- Prepositions + Accusative Nouns. Stable configuration: Preposition + Accusative Noun (towards the tree).
- Transitive Verbs + Nouns. Stable configuration: Nominative Noun + Transitive Verb + Accusative Noun (The Soviet Union attacks USA).

Determinations, i.e. one-sided attraction of modifier to head.

- Nouns + Adjectives, with adjectives as modifiers, nouns as heads. Stable configuration: Adjective + Noun (green grass).
- Verbs + Prepositions with prepositions as modifiers, verbs as heads. Stable configuration: Verb + Preposition (rolling towards).

These attractors are system attractors in the sense that they hold for classes of words. However, they are still local processes working between individual words.

The resulting syntactic system is a variant of dependency grammar, where the subordinate part owns a force attracting it towards the superordinate one (Fig. 5.1).

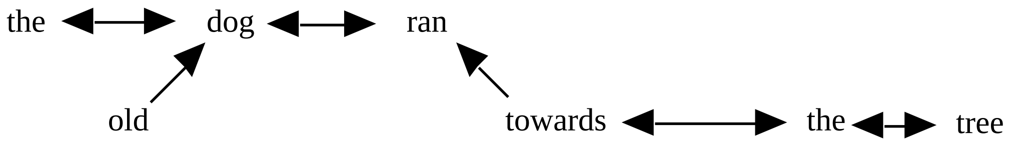


Fig. 5.1. Dependency diagram

The semantic system is represented by Fig. 5.2, a landscape with a tree, a ball and a dog, of which the latter two can move. Thus, the space is a simple two-dimensional space where the objects are characterized by their coordinates <horizontal, vertical>.

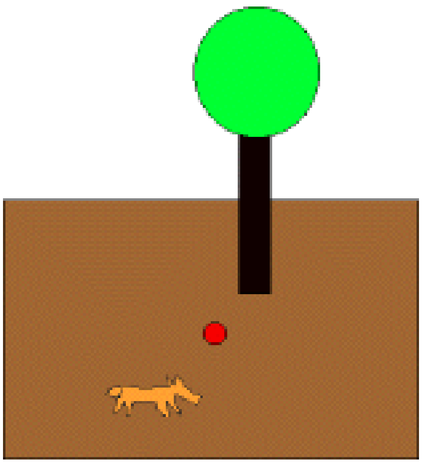


Fig. 5.2. Semantic system

Fig. 5.3. Syntactic system

The syntactic system is represented by a similar two-dimensional space <paradigmatics, syntagmatics> (cf. Section "Communication") with words and syntactic forces in it. The paradigmatic dimension is interpreted as modality (more or less actual) and the syntagmatic dimension as time-sequence. Each object is characterized by its coordinates in this space, <modality, time>. In the beginning of a simulation, the words were scattered randomly as shown in Fig. 5.3.

We want to investigate whether we can make the words move towards a global attractor of the type displayed in Fig. 5.4 (the paradigmatic dimension increases from top to bottom because of the conventions of the computer screen) only using local forces.

This attractor should have the following properties:

- It must be a fixed point attractor with one steady state. The interpretation is that the speaker has decided to say one utterance and is not wavering between three.
- There must be one syntagmatically aligned sequence of words with the same modal value that is higher than the value of all other words. The interpretation is that the speaker has decided to actualize this utterance.
- The utterance must count as a description of events taking place in the semantic system. When the attractor is 'dog stops running towards tree', then the dog in fact must stop moving towards the tree in Fig. 5.2.
- Non-used words must assemble in columns above the actualized words so that words belonging to the same word-class are located in the same column (e.g. nouns like tree, grass and dog occupy the same syntagmatic position). The interpretation is that when an utterance is realized, then possible, but not actualized fillers of its slots must be present in its vicinity and influence what is actually said and the way it is understood.
- Formation of paradigms and syntagms must be an emergent process caused by many local interactions between words. Paradigms should form spontaneously, since words subject to similar attractors end near the same syntagmatic slot where all but one are repelled. For example, nominative nouns will come to form a paradigm because they are all attracted to the left of the finite verb. Thus, the paradigms should not be presupposed, but explained by means of the combined forces of syntagmatics and paradigmatics. Paradigms and syntagms are explained as the result of a self-organizing process.

It turned out that, apart from the system forces described above, the following additional use forces were necessary to produce the desired attractor.

- Words occupying the same syntagmatic segment must try to make each other impossible so that every word repels its syntagmatic competitors upwards. Interpretation: our speech organs cannot produce two words at the same time, so if a word is to succeed being pronounced, it must hinder its competitors (See Fig. 5.5)[2].
- The syntactic force field is perturbed by the visual system so that relevant words get a larger force and therefore attract their targets more strongly in the syntagmatic dimension than irrelevant words.

- If the force of a word is below a certain threshold, it looses its ability to repel words in the paradigmatic dimension. The reason is that if all words are allowed to push its competitors into the space of impossibility, i.e. upwards, the whole sentence will keep moving upwards: when A and B are aligned vertically, A pushes B upwards, and B does the same to A.

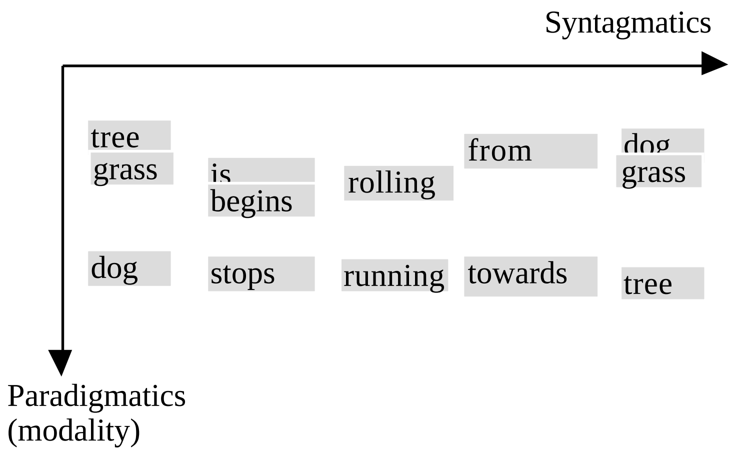


Fig. 5.4. The desired attractor.

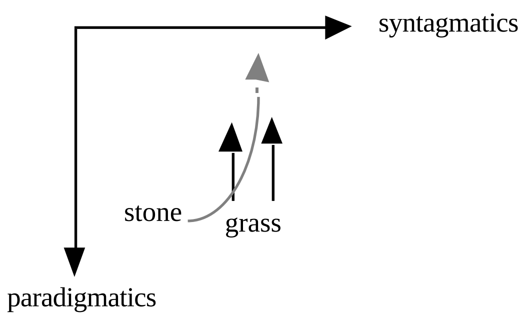


Fig. 5.5. Paradigmatic forces. Gray: the trajectory of ‘stone’. Black: the force of ‘grass’.

The attractor in Fig. 5.4 consists of a balancing of forces. The syntactic system becomes stable when words have moved into positions where the forces influencing it cancel each other. The words so to speak compete for becoming realized.

This feature of the model predicts the presence of other utterances than the one actually uttered, as required in section “Communication as signal transmission”. These other utterances will have a modality value lower than the produced utterance, but will still be present for the mind. The notion of multiple utterances competing to be realized predicts speech-errors such as blendings:

> Sometimes they [the speakers] discover simultaneously two equally suitable words, such as **slick** and **slippery**, and find themselves unable to decide between them, and program a blend from elements of both words, here **slickery**. (Clark and Clark 1977: 281)

If slick and slippery were not both present to the mind, how else could their blending be pronounced?

The use forces, here the perturbation from the semantic system, can have two components in the computer model: the force of an individual word can be increased (4) or the particular forces between two words can be increased (5).

(4) Force('X') ≈ Measurement (X, Y)
(5) Force('X', 'Y') ≈ Measurement(X, Y)

(4) says that the intrinsic force of a word 'X' is related to a measurement of its referent X in relation to another object, and (5) says that the force between two words 'X' and 'Y' is related to a measurement of the referents X and Y of the words. (6) is an example of rule type (4), (7) - (9) examples of type (5).

(6) Moving objects are preferred as subjects. Force('X'+nom) ≈ |velocity(X, Y)|. The intrinsic force of a nominative noun 'X' is proportional to the absolute velocity of the referent X in relation to some other object

(7) 'Rolling' implies that the subject is moving. Force('X'+nom, 'rolling') ≈ |velocity(X, Y)|. The force between a nominative 'X' and the verb 'rolling' is proportional to the velocity of X in relation to some other object. Similar analyses can be made of other verbs of motion, such as 'walk', 'run', 'fly', 'sail', etc. The verbs differ in their manner of movement.

(8) 'Begin' implies acceleration. Force('X'+nom, 'begin') ≈ Acc(X, Y). The force between a nominative 'X' and the verb 'begin' is proportional to the acceleration of X in relation to some other object. Similar analyses can be made of other aspectual verbs such as 'keep'(acceleration 0) and 'stop' (acceleration negative).

(9) 'Towards' implies that the distance between the subject and object reference decreases. Force('X'+nom, 'towards') = Force('Y'+ acc, 'towards') ≈ -Velocity(X, Y). The force between 'towards' and two nouns, a nominative and accusative, is inversely related to the velocity of the referent of the nominative in relation to the referent of the accusative. Similar analyses can be made of other directional prepositions, such as 'from', 'over', 'under', 'past', etc.

The use-forces add small chunks of force to the global force-field, and the global field is simply the sum of the system and use forces. Thus, the combination of system and usage is simple and well-defined. See Fig. 5.6.

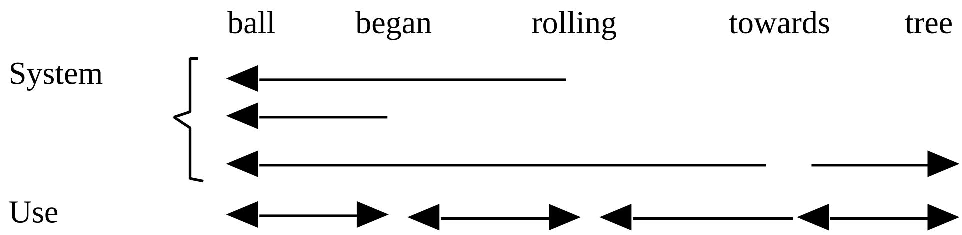


Fig. 5.6. Sentence formation as a combination of unmarked and marked dynamics.

In addition, the system and use components are made of the same stuff, namely forces. This makes it possible to suggest ways in which features of usage are converted into system properties. One possibility is the notion of traces: use processes leave traces behind them, adding up to invariant system processes.

The relative importance of system and use forces is an empirical question. In simple cases, it is possible to just increase the force of the individual words (cf. 4), and let the system forces do the rest of the work. In more complicated cases, the more specific rules of type (5) are necessary. Thus the model predicts that in routine situations, just knowing the relevant words is enough for the syntactic system to produce sentences, whereas in complex settings, precise forces between the individual words must be supplied.

The perturbation of the semantic system by the syntactic system can be described in the same manner. The rules below only use the sequence of words as a perturbator and the only measurements the semantic system makes is looking for patterns of words. Examples are:

(10) If the sentence contains the pattern ‘A’+nom ... from ‘B’+acc then create repellers with A as target and B as source (A moves away from B).

(11) If the sentence contains the pattern ‘A’+nom ... to ‘B’+acc then create attractors with A as target and B as source (A moves to B).

(12) If the sentence contains the pattern ‘A’+nom moves then create repellers or attractors with A as target (A moves somewhere).

<u>Semantics</u>

In this section I shall try out the same ideas in the domain of logic. My point of departure is logical accounts of meaning. The exposition will be sketchy and details can be found in Andersen 1995b. I shall concentrate on how to build a logic that can handle contradictions and dilemmas and which does not break down in the event of language change, i.e. is robust to changes of concepts.

The reason for this is threefold:

- As argued in Section "Truth and reality", the self-reference of language by necessity makes contradictions possible, so models of semantics and logic must be able to work in this environment in order to be realistic. Models that break down when faced with contradictions are ruled out on empirical grounds. Since standard logic has $\neg\ (A \quad \neg A)$ as an axiom, it does not qualify as an empirical model of human reasoning
- Furthermore, data from literature and everyday life in fact contains contradictions — literature even thrives on them — and there are conventional strategies people use in this situation. The model should compatible with these strategies (cf. the 'recursion-protector' described by Hofstadter 1985: 531).
- The same holds for models that can only work in stable environments. We know that language and concepts change every day, and still we are able to reason and argue rationally. Models that rule out changes of concepts are disqualified a priori.

Apart from these extra requirements, the model must be able to account for the stock-in-trade of semantics. In particular it must embody the notions of extension, intension, logical connectives, class inclusion, antonymity, deduction, etc. In addition it should allow for different types of concepts: Aristotelian types with sharp boundaries and fuzzy concepts with blurred boundaries.

In the previous section we were only concerned with episodic memory, i.e. events characterized with respect to time and place. In this section we will add semantic or conceptual memory. The dog in the previous section was characterized by the tuple <horizontal, vertical> and in order to create conceptual representations of the animal, we simply enlarge the episodic phase-space to include dimensions that are useful for classifying dogs, for example gender ('dog' versus 'bitch') and age ('dog' versus 'puppy').

In our simple example, the two-dimensions are increased to four, each object now being represented by a quadruple <horizontal, vertical, gender, age>. Attractors and repellers can be defined in all dimensions.

Let us consider our dog from the previous section. The fact that the dog is running towards some location is represented by an attractor pulling the dog in the spatial dimensions. The fact that it is a ‘dog’, and not a ‘puppy’, is similarly represented by an attractor, keeping the dog at the ‘dog’ location. See Fig. 5.7.

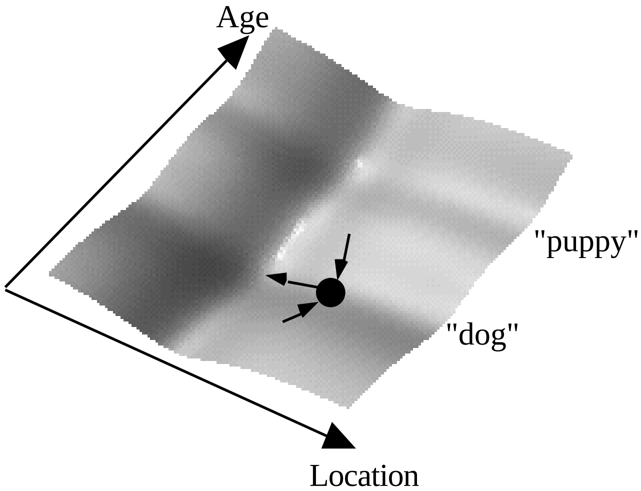


Fig. 5.7. ‘The dog is running towards the tree’

The difference between episodic (‘It is running towards the tree’) and conceptual (‘It is a dog as opposed to a puppy’) knowledge is thus a matter of degree, more precisely of the relative stability of the forces. Episodic forces change fast, whereas conceptual ones are more slow. The ‘tree-attractor’ may change in a minute, whereas the attractors in the age dimension change much more slowly, the latter being diachronic attractors defining the meaning of ‘dog’ and ‘puppy’.

This analysis, where episodic and conceptual knowledge are treated as variants of the same basic phenomenon, can be found in e.g. Barsalou 1995:

> Rather than viewing episodic and generic memories as sharply differentiated [...], these findings suggest that it may make more sense to view episodic and generic memories as a continuum. (Barsalou 1995: 204)

Concepts are thus represented as slowly changing attractors in particular dimensions, and their extensions are simply the set of objects located there. How did such attractors emerge in the first place? If we look at Fig. 5.7, we can imagine that the number of objects placed in a certain location on the ‘paper’ begins to weigh down, leaving a buckle as their trace. This can be interpreted as claiming that the location of concepts is determined by the frequency distribution of objects and events. The locations of the attractors thus represent the <u>extension</u> of the concepts.

Classification of episodic knowledge is effected by the gradient dynamics of the conceptual fields: the item to be classified is pulled towards the closest equilibrium. When the age of the female individual in Fig. 5.8 is small, she is attracted to the ‘girl’ concept, whereas she moves towards the ‘woman’ concept after a critical limit has been transgressed (the exact location of this limit is the subject of heated discussions among teen-agers and parents).

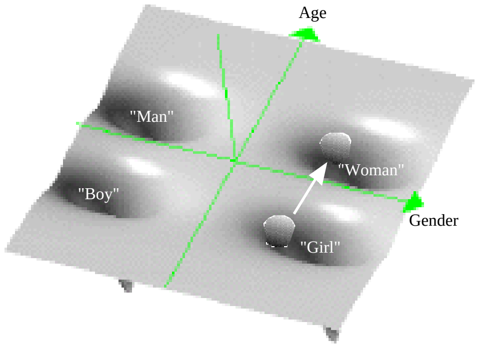


Fig. 5.8. Large magnification. The individual is seen as changing properties.

There are two ways of formalizing the process of classification.

Catastrophe theory (Thom 1989, Wildgen 1982, 1985, and Saunders 1990) lets the dimensions control the shape of the field. A young female will produce a minimum in the lower right quadrant of Fig. 5.8. and turn everything else into slopes, making the individual move down into the ‘girl’ location. As the girl grows up, a new minimum will emerge in the top right quadrant, and the ‘girl’ minimum will disappear. At some critical point, the individual will roll from the now disappeared ‘girl’ location to the now deep ‘woman’ location.

Another way of formalizing the classification mechanism (the pinball metaphor) is have all minima present at the same time, to first position the individual according to its perturbation values (e.g. young = 3, gender = female) and subsequently let it move along the gradient. Placed in the lower right quadrant it will end in ‘girl’, in the upper right quadrant in ‘woman’.

The pin-ball method predicts the phenomenon of prototypes. It claims that conceptual fields have fixed attractors, probably reflecting the position of typical specimens having left a ‘buckle’. If an individual with specific values is dropped into the field, it will move towards one of the prototypes. Thus, even if the girl is actually 15 years, classifying her as a girl makes her move into the typical girl attractor, which to her regret may be located at the age of 12.

Which dimensions of an episode are focused depend upon the level of magnification. Compare the three sentences

(1) The horses raced
(2) The race was moved to Copenhagen.
(3) The race was more exiting than previous week.

When we are close to the event, we thematize fast changing properties of the individual, such as the exact location of each horse. However, if we look at the trajectory in a smaller spatial and temporal magnification, we can no longer discern the individual fast changes and see the trajectory as a unit. However, due to the larger span of time and space, dimensions that looked constant before, such as the racecourse — the container in which the trajectory took place — may now begin to change and thus form a trajectory, possibly moving in the same or other dimensions than the faster one. (2) is an example of the former, (3) of the latter.

Thus, in the magnified version of an episode we notice the changes of the participants ('The horses raced'), while the reduced one shows us the episode from afar as a unit whose properties can be compared to other episodes ('The race was more exiting than previous week').

Fast changes are converted into verb-meanings, slower ones into adjective and noun meanings. That nouns in fact thematize stability can be seen from the role stability plays in the structure of complex the noun phrases, cf. Halliday 1994: 180 ff.:

(4) (Look at) those two splendid old electric trains with pantographs.

The farther words are from the head (<u>trains</u>), the more unstable properties do they denote. We can in fact see this mechanism at work in daily life. Managers and administrators are concerned with slow changes, whereas the shop floor personnel handle fast changes. Therefore, the former verbalize tasks as nouns, the latter code them as verbs.

If the location of attractors represents extensions, then movements of attractors reflect a <u>material</u> change in the environment. For example, the location of modern <u>car</u> in a property space is different from Latin <u>carrus</u>, because the typical means of transportation has changed materially. Similarly, <u>life</u> and <u>death</u> were previously assumed to be non-overlapping classes, but discovery of virus has created a non-empty intersection. In fact, change of the tasks or objects seems nearly automatically to cause corresponding language changes (Ullmann 1962: 210)

<u>Intensions</u> or <u>senses</u> are often given by meaning postulates. For example, the antonymity of <u>life</u> and <u>death</u> can be given by the postulate <u>Dead(x) → ¬ Alive(x).</u> Whereas extensions are determined by experience, intensions are criteria for individuals to be members of the classes subsumed under the concepts, and thereby they reflect our conventional beliefs of how the concepts relate to one another.

In order to use meaning postulates, we have to define dynamic versions of logical connectors. In Andersen 1995b the following was proposed:

(5) Let f(P) denote the field of the predicate P. For simplicity's sake, f(P) is assumed to be x^2 for all predicates. Predicates thus only differ in the location of the minimum and in the steepness of the curve. The actual nature of the fields is an empirical issue (cf. again the discussion of property spaces in Gärdenfors 1992).

The logical connectors are defined as follows:

(6) $f(P \quad Q) = \min(f(P), f(Q))$

(7) $f(P \quad Q) = \max(f(P), f(Q))$

(8) $f(\neg P) = -\int \frac{1}{f'(P)}$

The negation potential is thus the negative of the potential whose gradient is inversely proportional to that of the original field. If the field of P is as in (5), (8) can be calculated as

(9) $f(\neg P) = \frac{-\ln|x|}{2}$

As suggested in section "Truth and reality", truth is defined as stability. Thus, a predicate is true of an individual iff the gradient of f(P) influencing the individual is below a certain small value ε. If individuals are influenced by the negative gradients, they will tend to end up in equilibrium locations. Thus, the whole system will move towards truth, if this is possible (related ideas can be found in Gärdenfors 1988).

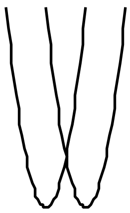


Fig. 5.9. F(P), f(Q)

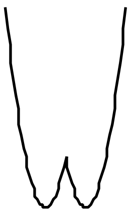


Fig. 5.10. F(P Q)

Fig. 5.11. F(P Q)

However, qua gradient dynamic, the model predicts that this is often not possible: there may be no equilibria at all, or the individual may be located in a way that prevents it from finding an equilibrium. Thus, in life as well in literature, instabilities are the norm rather than the exception.

Example fields of the connectors are shown in Figs 5.9-5.15.

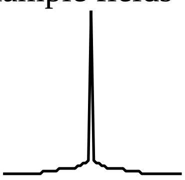


Fig. 5.12. F(¬ P)

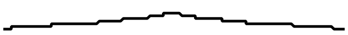


Fig. 5.13. Antonyms. F(¬ (P Q))

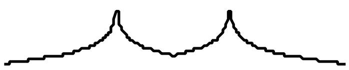


Fig. 5.14. F(¬ (P Q))

The intensions are thus represented as a modulation of the fields of the individual predicates.

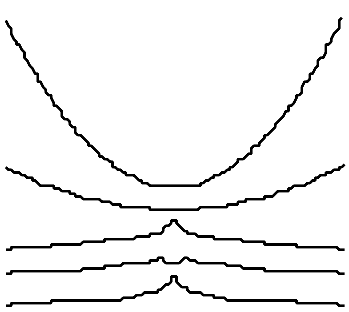


Fig. 5.15. Implication, dynamic version

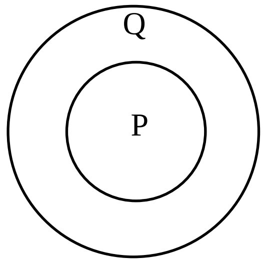


Fig. 5.16. Venn Diagram.

Class implication is expressed as P Q ≡ P ¬Q. Fig. 5.15 shows the dynamic interpretation. In the example the critical points of P and Q coincide, but Q's gradient is smaller than P's. Therefore, whenever the gradient of P is below ε, then so is Q's gradient. Therefore, if P is true of an individual, then so is Q. The truth locations of P Q is the small crater of the volcano representing P Q (= P or not Q) in Fig. 5.15. If P is offset so that the critical points no longer coincide, the crater disappears and there are no stability locations left (Fig. 5.15, bottom).

Instabilities. Instabilities are created whenever extension (the actual distribution of episodes) and intension (our ideas of how concepts are related) do not match. For example, if we believe that (P Q) but P and Q are actually distant we get the modulation in Fig. 5.11. If P is Desire and Q Virtue, then (P Q) lures us to believe that Desire and Virtue can be fulfilled. However, if their extensions are as in Fig. 5.9, this is actually not true, so there is no equilibrium location in the field (the 'minimum' in Fig. 5.11 is not a real minimum, since the function is not differentiable at the bottom). Thus, the individual will oscillate between Desire and Virtue, one time succumbing to Desire, another time honoring Duty. This is the stuff classical tragedies (and parts of real life) are made of.

Oscillation is thus one of the strategies predicted for handling paradoxes and dilemmas. However, there are two other main strategies: change reality (the extension of concepts) or change the sense (the intension of concepts).

Change of extensions. If two extensions connected by a conjunction are moved towards each other, we get the modulation change depicted in Fig. 5.17. If P and Q are irreconcilable demands posed by children and employer upon parents, then Fig. 5.17 depicts the result of introducing parental leave: in the background there is no compromise, but the foreground defines a equilibrium. However, we can also change the intensions.

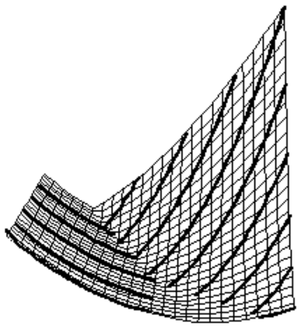


Fig. 5.17. Change of extensions. P Q with P and Q moving together in the foreground.

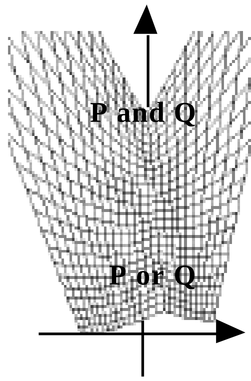


Fig. 5.18. Change of intensions: P Q (background) changes to P Q (foreground).

Change of intensions. Change of intensions means that we change our definition of the concepts, not reality. For example, our parents could solve their dilemma by changing the relation between good parents and a good employees. Instead of requiring both predicates to be true (conjunction), they may satisfy themselves with sometimes being a good parent, sometime a good employee (disjunction). If we want to represent changes of intensions, we must parameterize the conjunctions. (10) shows a neutral conjunction that can change smoothly between working as a (the a-parameter = 0) and a (a = 1).

(10) $F(P \quad Q) = \min(f(P), f(Q)) + a(\max(f(P), f(Q)) - \min(f(P), f(Q))$,
for $0 \leq a \leq 1$.

Fig. 5.18 shows the morphing of and into or.

Deduction uses the same gradient techniques. For example, tollendo ponens allows us to conclude Q if we know P Q and ¬P. In dynamic terms, what happens here is that we start with Fig. 5.10 with two equilibria and add Fig. 5.12 on top of the P basin; the only remaining equilibrium is the Q basin. If an individual is located in the P-basin, it is expelled into the Q-basin.

Summary

In this and the previous sections I have shown that the same simple gradient dynamics can be used to account for a number of known syntactic and semantic phenomena.

In the syntactic domain I showed that traditional syntactic relations had a natural dynamic interpretation. Interpreting the traditional dimensions of syntagmatics and paradigmatics as dimensions of the syntactic state, I showed how paradigms and syntagms emerged from many concurrent and local interactions between words, and I described the sentence actually uttered as an attractor of these local forces.

In the model, words are competing for being pronounced or written, and this explains both the ‘multi-voicedness’ of Bakhtin, and the speech errors described by Clark and Clark 1977. The model predicts the creative aspects of verbalization and the fact that verbalization can have unforeseen deep cognitive and emotional repercussions upon the speaker; the reason is that communication consists of a psychic system interacting with an autonomous social syntactic system in a non-linear fashion and that the latter that determines the articulation of the perturbation caused by the former.

In the semantic domain, the model can account for the concepts of extensions and intensions.

The same gradient dynamics as was used in syntax accounts for the phenomenon of classification. Since semantic fields will have critical points, the model predicts ‘categorial perception’. This happens when the trajectory of an individual moves across saddlepoints and unstable critical points.

The model is basically dynamic and incorporates change of extensions as well as intensions. The former is represented by changing the location and steepness of the attractors, the latter by changing the meaning postulates defining the modulations of the extensional fields. These two processes are suggested as the main means whereby speakers can remove the unavoidable paradoxes and dilemmas of self-referential systems: change your reality or change your conception of the relation between concepts — do something or adapt your ideology! Thus, the model accommodates a theory of action as well as a theory of interpretation, and invites descriptions of the interplay between the two. For example, one guess may be that change of intensions (ideology) is caused by the instabilities generated by real contradictions and paradoxes. However, change is not a necessity since living with a paradox is well-defined and consists in oscillations that unfold the paradox in time.

Let us return to the dynamics of episodic and conceptual semantics. They clearly differ in the dimensions they employ, episodic semantics being concerned with space and time, conceptual semantics with features such as animacy, gender, age, etc. Do they also differ in their dynamics or can we assume that similar dynamics are unfolding in different scenographies? If cognitive semantics is correct we should expect the latter, dynamic patterns originally evolved for moving in space-time being transferred to worlds with other dimensions. Consider again a classical task in robotics, namely making the robot seek a goal while avoiding obstacles (Fig. 5.19). As already mentioned, one technique for accomplishing this exploits the potential fields used in this section. In Fig. 5.20 the goal (e.g. being at a certain location) is represented by a general attractor from the robot to the goal, and the obstacles (e.g.

tables or chairs) by repellers. By moving along the resulting gradient, the robot avoids the obstacles while getting nearer to its goal.

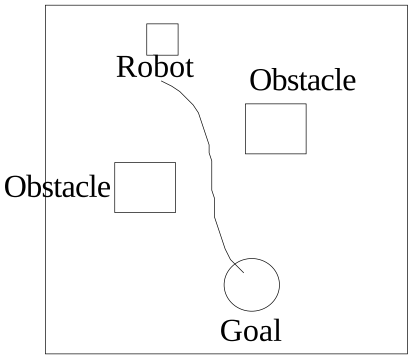


Fig. 5.19. Robot, goal and two obstacles

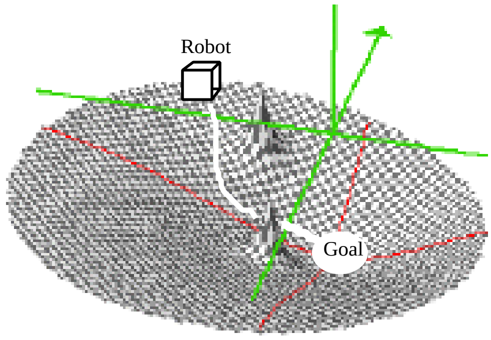


Fig. 5.20. Force field of repellers and attractor

If cognitive semantics is right, then landscapes like Fig. 5.20 ought to be useful for describing reasoning processes as well. The moving point in Fig. 5.20 will no longer represent the robot in its spatial-temporal world, but the location of the psychic system in a conceptual world. Attractors represent beliefs the system tries to prove, whereas repellers are counter-arguments that block the way and must be overcome. A basic metaphor for thinking is thus the <u>travel</u> (cf. Johnson 1992).

Downwards causation: a problem of the model

As all other models, the model presented in this paper suffers from weaknesses. Here I shall only present one that is particularly vexing for this type of model.

The problem is how to account for the formation of wholes with a behavior different from their parts. This concept is necessary to account for many basic linguistic facts as is demonstrated by Jespersen's concept of nexus (exocentric constructions, section "Syntax"), the syntactic reality of phrases and the psychological reality of chunking. It is also needed to account for the fact of 'Systemzwang' where the language system is experienced as constraining the activities of the language users that made it come into existence in the first place. The problem has been named 'downwards causation' in biology (Campbell 1975, cf. also Køppe 1993 and Andersen forthcoming).

The cause of the difficulty is that the model describes wholes as emergent entities, generated by the activities of the parts, but does not specify the relation between the new macro behavior and the micro behaviors that created it.

One possibility for handling the problem is the notion of <u>boundary conditions.</u> The idea is that the emergent behavior stabilizes and acquires a life of its own because it changes its environment and thereby its boundary conditions. This is the explanation offered by Latour 1994 to account for the way technical artifacts stabilize social patterns. Social patterns become stable because they effect a physical imprint in the environment that outlives the individual and serves as a collective memory. A similar explanation appoints the cell-wall as the new environment that stabilizes otherwise wildly improbable biochemical processes in its interior.

However, it is still hard for me to see how this can be extended to explain the emergent properties of semiotic units. A clause behaves like a unit, and very differently from any of its parts, but it is not possible to point to any analog to a cell wall that could stabilize this behavior, a problem that has also been raised in the domain of sociology (Mingers 1995) .

The formation of wholes and their (presumed) control of their parts is thus a major problem in a dynamic semiotics. However, it must be emphasized that the algebraic traditions do not solve this problem but just postulate wholes (such as NP, VP, Sentence) without explaining them. The dynamic approach at least enables us to see and discuss the problem.

Footnotes

1 Possibly it should be the other way around, namely that the modifier attracts the head to itself. In this way one could explain the occurrence of expletives like ‘there’ and ‘one’. In ‘a blue one’, ‘blue’ is a modifier that cannot find a head to relate to. In the lack of better, it draws in the dummy word ‘one’.

1 This is an example of perturbations from the biological system, which is also part of the environment of the syntactic system, as emphasized in section “Communication”. Another example of biological perturbation is intonation patterns that can be traced back to infant cries.

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Caption list

Fig. 3.1. The conveyor tube model

Fig. 4.1. $S_t = F(S_{t+1,} P)$. The basic model.
Fig. 4.2. Fraction of the Mandelbrot set.
Fig. 4.3. Two periods, 3.4x(1-x)
Fig. 4.4. Four periods. 3.5x(1-x)
Fig. 4.5. Eight periods, 3.56x(1-x)
Fig. 4.6. Chaotic, 3.6x(1-x).
Fig. 4.7. Semiosis as perturbed recursion
Fig. 4.8. Semiosis
Fig. 4.9. Interpretation
Fig. 4.10. Verbalization
Fig. 4.11. Communication
Fig. 4.12. Standard turn-taking communication (Se = signified, Sr = signifier)
Fig. 4.13. Standard course-order protocol from the maritime domain.
Fig. 4.14. Verbalization followed by interpretation
Fig. 4.15. Interpretation followed by verbalization
Fig. 4.16. Monologue
Fig. 4.17. Turntaking in dialogue
Fig. 4.18. ‘Turntaking’ in monologue

Fig. 5.1. Dependency diagram
Fig. 5.2. Semantic system
Fig. 5.3. Syntactic system
Fig. 5.4. The desired attractor.
Fig. 5.5. Paradigmatic forces. Gray: the trajectory of ‘stone’. Black: the force of ‘grass’.
Fig. 5.6. Sentence formation as a combination of unmarked and marked dynamics.
Fig. 5.7. ‘The dog is running towards the tree’
Fig. 5.8. Large magnification. The individual is seen as changing properties.
Fig. 5.9. F(P), f(Q)
Fig. 5.10. F(P Q)
Fig. 5.11. F(P Q)
Fig. 5.12. F(¬ P)
Fig. 5.13. Antonyms. F(¬ (P Q))
Fig. 5.14. F(¬ (P Q))
Fig. 5.15. Implication, dynamic version

Fig. 5.16. Venn Diagram.

Fig. 5.17. Change of extensions. P Q with P and Q moving together in the foreground.

Fig. 5.18. Change of intensions: P Q (background) changes to P Q (foreground).

Fig. 5.19. Robot, goal and two obstacles

Fig. 5.20. Force field of repellers and attractor

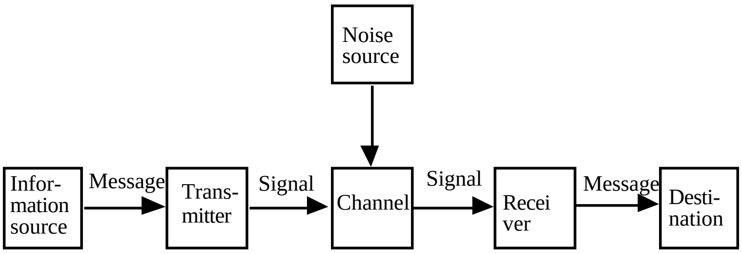

Noise
source
Infor-
mation
source
Message
Trans-
mitter
Signal
Channel
Signal
Recei
ver
Message
Desti-
nation

Fig. 3.1.

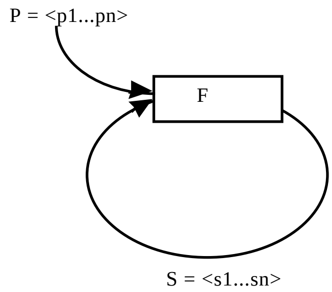


Fig. 4.1..

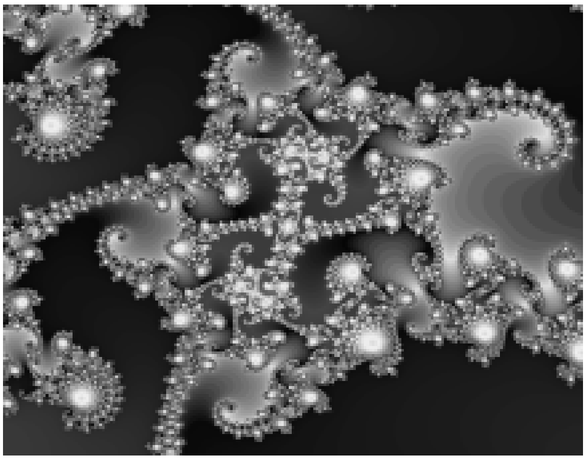


Fig. 4.2.

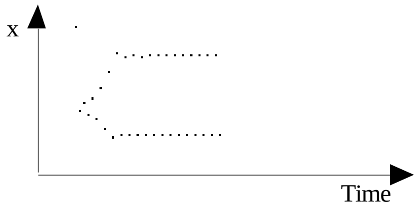


Fig. 4.3.

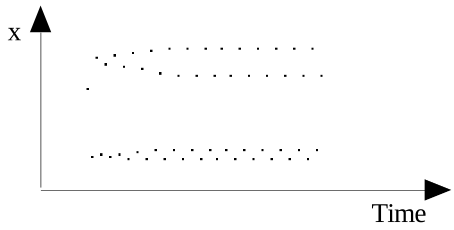


Fig. 4.4.

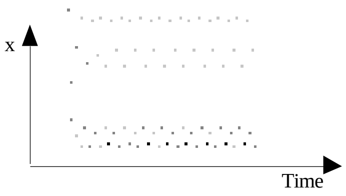


Fig. 4.5.

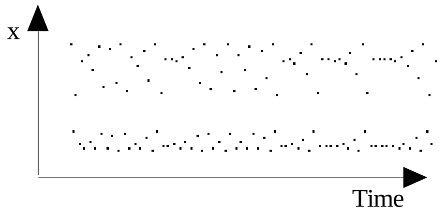


Fig. 4.6.

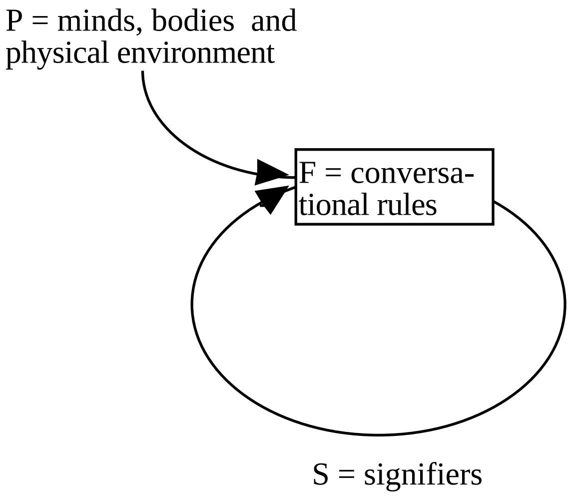

P = minds, bodies and physical environment
F = conversational rules
S = signifiers

Fig. 4.7.

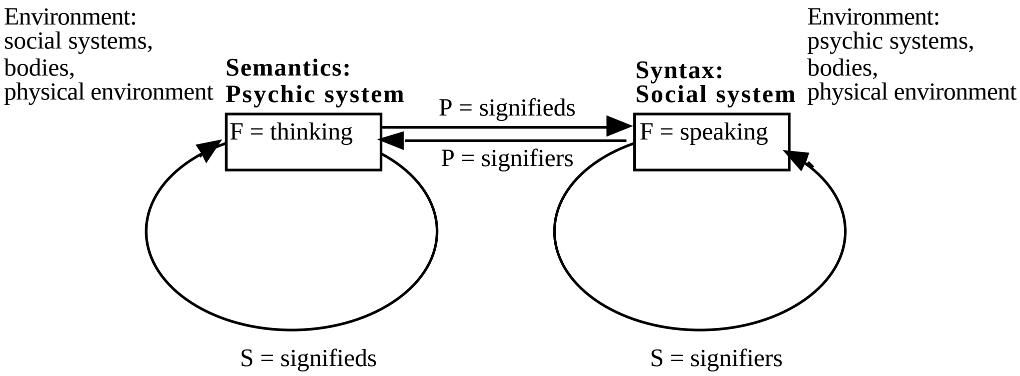

Environment:
social systems,
bodies,
physical environment
Semantics:
Psychic system
F = thinking
P = signifieds
P = signifiers
Syntax:
Social system
F = speaking
Environment:
psychic systems,
bodies,
physical environment
S = signifieds
S = signifiers

Fig. 4.8.

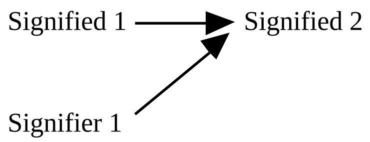


Fig. 4.9.

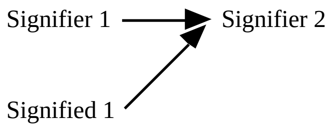


Fig. 4.10.

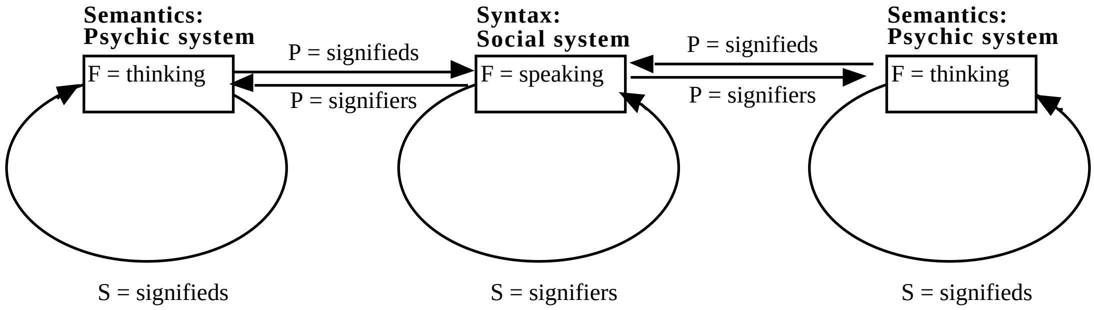

Semantics:
Psychic system
F = thinking
P = signifieds
P = signifiers
Syntax:
Social system
F = speaking
P = signifieds
P = signifiers
Semantics:
Psychic system
F = thinking
S = signifieds
S = signifiers
S = signifieds

Fig. 4.11.

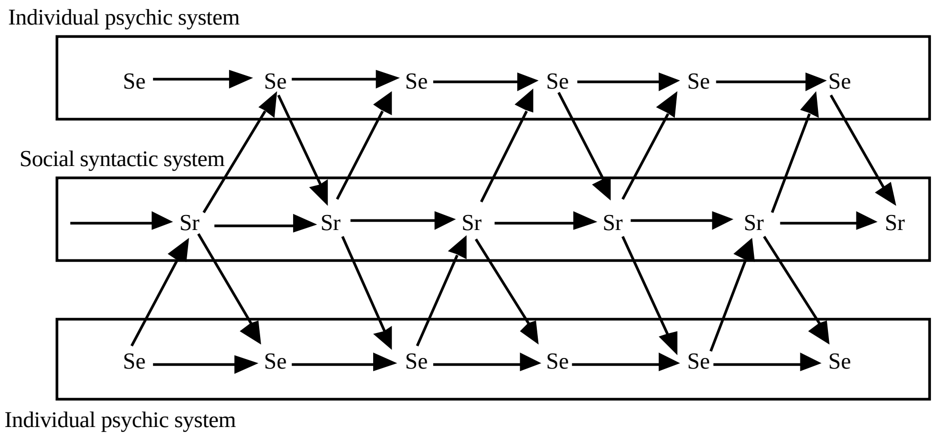

Individual psychic system
Se
Se
Se
Se
Se
Se
Social syntactic system
Sr
Sr
Sr
Sr
Sr
Sr
Se
Se
Se
Se
Se
Se
Individual psychic system

Fig. 4.12.

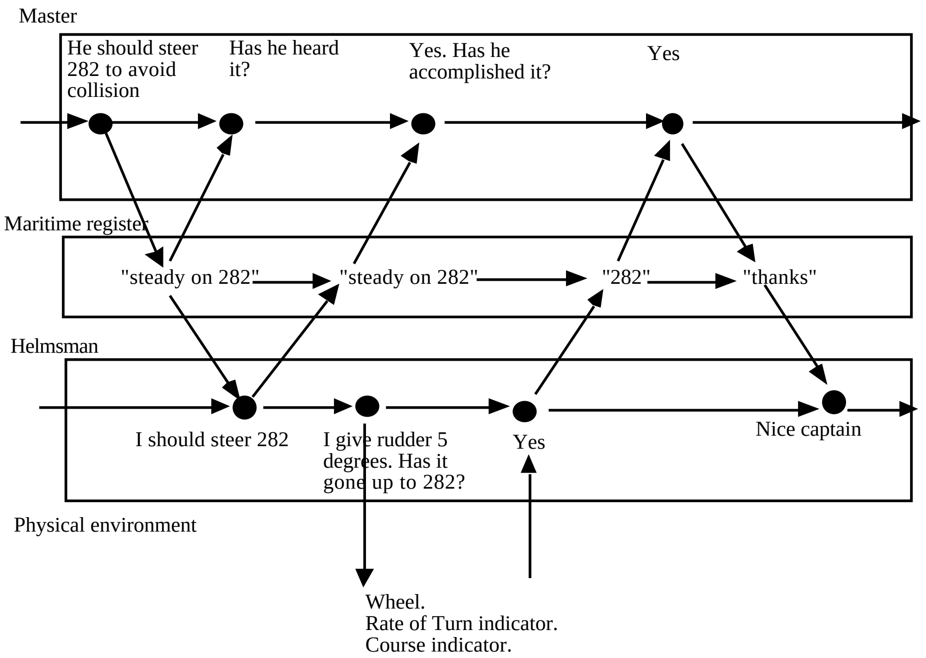

Master
He should steer 282 to avoid collision
Has he heard it?
Yes. Has he accomplished it?
Yes
Maritime register
"steady on 282"
"steady on 282"
"282"
"thanks"
Helmsman
I should steer 282
I give rudder 5 degrees. Has it gone up to 282?
Yes
Nice captain
Physical environment
Wheel.
Rate of Turn indicator.
Course indicator.

Fig. 4.13.

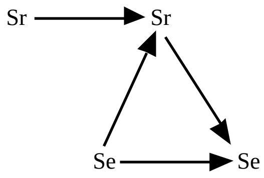


Fig. 4.14.

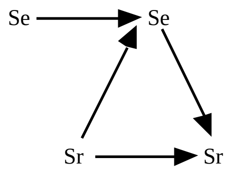


Fig. 4.15.

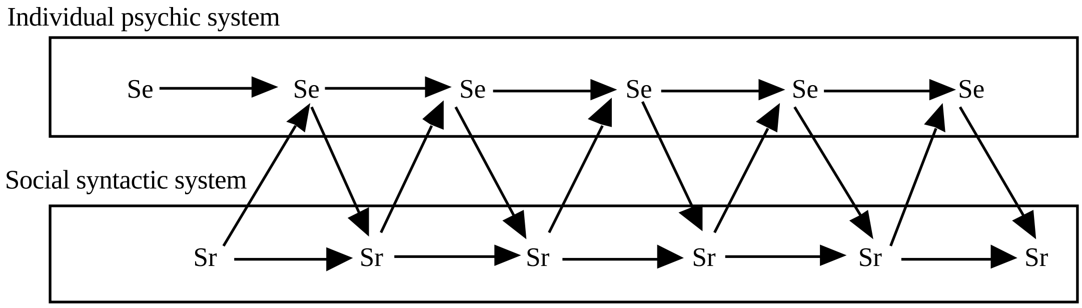

Individual psychic system
Se
Se
Se
Se
Se
Se
Social syntactic system
Sr
Sr
Sr
Sr
Sr
Sr

Fig. 4.16.

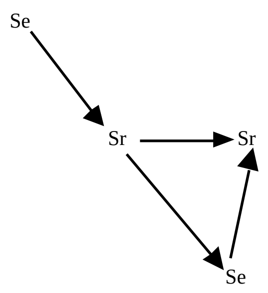


Fig. 4.17.

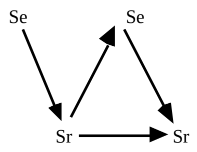


Fig. 4.18.

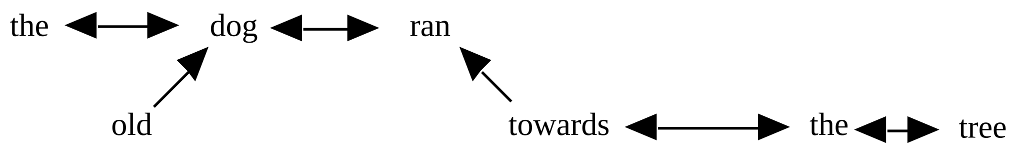


Fig. 5.1.

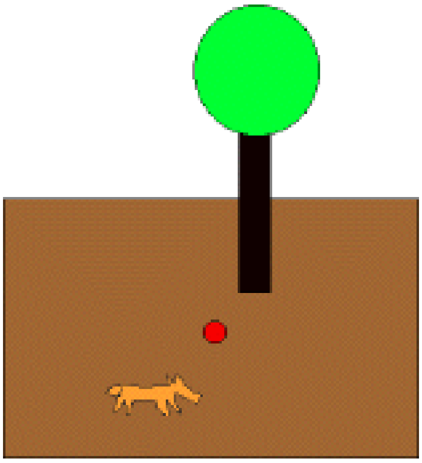


Fig. 5.2.

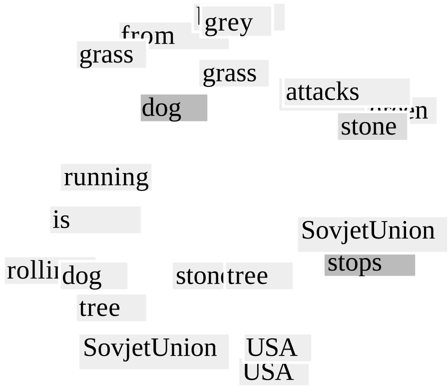

grey
from
grass
grass
attacks
dog
stone
running
is
SovjetUnion
stops
dog
tree
tree
SovjetUnion
USA
USA

Fig. 5.3.

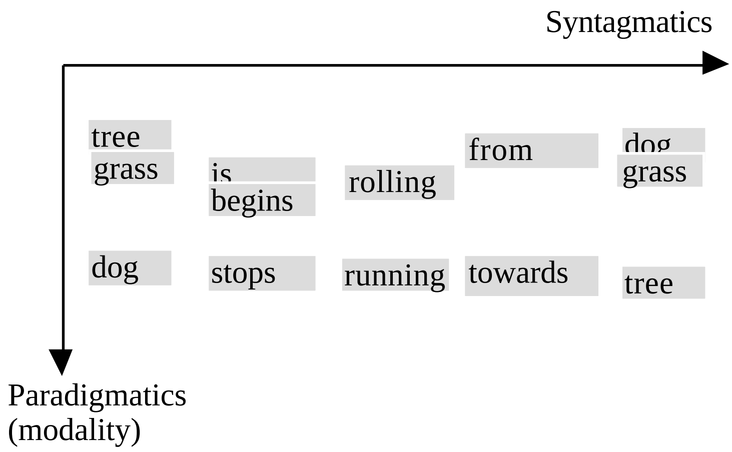

Syntagmatics
tree
grass
is
begins
rolling
from
dog
grass
dog
stops
running
towards
tree
Paradigmatics
(modality)

Fig. 5.4.

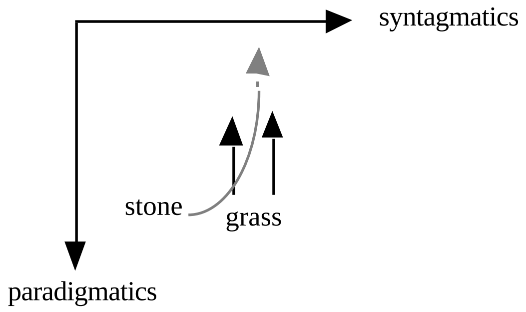


Fig. 5.5.

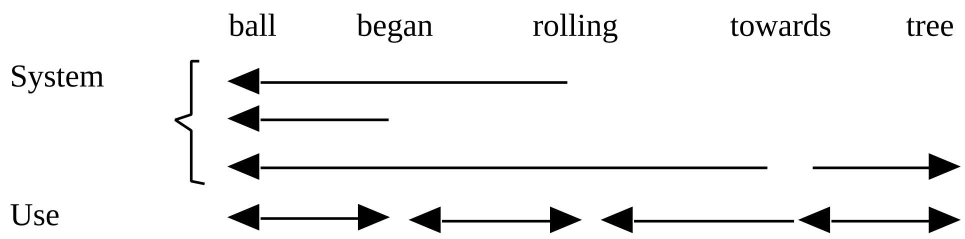
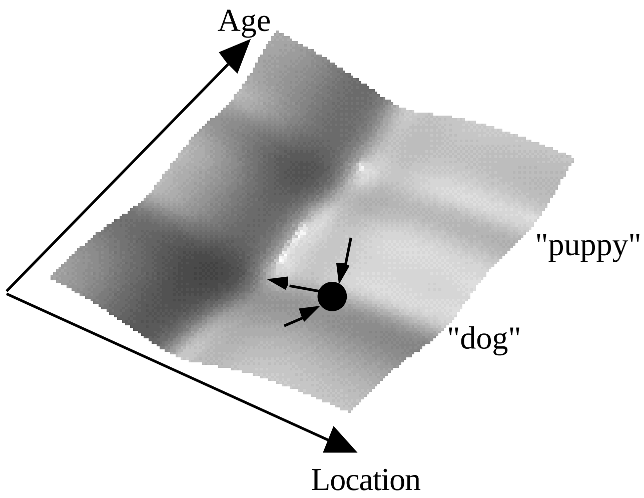


Fig. 5.6.



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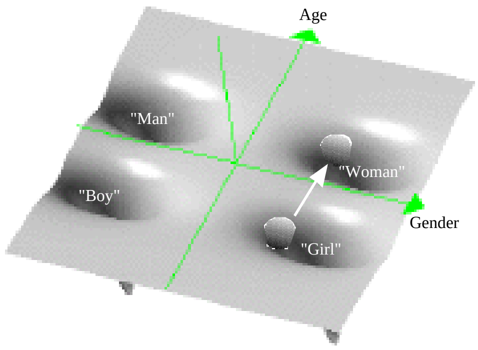
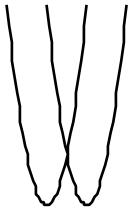


Fig. 5.8.



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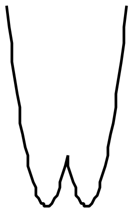


Fig. 5.10.

Fig. 5.11.

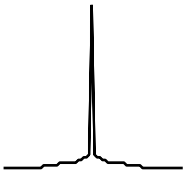


Fig. 5.12.

Fig. 5.13.

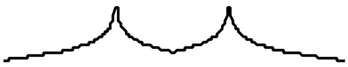


Fig. 5.14.

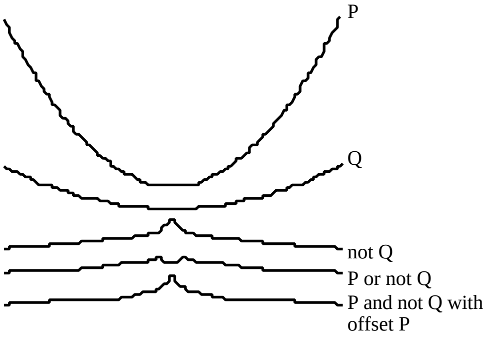


Fig. 5.15.

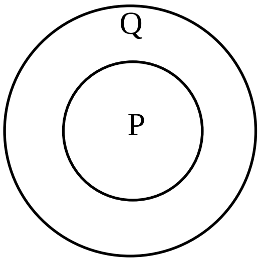


Fig. 5.16..

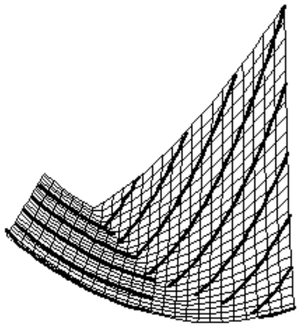
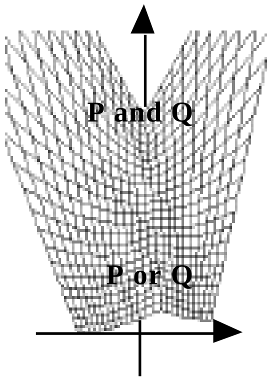


Fig. 5.17.



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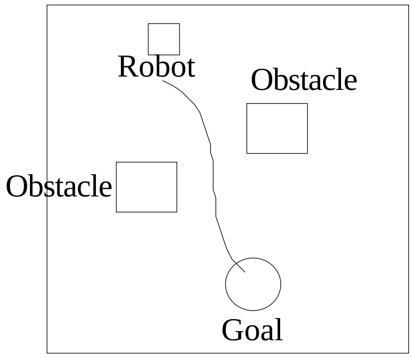

Fig. 5.19.

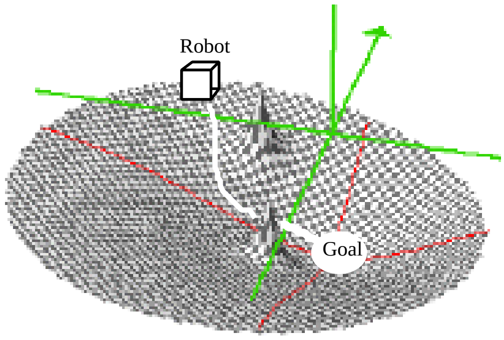

Fig. 5.20.

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[1] Possibly it should be the other way around, namely that the modifier attracts the head to itself. In this way one could explain the occurrence of expletives like ‘there’ and ‘one’. In ‘a blue one’, ‘blue’ is a modifier that cannot find a head to relate to. In the lack of better, it draws in the dummy word ‘one’.

[2] This is an example of perturbations from the biological system, which is also part of the environment of the syntactic system, as emphasized in Section 4.4. Another example of biological perturbation is intonation patterns that can be traced back to infant cries.