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SELF-ORGANIZING SYSTEMS AND TRANSFORMATIONAL-GENERATIVE (TG) GRAMMAR

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INTRODUCTION

For a linguist, one of the most interesting areas explored in management science, at least as taught at the Hochschule St. Gallen, is that known as systems theory. This branch of science deals with the nature of complex systems and describes their basic characteristics, so that students of management may learn better how to practice their art/science and thus avoid the pitfalls that await the rash and the overconfident.

Why, one may wonder, should the linguist be interested in what systems science and cybernetics have to say? The answer is relatively easy to give, namely, that the systems scientist has learned much about systems—especially complex ones—that can be of use to the linguist. The linguist is generally aware that language is indeed a complex system (and how!) but rarely has any very clear idea of the characteristics of systems in general or of complex ones in particular. That these have their own laws and features should be evident, even at a cursory glance, but most of us linguists tend to think that it is sufficient to have grasped that language is a complex system and that cognizance of this fact will preserve us from errors in our perception of what language is and how it works. This may be true at certain levels

The stimulus for this skirmish with self-organization came from a very interesting seminar conducted at the Hochschule St. Gallen by Gilbert Probst and Michael Ben Eli. I am deeply indebted to both of them for the insights they gave me. A stimulating discussion of self-organization can be found in Probst (1987).

of linguistic analysis, but, if we wish to achieve an adequate overview of language—the object of our study—then we must look to those who have expert knowledge of such systems as language. After all, we would (surely!) hardly dream of attempting to venture very far down the paths of sociolinguistics without first acquainting ourselves with the rudiments of sociological analysis, the classes that sociologist divide our society into, the reasons why they make these divisions, etc. If that is so, it is singularly imprudent to imagine that we linguists can simply dispense with the knowledge that others possess about systems, if for no other reason than that language is an excellent example of a complex system and exhibits many features that are characteristic of them.

Ferdinand de Saussure (1965) points out that it is above all through its systematic nature and structure that language works. A lexeme's meaning is determined not absolutely but by those of the lexemes that surround it and form a network of semantically related terms with it. Each lexeme's meaning is determined by those of all the others, there is nothing that exists without or beyond the system, and the same applies at the phonological level. The networks of relations at the lexical level are multilayered and multidirectional, and therefore highly complex.

At the level of grammar/syntax, the structures are even more complex, so that it remains a problem for linguists to produce a description at this level that can be called complete or can command general approval. This may be in part because we cannot agree on the way to describe language, and that is largely because we cannot agree on the nature of the phenomenon that we are setting out to study.

There are those who subscribe to the "structuralist" view, which concentrates on the structure of language and sees this as central to understanding what language is and how it works. However, others think that the foundations of language are laid elsewhere than in mere structure, and that is just the surface that language presents to the outside world, while keeping its deep structure hidden from the casual observer and user (I shall return to this point later). In any case, it should already be clear that one of the deepest divisions among linguists is due to a profound disagreement as to the nature of language.

OPEN AND CLOSED SYSTEMS

One can distinguish between two basic types of system: open and closed. Closed systems are the kind that, for example, obey the second law of ther-

modynamics and result in homogeneity, i.e., if two bodies at different temperatures are placed in contact, heat will pass from the hotter one to the cooler one until the temperature of both bodies is the same. These systems, of course, do not and cannot organize themselves. However, there are also what are usually called "open systems," where energy can be gained from the environment and used for the purposes of the system. Such systems can also adjust themselves as a result of many factors both internal and external. Clearly, language is an example of an open system, since it does not tend towards homogeneity and obviously organizes itself in the wake of various things that happen to it. A tendency toward homogeneity would presumably take the form of a reduction, over time, of the number of phonemes in a language's phonemic system. The fact that this is not visibly happening anywhere—at least if one takes the long-term view—suggests very strongly that languages are constantly receiving inputs of energy from outside themselves, in other words, that they are indeed open systems.

HOMEOSTASIS

If the second law of thermodynamics belongs to physics, other sciences can also contribute to our knowledge about systems. One idea that is used in biology and is relevant to systems is that of homeostasis, or dynamic equilibrium. This refers to the characteristic of many states of equilibrium whereby, if that state is disturbed, mechanisms intervene to reestablish the lost equilibrium. A simple example is the salinity of blood, which is maintained by a bodily mechanism at a given level, as is blood pressure, etc. The principle of homeostasis is clearly of relevance to language, since otherwise languages would change continually and at vast speed. The fact that it is impossible for an individual to make any significant impact on the language of his or her country shows that there are forces at work in the system of language that tend to keep it in a stable condition. The fact that, as de Saussure saw, *la langue* resides in the brains of *all* the users of a language is clearly responsible for this homeostasis, as is the simple fact of the arbitrary nature of the linguistic sign, by virtue of which it is impossible to use any other linguistic code than that used by those around one if one wishes to be understood when one says something. The connection between the concept "cow" and the sound sequence /kau/ is totally arbitrary, as is proved by the fact that the same is called /ku:/ in Germany and /vaš/ in French.

It is typical of social systems that self-organization is often employed to maintain an equilibrium that would otherwise be upset. A simple example is

quoted in Rapoport's "Pigs of the Ancestors." The lives of a society that he describes are organized to preserve homeostasis, largely through a set of rituals. The people share their environment with a population of pigs, which can live in harmony with the humans as long as its size does not increase beyond the point at which the pigs begin to intrude into the humans' sphere. When that point is reached, the human society becomes gradually more agitated until, more or less spontaneously, a ritual takes place in which a proportion of the pigs are slaughtered, thus reestablishing homeostasis.

In language, homeostasis arguably characterizes the ability to communicate meaning, which is after all the function of language. This ability is subject to a variety of attacks from outside the linguistic system, and yet language is always able to communicate what people require it to communicate, provided that the individual user is able to handle the language with sufficient skill. Interestingly, this capacity of language to defend itself operates, in a sense, blindly, i.e., no body or person sits down to decide what shall be done to counter a threat to the system's power to signify. There is a reaction in the mass of speakers of the language rather like that related by Rapoport, in which something happens in the mass of speakers that produces a countermove to the attack that is taking place on the system. For example, if part of the phonological system is eroded, thus causing the disappearance of a distinction that is important in the grammar of a language, then something will usually happen that enables the distinction to be made again with other means, e.g., a particle that was basically redundant because it was at best co-distinctive with the lost element may take over the signifying function entirely; alternatively, as a result of a reorganization of the language's resources, a new structure of the phonological system may emerge that will enable the distinction to be made nonetheless, but with a different phonemic basis.

SELF-ORGANIZATION

The following are a couple of examples of self-organization at work. First, on the phonological level, there are countless instances of the self-organizing nature of language coming to the rescue when the situation starts to become difficult. A look at the development of the Latin declension system should make clear the kind of event that comes under the heading of linguistic self-organization. Classical Latin had six cases, identified by endings, and was thus able to have very flexible syntax:

Petrus amat Juliam
Juliam amat Petrus
Juliam Petrus amat
Amat Petrus Juliam
Petrus Juliam Amat
Amat Juliam Petrus

All these meant the same thing, and this was made possible by the fact that the endings of the words indicated the case and therefore the function of each word in the sentence. By the Vulgar Latin (VL) period, due to phonetic erosion, the case system was beginning to disintegrate and, simultaneously, a new organization was emerging, which represented a sort of tidying-up of a rather arbitrary system, e.g., neuter plurals ending in $-a$ were often assimilated to the feminine *-a* (first) declension (*folium/a* > *folia/ae*). At the same time, the fourth declension nouns ending in *-us* were assimilated to the more numerous second declension (e.g., *portus*), and nouns of the fifth declension were assimilated mainly to the first declension (*rabies* > **rabia*), though a few passed to the third declension (*fides*), etc.

Here, we see a language tidying up a rather incoherent declension system, doubtless due partly to the disappearance of certain contrasts as a result of phonetic erosion (resulting in an even less coherent system than that inherited from classical Latin) and partly to a developing (unconscious) feeling among the speakers of Latin that the system of declensions was illogical and untidy anyway. In Old French, the VL flexional system (two cases) subsisted for a while due mainly to the preservation of final *-s*, and so there was a period of relative stability in the declensional paradigm. However, phonetic erosion is a force that never rests, and, roughly by the mid-14th century, the two-case system had collapsed. By about a century later, the remaining distinction (between singular and plural) had ceased to be manifested in the morphology of the declension system of the spoken language.

The disappearance of the case system (with the meanings that it expressed) was a weakening of the language's semantic power, so that the self-organizing feature of language came into play: the lost endings were replaced by particles (prepositions) which had already begun to be used together with the endings before the latter disappeared. Also, to enable the distinction between subject and object to be clearly made, despite the phonetic collapse of the endings that served to make this important distinction, the language gradually evolved a system of more and more rigid syntax, so

that, in modern French, one knows that the subject, in an affirmative clause, will almost always come before the verb, the object after the verb.

Thus, in its passage from classical Latin to modern French, the language has constantly marshalled and organized new resources and strategies to counterbalance losses caused by phonetic erosion. In so doing, it has passed from free syntax to rigid syntax, from the category known as "synthetic" (using endings to denote grammatical relationships between words) to that known as "analytic" (using words and syntax for that purpose), entirely by its own self-organizing dynamics.

Some linguists feel a degree of uncertainty as to the exact relationship of cause and effect here; in particular, some argue that it was the very fact of the presence of the substitutes that led to the decay of the declension system—the endings were redundant and could therefore disappear without any very grave consequences for the communicative power of the language. This viewpoint seems rather questionable to me because phonetic erosion is a real and powerful force that does not wait for a favorable terrain on which to get to work. It operates without regard to its own consequences and is unlikely to be affected by the presence or absence of substitutes for the elements that it weakens or destroys.

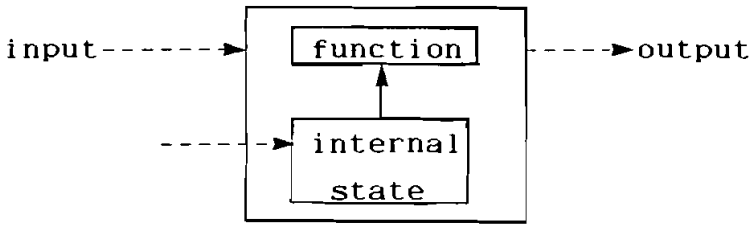
At most, one might concur that the presence of usable substitutes may have speeded the process up a little; clearly, it would obviate the need for the language to struggle to prevent the loss of the endings, and to that extent the substitutes were in part responsible for the demise of the case endings. Such considerations are doubtless irrelevant to the point that I am making, but I felt that they should nonetheless be pointed out. In any case, the events speak for themselves and show how a language can organize itself to recreate order out of impending chaos. It must do so because, if its system breaks down, its communicative power is lost, since we can only communicate via language as long as we share the same conventions. If phonetic erosion disrupts the system, then it also disrupts communication.

COMPLEXITY: TRIVIAL AND NONTRIVIAL MACHINES

Another characteristic exhibited by systems is complexity. This feature, which is also found in language, involves a distinction by cybernetic ians between trivial and nontrivial machines. By "machine" is meant not a mechanical device but something that behaves like a machine, in that its internal state and the state of its surroundings define the next state it will go to. A

trivial machine (TM) is characterized by the relationships of three elements: input, function and output, which one could represent thus:

or: $y = Fx$. A TM's behavior is independent of the machine's history, i.e., events will not modify the way in which it reacts to a given input. In other words, it is predictable. It is thus analytically determinable, even if it is a black box to the observer. On the other hand, a nontrivial machine (NTM) is not independent of history, so that it is liable to change its response to what happens to it or, more accurately, to its internal state, the latter being influenced by what happens to the NTM as well as by developments that are internal to the NTM's internal state. An NTM is, therefore, both unpredictable and analytically undeterminable. One could represent this situation thus:



The function may be analyzable as a TM, but it is influenced by the machine's internal state, so that it can change at any moment and the machine's output can also change. Thus, it is truly unpredictable, and this is a quality that comes from the nature of the machine itself. This is an important point, namely, that the difference between a TM and an NTM is not quantitative but qualitative. An NTM is not just a collection of TMs whose output is predictable if the input is known. The internal state of the NTM influences the machine's output so that we can never be absolutely certain what will emerge. So an NTM represents not just a collection of TMs which, being all predictable, would produce a predictable result, but rather a different *type* of machine. Managers often behave as if management were a TM; clearly, some parts of management are TMs, but it is a trivialization of management to hold such a view, since, if some parts of management are TMs, others are not, and management as a whole simply has to be an NTM.

Language too has to be an NTM, given its very nature as a highly

complex phenomenon involving the simultaneous operation of many different and complex mechanisms, with the ever-present possibility of one mechanism influencing the other. The influence of phonology and syntax on the meaning of an utterance is all too clear, but intonation and stress also affect referential meaning. Then there are the other layers of meaning, such as connotative, pragmatic, affective, and collocative meanings. Since these can also influence one another, the system of a language clearly has little in common with a TM, from which it differs qualitatively by virtue of the nature of its complexity.

RECURSION

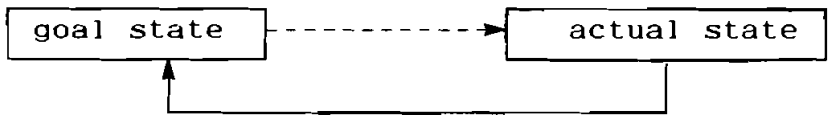
Recursion exists inevitably in language because of the very nature of language and of its relationship with the society that uses it. It is clear that language is its own environment, or, put another way, that it is (adults') language that propagates language in children, just as today's linguistic usage is what produces tomorrow's usage in adults. To a certain extent, too, today's usage produces next year's language, e.g., today's slang words quite often become everyday words in 1 or 2 years' time. While not wishing to get involved in a discussion of the (still uncertain) origins of language in human beings, I think it is arguable that the mere fact that language is in use in society (and acquits itself so well of the tasks that we entrust to it) is the main reason why its use is continued from generation to generation. One might incline to the view that, if language did not exist, we should have to invent it, but that does not invalidate the idea of recursion, which implies that, for language to be brought into existence in each infant, it must already be there in that child's world, i.e., used by his/her parents and by the other adults surrounding the child. Language is part of the situation that it refers to and encodes, since it is all-pervasive and is the means by which the situations in which it is used are talked about.

I have already edged, in the above, to a second view of the ontological nature of language. A society and the language that it uses are bound together inextricably, so that the language expresses much about the society (not least because it is that society's principal means of expression), and it is hard to imagine one without the other. If there were no society, there would be no reason for language to exist. Equally, if there were no language, it is difficult to see how society, especially today's highly integrated society, could exist. Thus, in a sense, and on given level of abstraction, language and society are but two aspects of the same reality, and to that extent too there is

an ontological relationship between these two aspects of the same reality. Moreover, by virtue of its evolution, society constantly puts new demands on language, causing it to evolve partially in its (society's) own image. So language and society both presuppose each other.

FEEDBACK

It is important not to confuse the idea of recursion with a similar but quite different concept that is also important with regard to systems, namely that of the feedback loop. The latter is involved in homeostasis, and functions by means of a constant comparison between the actual state and a goal state, and produces adjustments aimed at bringing the former back to conformity with the latter as soon it diverges from it. One could represent a feedback loop by the following diagram:



The purpose is to maintain a stable situation, and the process has nothing to do with something producing itself. On the other hand, recursion is all about an evolving situation, about reacting and adjusting to it.

REDUNDANCY

Another important feature of self-organizing systems is redundancy. This is a mechanism by which such systems maintain their stability, because it means that, if an element should cease to be available or efficient, there is a standby waiting to replace it. This basic principle of all good, organized activity is found not only in any properly designed space shuttle and in the best-designed management structures, but also in language. Earlier, I said that language possesses a homeostatic force. Part of the mechanism of this homeostasis is provided by redundancy, as many elements of language, both grammatical and lexical, have considerable degrees of redundancy built into them. For most words, there is a synonym available, should the word suddenly drop out of use for some reason.

Indeed, as suggested earlier, the very presence of the synonym means that it is possible for a word to simply die out without any visible ill effects

for the language. Of course, the system of semantically related words of which the lost word was part will be changed, so the semantic value of each of the remaining words will also be changed, but this will probably be of little consequence, since the disappearance of a word probably occurs mostly in cases where the word is no longer needed because the thing that it referred to has ceased to exist.

Thus, the loss of the word in fact only constitutes an adaptation of the language to the external reality that the language relates to. A simple example would be the word *yatrov*, which, in 19th century Russian, designated the husband's brother's wife. This relationship used to be important, since it designated a woman from outside who had married into the father-centered household. The significance of this status has entirely disappeared nowadays, and so contemporary Russian has dropped the term and organized the network of Russian kinship terms into a different structure, which reflects lexically the kinship structure of contemporary Russian society. Another example of redundancy is the changes, mentioned above, that took place in the declension system of classical and vulgar Latin and Old French, during the evolutionary process that ends in modern French. The redundancy of the case endings—because of the presence of particles that could be used with them, thus making the endings only co-distinctive—paved the way for the final collapse of the case system under the assault of phonetic erosion. The redundancy of these endings, apart from facilitating their demise, also meant that the homeostasis was not disturbed: the language's ability to transmit meaning was in no way impaired.

AUTONOMY

Yet another characteristic of self-organizing systems is autonomy. By this is meant that complex systems are composed of networks of semiautonomous wholes. To my mind, this concept applies to language at various levels and adds a useful dimension to thinking about the nature of the linguistic system. It is clear that the different levels of linguistic structure are autonomous with regard to the others. Thus, a language's phonological structure is autonomous and not visibly constrained by grammar or lexis. Equally, these two also possess autonomy from each other and from phonology: each level of language can evolve in any way without being hampered by another level, a tendency that is favored by the fact of redundancy discussed above. If one moves outside language itself to those who use it, one notices that users possess autonomy with regard to their language because they are free to use

it or not to use it (though they would probably not refrain from using it for very long, whether for interpersonal communication or for talking to themselves).

They are also autonomous with regard to the system of language, though this is a very limited autonomy, since, while neologisms are tolerable in small numbers, they will render communication very difficult if not impossible if they become too numerous. By neologism, I am referring to the lexical level, but the user of a language may invent on other levels of language, e.g., the grammatical level. Departures from standard grammar are much more likely than neologisms to cause a breakdown of communication, though clearly they can be of varying gravity; for example, a person who decides to reverse the usual order of subject and object in sentences will probably not be understood, but one who decides not to use the genitive *-s* will probably not cause much confusion in his/her listeners. However, as a general rule, one can say that individual innovation in language is counterproductive and for the most part doomed not to be copied by other users, except on very rare occasions. This is partly because of the autonomy of all other users but mainly because of the autonomy of all other users but mainly because of the homeostatic nature of the system. After all, the system is a set of conventions and belongs to everybody who speaks that language. Linguistic (indeed all semiotic) conventions are by definition homeostatic. If they were not so, communication would be impossible, because there would be no shared basis for constructing and comprehending an utterance.

Conventions are also by definition arbitrary, as de Saussure pointed out, which means that they are not motivated by anything external. Therefore, they can change, though probably gradually rather than suddenly. There is no reason why, in classical Latin, a horse was called *caballus;* that is why, in French, it is called *cheval.* Had there been any motivation for the designation *caballus*, it would probably still be the word used in modern French to refer to a horse.

Autonomy has another aspect with regard to language. A language is a highly autonomous system in itself, as is witnessed by the lack of success of those who set out to change it in any way. Given the homeostatic nature of linguistic systems, this is not surprising, but it seems to me worth pointing out that those who set out to influence language in any way are doomed to fail, except perhaps primary school teachers, who may just succeed in drumming a few precepts into the heads of their pupils. Politicians, the media, self-appointed experts, and many others all try, but without the slightest hope of success. Given its important role as a focus of personal, regional, and

national identity, it is not surprising that language is highly refractory to direct attempts to influence it. Thus, attempts by the Norwegian government to make Norwegians speak Nynorsk have so far failed and even produced a quite unexpected turning back to a more archaic form of Norwegian by many people. Likewise, all efforts by the British government have so far failed to revitalize the Welsh language, and, in India, attempts to impose Hindi as the official language have equally failed, as is tacitly admitted by the attribution to English of the status of "associate official language."

EXAMPLES OF SELF-ORGANIZATION

After this brief look at some of the characteristics of self-organizing systems and the ways in which these characteristics are also found in language, I should like to list a few aspects of language that could be construed as reflecting the self-organizing nature of language.

Firstly, on the level of phonology, the way in which a language organizes its resources into a coherent system is fascinating. If one looks at a typical system of plosive consonants,

(voiced)	b d g
(voiceless)	p t k

one is struck by its symmetry. This symmetry is not purely external to the system, but is an essential part of it, though why this is so goes far beyond the scope of this paper. If, in a given language, the phoneme /b/ were to cease to be used in final position, this would produce an asymmetrical system of final plosives:

(voiced)	d g
(voiceless)	p t k

Such a system is inherently unstable because of its own asymmetry and because it is also asymmetrical with the system of plosives in other positions. If a situation of this type occurs, it is bound to provoke a tidying up of the system, either by the shifting of another phoneme to occupy the space vacated by /b/ or by the unvoicing of all final plosives or indeed of all final consonants, with the result that final /d/ and /g/ are replaced by final /t/ and /k/, and the gap left by final /b/ is occupied by final /p/. Such an unvoicing may in fact have already begun generally, so that the disappearance of final

/b/ was only an initial (and slightly unsynchronized) sign of the impending shift. In any case, it is interestingly easy for two plosive paradigms (final and nonfinal) to coexist in a single language (e.g., German) without the asymmetry between the two paradigms causing any problems or provoking any attempts to tidy up the system.

System, at least in language, seems to imply a sense of tidiness or symmetry of structure, presumably mainly because of the nature of human thought and perception processes. A rather simplistic expression of one of the laws of physics says that Nature abhors a vacuum; so do languages. This is why the gapped distribution of final plosives discussed above is bound to be unstable, i.e., the economy of the language's organization has been upset and made asymmetrical. Such an event will almost inevitably provoke a language's self-organizing element, so that order is re-created with a minimum waste of phonetic resources. A fascinating example of how economically phonetic changes can operates is the well-known first sound shift (also called Grimm's Law) that occurred in the transition from Proto-Indo-European to Proto-Germanic; this sound shift can be represented in a slightly simplified form:

Aspirated voiced plosives		Voiced plosives		Voiceless plosives		Voiceless fricatives
bh	>	b	>	p	>	f
dh	>	d	>	t	>	θ
γη	>	g	>	k	>	h

While the exact chronology of these changes is uncertain, it is also not directly relevant to the point that I wish to demonstrate, namely the *economy* of the changes that occurred. Thus, both types of plosive consonant were retained, and the net result of the immense shift was the disappearance of the aspirated plosives and the appearance of the voiceless fricatives. Where feasible, known territory was occupied rather than abandoned, thus minimizing the wastage of available phonetic resources.

We can see language's self-organizing element at work elsewhere, e.g., on the morphological level, if we look again very briefly at the example, discussed above, of the disappearance of case endings and the consequent increasing use of particles to indicate relationships that had originally been expressed by endings. The endings also served the purpose of indicating whether the noun was singular or plural, so that, with their demise, it was

often difficult to know, from the form of a word, this important piece of information. To remedy this undesirable situation, the definite articles, which had, until then, been optional, were given the function of distinguishing singular from plural, and thus became compulsory. The definite articles, interestingly, are derived from what were, in Latin, demonstrative adjectives (*illus*, etc.), whose demonstrative force obviously weakened with their increasingly frequent use as articles. This shift of the demonstratives into an article function, which was itself probably the result of the language's self-organizing capacity, caused a further piece of self-organizing to occur: as the original Latin demonstratives were becoming definite articles, new demonstratives were created to fill the opening gap in the language's resources; this process, by the way, had probably begun in the Vulgar Latin period.

Self-organization does not occur only at the phonological and grammatical levels; it can also be seen operating at the semantic level, indeed at that level, it is the system that is everything. One simple example will suffice to make the point clear. A language's basic color terms, however numerous they may be, are usually so organized that they cover the whole of the spectrum. This will be the case, even if they are only three in number. The same are of spectrum can equally be covered by eleven color terms, and the number of areas that the spectrum is divided into by a language corresponds (according to Berlin and Kay, 1969) to the degree of technological sophistication of that society. It is arguable that, as a society evolves technologically, its language's color-term system evolves simultaneously, adapting itself to the changing circumstances and needs of the society concerned. So a language can be seen as self-organizing on the semantic level, since it adapts the meanings that it can express to the needs of its users.

A good example of self-organization at work in language is the way in which it constitutes a constantly changing but at the same time faithful mirror of the society that uses it. The tenor of the so-called Sapir-Whorf hypothesis is that language shapes the thoughts of its users by virtue of the words (i.e., meanings) that it contains as well as by the nature of its grammar (i.e., by the way of seeing the world that the grammar encapsulates). The most famous example of this idea quotes the Amerindian language Hopi as a classic bender of thoughts. Hopi possesses a verb grammar that is strange to speakers of Indo-European languages. It includes, among other things, a system of nine voices (e.g., active, passive) and nine aspects (e.g., continuous, perfective, iterative). It seems obvious that the speaker of Hopi will have a somewhat different view of the world from that possessed by a speaker of English. The extent to which language shapes peoples thoughts is

still the subject of much debate, but there seems little ground for denying a degree of influence of language on thought patterns, and one's experience of talking to speakers of other languages provides enough evidence to leave little room for doubt that language shapes thoughts to some extent.

The Sapir-Whorf hypothesis does not only argue that language shapes people's thought processes, it also sees a counterpart of this in a gradual shaping of a language to suit the needs of its users by a process that one could call self-adaptation. Typically, if a thing for which there is no readily available word comes into existence, the language will react by supplying a word. Looking more closely at what happens here, one could analyze it as a process in which perhaps an individual creates the necessary word; however, the individual's creation will not become the name for the thing concerned unless the language picks up and puts its seal of approval on the new word. One is tempted to argue that, in such a case, the language itself has not really done anything except adopt the invention of one of its speakers. Such a point of view has some merit; however, it is possibly a mistaken perspective on the question. One could equally take the view that a language is not in practice separate from its speakers, even if linguists—for obvious reasons of scientific convenience—work on the basis that it has a separate existence. The simple fact that a language to all intents and purposes ceases to exist if its users die out suggests the intimate link between a language and those who use it, a link whose upshot is that it is difficult, in the end, to separate one from the other. Given this fact, it could be argued that, when a speaker of a language invents a word for something, this in fact corresponds to the language inventing the word, since speaker and language are essentially inseparable.

Ullmann (1959, p. 300) expresses very well the relation between a language and its users, when he states,

> Dépositaire de l'expérience accumulée des générations passées, il [le système linguistique] fournit à la génération future une interprétation de l'univers.

This expresses very well how people shape language by their lives and thoughts about the world around them. The words that they use to talk about their lives and the world around them, the way in which they talk about these things, and their experience of life will inevitably leave an imprint on them and, through them and their language, on the language of the next generation. This store of experience will be particularly obvious at the lexical level,

and will naturally influence how the next generation of users of the language sees the world, because it will provide the words, and therefore the concepts, by which the world will be analyzed and categorized. It is more difficult to see instances of how the grammar of a language is shaped by people's experience of the world, and one is tempted to think that, in this case, the influence is largely from language on thought processes, unlike what happens at the lexical level. The example mentioned above of the disappearance of the case system of classical Latin is difficult to interpret as a shaping of the language as a result of which it reflects better the lives of its users, unless one falls back on vague notions such as economy of effort, which is often invoked to explain phonetic changes. It seems to me difficult to extract much illumination of the phenomenon from the idea that speakers of Latin were, somehow, making an economy of effort when the case system was simplified. After all, the same meanings still had to be expressed, but, after the simplification of the case system, these meanings had to be expressed by means of the particles that had, until then, been co-distinctive. The only arguable economy of effort could be seen in the fact that it became unnecessary to use all the classical Latin endings because the particles, which were often used despite the fact that they were redundant, were there anyway, so they might as well be the bearers of the information that was otherwise encoded in the case endings. This means that it was not the particles that were perceived as redundant but the endings, which is presumably why they gradually disappeared from use.

I think it has arguably been established, in the preceding discussion, that language is indeed a self-organizing system. This is confirmed by its conformity with so many of the characteristics of such systems, in particular with the open, complex type of system. Language is characterized by homeostasis, complexity, recursion, redundancy, and autonomy, all of which also characterize complex systems.

METHODS OF ANALYSIS OF TMs AND NTMs

It would be useful to draw one further lesson from the theory of complex systems which is very relevant to linguistics. I am thinking of an aspect of system theory that relates to methods of analysis of TMs and NTMs (see above) and that concerns the applicability of various approaches to the problem of analyzing such systems.

The function element in a NTM may be analyzable as a TM, but this does not reflect the actual nature of the NTM, because, unlike what happens

in a TM, the function in an NTM is influenced by the machine's internal state, and so produces an unpredictable output. This is not just a quantitative difference, because, if one put *n* TMs together, one would still not arrive at an NTM, for the simple reason that a series of TMs will give a predictable output, however many of them there may be, because the output of each TM is itself predictable. The pathway to the final output may be complicated, but it can be computed, and its point of arrival is determinable.

Thus, however complicated it may seem to a nonmechanic, a car engine is a TM, because each of its phases can adequately be reduced to a TM. One is tempted to think that the engine's internal state is highly relevant to its output, and this is true, but that internal state itself is in reality reducible to a series of TMs, each of which is perfectly comprehensible to a good mechanic. Thus, if the mechanic knows all the parameters of the engine, he or she can say that it will (or will not) function correctly. If the engine will not function, the mechanic traces the fault by analyzing a series of functions whose output is predictable because they are TMs. When the mechanic finds the fault, he or she corrects it. Provided there are no other faults, the engine is bound to function correctly. If it does not do so, then the mechanic knows that something else is also wrong, but it too can be localized and corrected. In the end, the engine will function according to its specification.

Indeed, the existence of a specification is an unambiguous statement that the engine is indeed a TM, for a specification of an output means that the horsepower produced at the end of the very complicated process is predictable, despite the complicated nature of the process involved, and is in fact predictable with a considerable degree of accuracy. Thus, it is clear that what one might call the internal state of a TM (in our example a car engine) is not comparable to the internal state of an NTM because the internal state of even a complicated TM can be reduced to a series of TMs and it has a predictable result for the function of the (complicated) TM.

The situation is quite different if one looks at an NTM. Here, the output is unpredictable even if the function of the machine may be analyzable as a TM, and this is because the internal state of the machine influences the output. this internal state is not comparable to what one might call the internal state of a TM, because, in the case of a NTM, it is not determinable for the simple reason that it is not reducible analytically to a series of TMs. The difference, therefore, is not a quantitative one, since the output of a network of a thousand TMs is predictable. It is a qualitative difference because the output of even one NTM is unpredictable.

It seems to me that linguists could perhaps learn something from the

theory of systems because language is a complex system *par excellence* and because cybernetics has formulated a whole body of theory and knowledge relating to systems that is relevant to language. I hope the demonstration of language's belonging to the category of complex systems can be taken for granted. I also hope that it has been clearly demonstrated that language is a NTM with self-organizing properties characteristic of such open systems, e.g., homeostasis, complexity, recursion, redundancy, and autonomy.

What particularly interests me is the question of the overall approach to the scientific study of language. There are reasons for thinking that the knowledge of systems gained by cybernetics should be taken into account when we linguists formulate our most fundamental ideas on language, since otherwise we run the risk of making unnecessary and avoidable mistakes. Here, the idea of the TM and the NTM would appear to offer a basis for evaluating the theories that inform our whole linguistic philosophy.

The now old-fashioned (at least in some people's view) structural approach to language sees the idea of system as profoundly important for our understanding of the linguistic phenomenon. It puts system at the center of the mechanics of language and recognizes that there are levels of organization in language that overlap and form complex structures. In this, it evaluates appropriately the role of system and accords it adequate recognition.

The dominant theory at the moment (though one that is perhaps decreasing in popularity) sees language from a very different point of view, and stresses the rule-governed nature of its workings. The deep structure of a language produces, by means of a series of transformational rules, a surface structure, which is the vehicle by which the deep structure is transferred from the speaker to the listener. This surface structure is formed, then, by the application of rules that organize the transformation process and include *inter alia* the notion of recursion (see above), though not with quite the same significance as in systems theory.

Looked at from the standpoint of systems theory, though, transformational-generative (TG) grammar contains one basic error in its approach to the study of language, namely, that it fails to make the distinction between TMs and NTMs. By trying to reduce the functioning of language to a collection of rules that produce a predictable outcome, TG grammar fails to perceive that language is by its very nature a complex system that cannot have predictable outcomes (though some may be successfully predicted), in other words it is an NTM, not a TM, which is what TG grammar attempts to reduce it to. The approach is bound to fail because it is a trivialization of an NTM to approach it as if it were a TM. Those who do so must fail to

perceive the full reality of the object that they are studying and will also inevitably fail to arrive at the correct analysis of it. So TG grammar is fatally flawed and can no more produce the correct answers than could the structuralist approach before it. Indeed, it is hard to avoid a sneaking suspicion that structuralism was a little closer to the correct path than is TG grammar, but that may be a mistaken idea. In any case, it seems arguable that the advances made by systems theory should be borne in mind by linguists, who have, until now, been content to ignore this related and very relevant science.

The significance of the above thoughts is that those who are looking for a new way to approach language are right to do so, since linguistics is currently exploring what looks rather like a dead end. A better approach would be one that took account of the ground already cleared by systems theory. It may seem rather difficult to incorporate this knowledge into a theory that will give us the leverage that we want, but it is doubtful whether we shall reach our goal if we use the wrong tools in our analysis. Indeed, since much of the argument among linguists concerns basically the intellectual tools used in linguistic analysis, it is all the more important to be certain of starting from the right point. De Saussure placed linguistics firmly in the context of the broader science of semiology, and semiology must of necessity be informed, at least in part, by systems theory. Since this is so, one basic fact is clear: we cannot expect to make real progress until we have assimilated the basis of systems theory.

How an adequate theory might look is not easy to say, though it is easier to stipulate what it should do, namely, take into account the elements of language which derive from its nature as a complex system, and which tell us certain things about language before we even start to examine it. We already know some things about language, such as that it will display homeostasis, recursion, redundancy, etc. These do not need to be documented *in extenso* and should be incorporated into our highest level of theorizing about language. In particular, though, if linguistics is to progress, the theory must take account of the difference between a TM and an NTM. The concrete consequence of this is that our theory will probably have to be more complicated than hitherto in order to somehow encompass the extra ideas. On the other hand, the idea that language is an NTM may make life easier because we can give up looking for the philosopher's stone, for the theoretically impossible entity, namely, a theory that will explain all about language in terms of predictable outcomes. As it is impossible to predict the output of an NTM, the same must also be true for language. Thus, we can, with an easy conscience, cease to look for the answers to certain questions for the

very simple reason that there is, in a number of cases, no predictable answer. This fact is recognized by historical linguists when they trace the development of Latin into French, Italian, Portuguese, and Spanish; it is difficult to cling to the idea of predictability of outcomes in the face of such a diverse collection of languages that are derived from the same root.

Therefore, linguists can give up looking for some basically unfindable things. This might be thought of by some as rather unscientific, but it is really rather the opposite, since it is surely more scientific to recognize the error of one's approach and correct that error than to persist in it despite the evidence that the search is pointless. Clearly, this suggests that the desire to reduce language to a series of transformational rules is misguided, because they do not provide an adequate tool to come to grips with the problems, failing, as they do, to recognize that the system of language is such that an analysis based on a TM approach does not operate on an appropriate level. Just as the NTM's internal state influences its output, so language's equivalent of that internal state influences language's outcomes. It is hard to state what the internal state is, but it must presumably reside somewhere in people. Just as people are unpredictable, so is their language.

One might wish to speculate further about the shape of a better theory of the nature of language. What elements it would contain I find hard to say. What I can say is that it will necessarily take account of the facts of systems theory and will thus not pretend to answer unanswerable questions or to provide information that cannot be provided. It will presumably not make out that language is based n a system of rules that each determine a predictable outcome. It will accommodate the inherent vagueness of the situation and thus be able better to reflect the reality of language. For me, this means that it will abandon the attempt to arrive at a series of equations that enable the creation of language, at least inasmuch as they are supposed to be a reflection of what language is about. On the other hand, I can quite imagine that such activities might be of use in machine translation or the like; however, I insist that they are not respectable on the level of theory. The distinction between surface structure and deep structure is a useful one in certain circumstances, but it unfortunately hides the important fact that the two levels are different, not only because one is generated from the other by means of a series of transformational rules, but also because a language's surface structure is of a different order of complexity than is its deep structure. At the surface level, language is an NTM, whereas it may be a TM at the deep structure level. Therefore, it seems to me, we have to look elsewhere than in TG grammar for the basis of an adequate theory of language.

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