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On the relationships between the biological realm and the semiotic realm

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Abstract

It could be suggested that every semiotic interpretation is represented in the cognitive systems of an individual. Since they are located in the brain, the cognitive systems have to be biological. However, in some complementary way, the structure and the function of such biological systems are conditioned by semiotic information, and semiotic information has its origin in the cultural environement of the individual. In other words, depending on the point of view, every semiotic interpretation can be considered not only in terms of the social context, but also in terms of the natural world.

I aim at showing that Neurocognitive Linguistics (Lamb 1999, 2004, 2005, 2006) helps us to understand that there is a biological basis for the semiotic realm. Concretely, relational networks developed by this neurolinguistic theory (which are neurologically plausible) help us to represent (some part of) the linguistic and cognitive systems of an individual. Those systems, which must have their biological basis in the brain, allow an individual to produce or to interpret signs, which *are not* part of such internal systems.

*Keywords***:** signs, social context, cognitive systems, biological basis, relational networks

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1. Traditional semiotic approaches and signs as constituents of the mind

Different and influential semiotic traditions assume (either implicitly or explicitly) that the cognitive system of an individual is composed of several kinds of signs. One of those influential traditions is the one promoted by Peirce (1934). According to this perspective, signs are triadic entities: Every sign makes reference to something (its object) and evokes a meaning in somebody's cognitive system (interpretant). Figure 1 provides an example: The Spanish word *gato* ["cat"] illustrates the interaction among the sign itself, its object, and its interpretant.

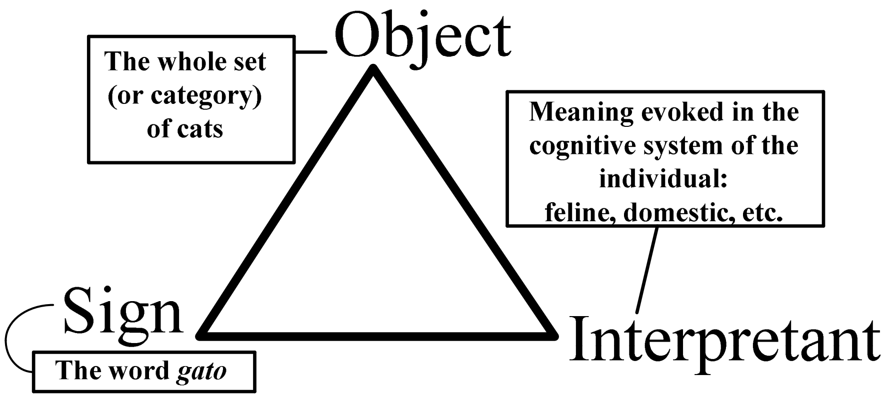

Figure 1: An example of Peirce's triadic sign

Saussure's conception of *linguistic* signs has also been highly influential: We have a diadic (or biplanic) sign here. The signifier is the acoustic image, or the mental representation of sounds, whereas the signified is the concept, or the mental representation of meanings (Saussure 1916). Figure 2 represents the link between the constituents of the linguistic sign. As it has been said, this conception has been highly influential, not only in the development of semiotics (Barthes 1964, Eco 1976, Lotman 1990) but also of esthetic theories (Culler 1975, Mukarovsky 1978).

Figure 2: An example of Saussure's biplanic sign

Independently from important differences and subtleties, semiotic traditions have the tendency to share the following related assumptions: There cannot be thought without signs, and signs, which are produced and interpreted by a single person, actually exist *within* the thought system (i.e., the cognitive system) of such a person. According to Peirce, signs are concrete constituents of the mind (or the quasi-mind):

> [T]here cannot be thought without Signs. We must here give "Sign" a very wide sense, no doubt, but not too wide a sense to come within our definition. Admitting that connected Signs must have a Quasi-mind, it may further be declared that there can be no isolated sign. Moreover, signs require at least two Quasi-minds; a Quasi-utterer and a Quasi-interpreter; and although these two are at one (i.e., are one mind) in the sign itself, they must nevertheless be distinct. In the Sign they are, so to say, welded. Accordingly, it is not merely a fact of human Psychology, but a necessity of Logic, that every logical evolution of thought should be dialogic (Peirce 1906: 523)

On the other hand, Saussure believes that linguistic signs are real entities in the mind, or the brain:

> Linguistic signs, though basically psychological are not abstractions; associations which bear the stamp of collective approval -and which added together constitute language- are realities that have their seat in the brain (Saussure 1916: 15).

However, can (linguistic and non-linguistic) signs be found *within* the mind or the brain of an individual? In fact, this fundamental semiotic assumption ("signs are located within the mind/brain") seems to be incompatible with concrete neurological evidence, being neurological evidence relevant because our cognitive system, which is able both to *produce* and *understand* signs, must have its physical basis in the brain.

Nevertheless, the hypothesis according to which (linguistic and non-linguistic) signs are part of the cognitive systems of the brain is disconfirmed by basic neurological evidence:

1. It requires a device in the brain that can read information in symbolic form, but our brains do not have such a device.

2. It requires some symbol storage, but the brain does not store symbols in the way that a computer does.

3. The process of interpreting symbols requires additional devices, not only storage for the symbols, but also a buffer in which to store the input item while the process of recognition is going on, and a device to perform comparisons. However, our brains do not have such additional devices.

On the contrary, the hypothesis according to which the cognitive systems of the brain store signs is compatible with the identification of the brain with computers. But it is well known that the brain is not a computer. In the foreword to Von Neuman's book, the Churchlands emphasize the crucial differences between the computer and the brain.

> As we now know, the brain contains roughly 10^{14} synaptic connections, each of which modulates the arriving axonal signal before passing it on to the receiving neuron. The job of the neuron is then to sum, or otherwise integrate, the inputs of those synaptic connections (as many as 10,000 onto a single cell) and generate its own axonal output in turn. Most important, these tiny modulatory actions all take place simultaneously. This means that, with each synapse being active perhaps 100 times per second (recall that typical spiking frequencies

> are in the range of 100 Hz), the total number of basic information-processing actions performed by the brain must be roughly 10^2 times 10^{14}, or 10^{16} operations per second! This is a striking achievement for any system, and it compares very favorably with our earlier count on 109 basic operations per second for a cutting edge desktop machine. The brain is neither a tortoise nor a dunce after all, for it was never a serial digital machine to begin with: it is a massively parallel analog machine (Churchland and Churchland 2000: xix).

Against the hypothesis that our brain stores symbols, a more realistic alternative is to assume that the internal structure does not have symbolic representations of signs of any kind, but *the means for producing and interpreting signs.* The relational network theory that will be applied here is also attractive from a neurological point of view because it is compatible with neurological evidence (see Section 4). Neuroscience research has shown that the cerebral cortex *is* a network and that learning develops as strengthening of connections. The basic processes involved in text comprehension operate directly in the network "as patterns of activation traveling the pathways formed by its lines and nodes" (Lamb 2005: 157). Everything which is considered semiotic is not stored as representations of signs, but *it is in* the connections. This is the hypothesis that will be considered in the next section.

2. The linguistic system as a network of relationships

The American neurolinguist Sydney M. Lamb developed a neurocognitive theory seeking to describe how language is represented in the human brain, a goal that only superficially seems to overlap with that of Chomskyan linguistics (Chomsky 1995, 2005).

In his book *Pathways of the Brain* (1999), Lamb pronounces himself against the idea that human brains contain such things as lexical items, syntactic objects and, above all, an object-manipulating device. In this regard, note the following statement made by the generative linguist Steven Pinker:

> The representations that one posits in the mind have to be arrangements of symbols [...] Remember that a representation [...] has to use symbols to represent concepts, and arrangements of symbols to represent the logical relations among them (Pinker (1994: 78).

Nevertheless, no direct or indirect evidence has even been found in support of the hypothesis that there are syntactic objects or symbols represented at brain level. In fact, the belief that syntactic objects, words, and morphemes lie within the "mind/brain" –to use a term first proposed by Fodor (1983) and then adopted by such eminent linguists as Steven Pinker and Ray Jackendoff (Pinker 1994, Jakendoff 2002, Pinker and Jakendoff 2005)– stems from an unwarranted and certainly feeble assumption: "what comes out" of the mouth of person *x* must have been previously present *within* his mind/brain, as if he were a "vending machine" or a "factory" of sorts (Lamb 1999: 109).

A plausible alternative is to suppose that what a person does is to produce words "on the fly": An individual's brain contains no lexical, syntactic objects or "phases" of syntactic objects; rather, what the human brain possesses are the *means* to produce linguistic expressions.

As it has been said, the idea that the mind contains signs or symbols manipulated by a special type of machinery is clearly rooted in the metaphor comparing the "mind/brain" to a computer. However, the brain's functioning cannot be seriously compared with that of a computer. Among other things, the brain contains no workspace, no storage areas, no transducers, no input devices (in terms of Fodor), no central processing unit, and no storage sectors. Another significant discrepancy is that the brain need not be understood as requiring full connectivity or computational efficiency (Anderson 1995: 304).

Microstructural neurological evidence reveals itself more than sufficient to reject a symbolic model based on the computer-brain analogy: where would all that equipment be located? The information storage hypothesis requires complementary equipment: a sort of buffer where the input item can be stored as the recognition process takes place, a mechanism affecting the comparison with an already-stored item, and, above all things, some kind of device (perhaps a "homunculus") capable of carrying out the whole process. The symbol storage and processing hypothesis cannot be justified by arguing that it is merely a non-structural, "functional metaphor." If that were the case, why do away with neurological evidence, which shows that this alleged "functional metaphor" is both unnecessary and implausible?

Generativist models have been erected upon the information storage hypothesis, which has been supported even by prestigious neuroscientists (cf. Churchland and Sejnowski 1992). In terms of such a hypothesis, information would be progressively stored at brain level as binary combinations, or perhaps as symbols of some other kind. This proposal may be amenable to our tendency to believe that information is stored and symbolically represented on certain media, like sheets of paper, blackboards, or compact discs. However, the fact that information can be represented by means of signs in some physical medium does not confirm the hypothesis that such signs are stored within the brain. If this hypothesis is to possess any neurological grounding, then its advocates should show how neurons or neuronal assemblies are capable of storing binary digits or other types of signs, and how such signs are handled in linguistic production, linguistic comprehension, and other observable processes. A computer's functioning is perfectly well understood: It depends upon process of comparison. If an input item appears, a given strategy is used to find likely candidates among the items stored in memory, and each of those candidates is compared to the item in question. Successful recognition occurs when a candidate is retrieved that matches the input item. Evidently, the brain does not work this way. Throughout his career, Lamb has argued that all the linguistic and neurological evidence available proves that an individual's linguistic structure constitutes a network, a system where information is not "stored" or "filed," but rather "localized" in, and "distributed" among, a myriad of connections. The need to accurately represent how information is connected in the network calls for a new system of notation, which Lamb devised under the influence of Michael Halliday's system networks (Halliday 1967/68). Nowadays, Halliday himself points out that a systemic-functional grammar must be represented in the brain as described by Lamb (1999) (Halliday and Matthiessen 2004: 24).

Relational network notation, which was first developed within stratificational grammar (Lamb 1966), explicitly shows that "linguistic information" is in the connectivity and that the system contains no signs of any kind. The labels written beside the connections are merely that: marginal visual indications for each connection (they work exactly as the road-signs located by the highway, which are not the highway proper). For Neurocognitive Linguistics, linguistic information exists only in the system's connectivity (Lamb 1996, 1999, 2004). Lamb draws inspiration from the works of Hjelmslev (1943) and Halliday (1967/68): From the former he adopted the idea that the linguistic system is a complex made up not of static units, but of *relationships*; from the latter, the type of notation used in systemic-functional grammar, which clearly distinguishes between syntagmatic relationships ("both/and") and paradigmatic relationships ("either/or"). This framework shows that once we identify a linguistic unit's immediate relations –such as those pertaining to the adjective *hard*, for instance– the linguistic unit as such disappears: All that is left is the relationships themselves, that is to say, the *connectivity*. In other words, a linguistic unit is nothing but a node within a network of relationships, and this claim is valid for all types of units, be them phonological features, phonemes, morphemes, lexemes, etc. By way of example, consider the main connections involved in the representation of the lexeme ("the word") *hard*, as depicted in Figure 3.

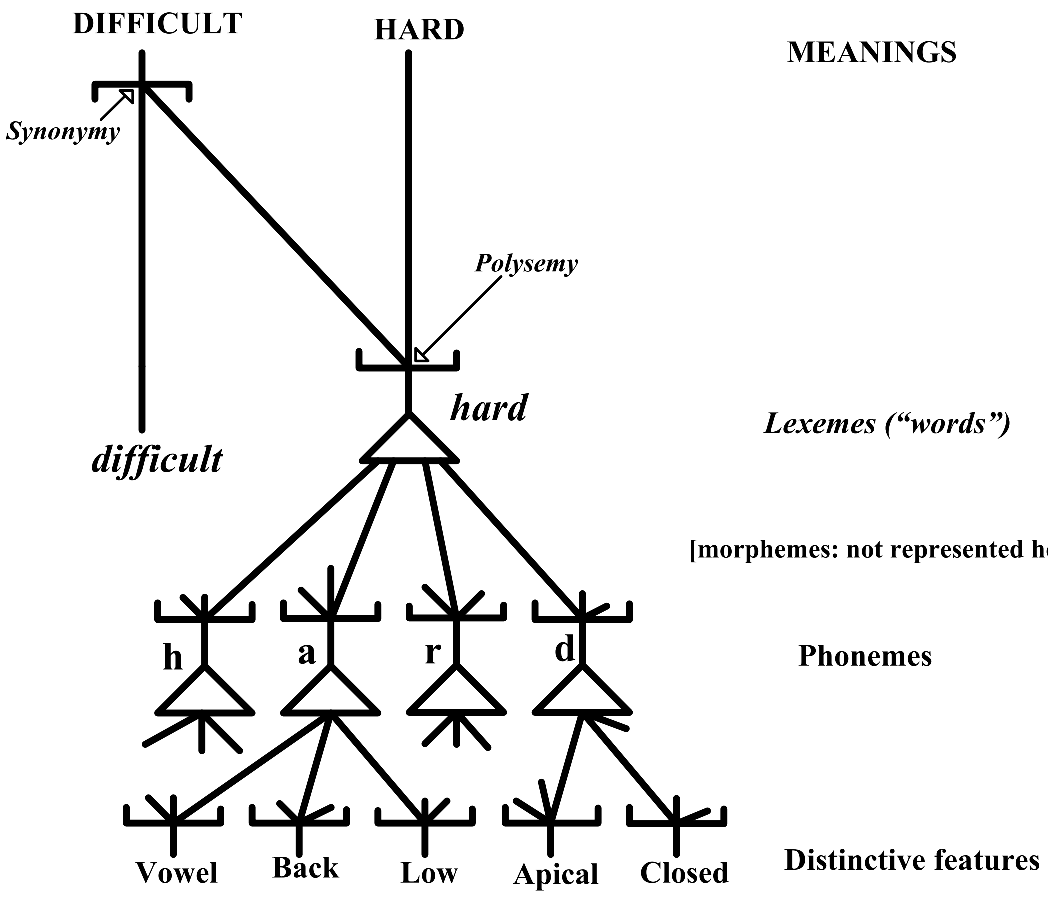

Figure 3: The lexeme *hard* as represented in the system.

All in all, a linguistic unit is what it is not just because it occupies a specific position within a network of relationships, but also because it depends upon the other nodes that are connected to it. Consequently, the notion of Saussurean "value" takes on an additional dimension: a linguistic unit is "what the others are not." Figure 3 captures part of this idea, as it shows that structural units, such as the lexeme *hard*, the concept

DIFFICULT, the phoneme /a/, the phonological feature “Vowel,” and so on, *are not part* of linguistic structure; rather, they are placed in the diagram as an aid to make it intelligible.

The “triangles” from which lines stem indicate ‘and’ nodes, whereas the “brackets” whence lines also stem indicate ‘or’ nodes. ‘And’ nodes can also represent sequential ordering, as in the case of the node for the lexeme *hard*, which is realized by the sequence of phonemes /h/, /a/, /r/, and /d/; but there is no such sequential ordering in nodes such as the one for the phoneme /a/, because distinctive features are realized simultaneously (hence, the lines linked to its node stem from a one and the same point).

Notice also that polysemy, indicated by an arrow in Figure 3, consists in a relationship between a single lexeme and several concepts (surely more than the ones represented in the figure). On the other hand, synonymy is the relationship between one meaning and several lexemes, which proves extremely easy to represent by means of relational network notation. In this sense, neurocognitive linguistics is a relational network theory that can account for linguistic information in terms of connectivity and relationships.

Due to space limitations, it is not presently possible to provide an in-depth explanation of this system of notation, but it is certainly possible to visualize some of its numerous advantages:

- It shows continuity between the subsystems, leading from distinctive phonological features (such as “Vowel”) to meanings (such as DIFFICULT), and vice versa.
- It explains how information can be, at the same time, both localized and widely distributed in the brain. So-called “words,” for instance, are nothing but signs placed next to the connections. Words, or, more precisely, lexemes, *have* no meaning; rather, they are *connected* to meanings.
- It contributes to explaining verbal production and comprehension. An individual who hears the sequence *hard* “goes” from its phonemes’ distinctive features to its meaning; an individual who says *hard* “goes” from its meaning to its phonemes’ distinctive features. Single nodes have no *value* in themselves; instead, their value is an attribute conferred by the other units in the system, as Saussure and Hjelmslev observed several decades ago.
- It is explicit in depicting the bidirectional nature of neurocognitive processes, thus allowing for adequate characterizations of linguistic production and comprehension –a goal unpursued (and perhaps unattainable) within the generativist framework.
- It should be emphasized again that relational networks help us to understand that “linguistic information” *is* in the connectivity. *The system contains no signs of any kind*. The labels written beside the connections are only additional indications for each connection.

One further point needs to be made: Lamb’s model seems to be neurologically plausible, as the nodes present in the system of notation are implemented as real cortical columns (Lamb 1999, 2004, 2005, 2006). This issue will be considered in section 4.

3. Semiotic information in relational networks

We could ask now whether semiotic representations can be handled by the same kinds of network structure that seem to be able to account for linguistic information, like in Figure 3. A crucial property of a conceptual system is that none of its concepts can be described without an account of its relationships to various other concepts. Thus, all the elements of a semiotic interpretation should be interrelated in a complex network. The following examples aim at showing that semiotic information can be treated as entirely relational.

A great deal of our knowledge of the world and of our culture is about activities, which tend to be more or less structured in our cognitive systems because they are predisposed to organize phenomena into systematic structures. Those activities which are relatively more standardized may be called "procedures". Figure 4 depicts a stereotypical Argentinean barbecue ("*asado*"). Relational network notation helps us to illustrate, for example, that starters are not obbligatory. But if you are invited to eat a real *asado* you must be given meat and T-bone. This information, which could be regarded as semiotic information, has to be represented in the cognitive system of an individual.

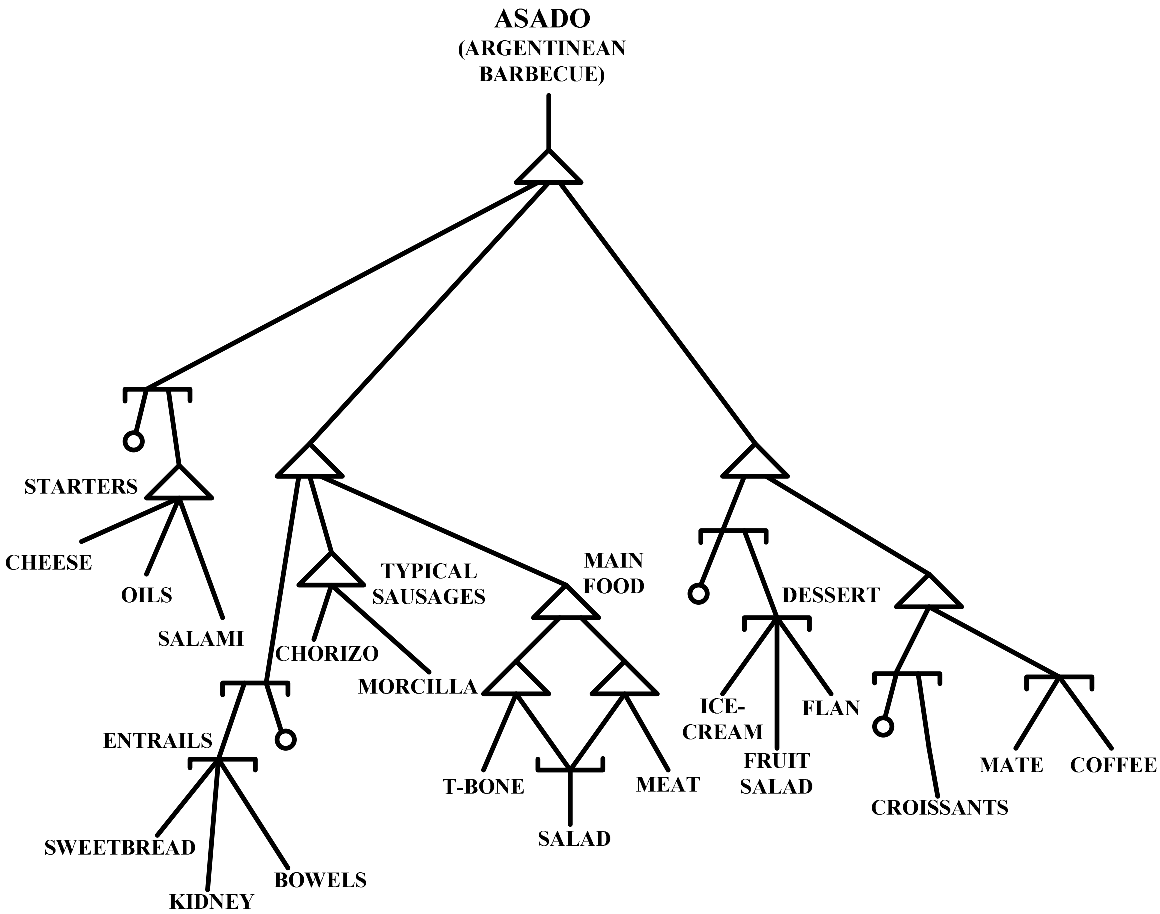

Figure 4: The sequences and options of an Argentinean barbecue (*asado*)

Examples like this indicate that procedures generally come in hierarchies. Figure 4 does not represent some specific *asado*, but a large category of barbecues. For example, this diagram represents clearly that MEAT is an obligatory constituent: As it has been said, if I invite you to eat *asado* and there is no meat, you will feel disappointed, or deceived.

On the other hand, by means of “downward unordered or” nodes it can be represented that a certain option is not obligatory: For example, you can perfectly eat an excellent *asado* without tasting any starter. Figure 5 depicts a detail of Figure 4 in order to show that upward activation goes to STARTER if possible; otherwise, it goes to the null option (NOTHING), which is represented by a circle.

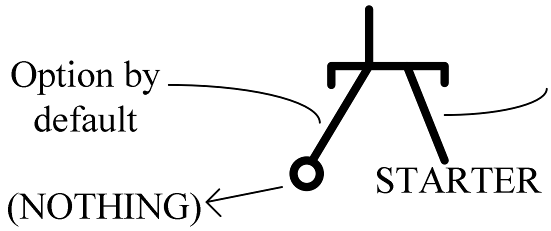

Figure 5: The unordered “or” node (in this case, “nothing” is the option by default)

Figure 4 can be interpreted as a fragment of the semotactic system of an individual, i.e., the general organization of social procedures in his/her cognitive system. There is an analogy here with linguistic information: Some specific *asado* that might be remembered by a person would be analogous to a memorized sentence, which might be remembered as one instance of tactics of sentence structure.

As another example of a complex multi-level procedural system, we may consider the social procedure of going to a football match in Argentina. Of course, many details of the structure of football matches, including various subprocedures, are not shown in Figure 6, which represents a fragment of semotactics because it covers the ritual of going football matches in general. The semotactis is the part of the cognitive systems dedicated to the organization of procedures: By means of it we can identify what comes first and what comes later, what is obbligatory and what is optional.

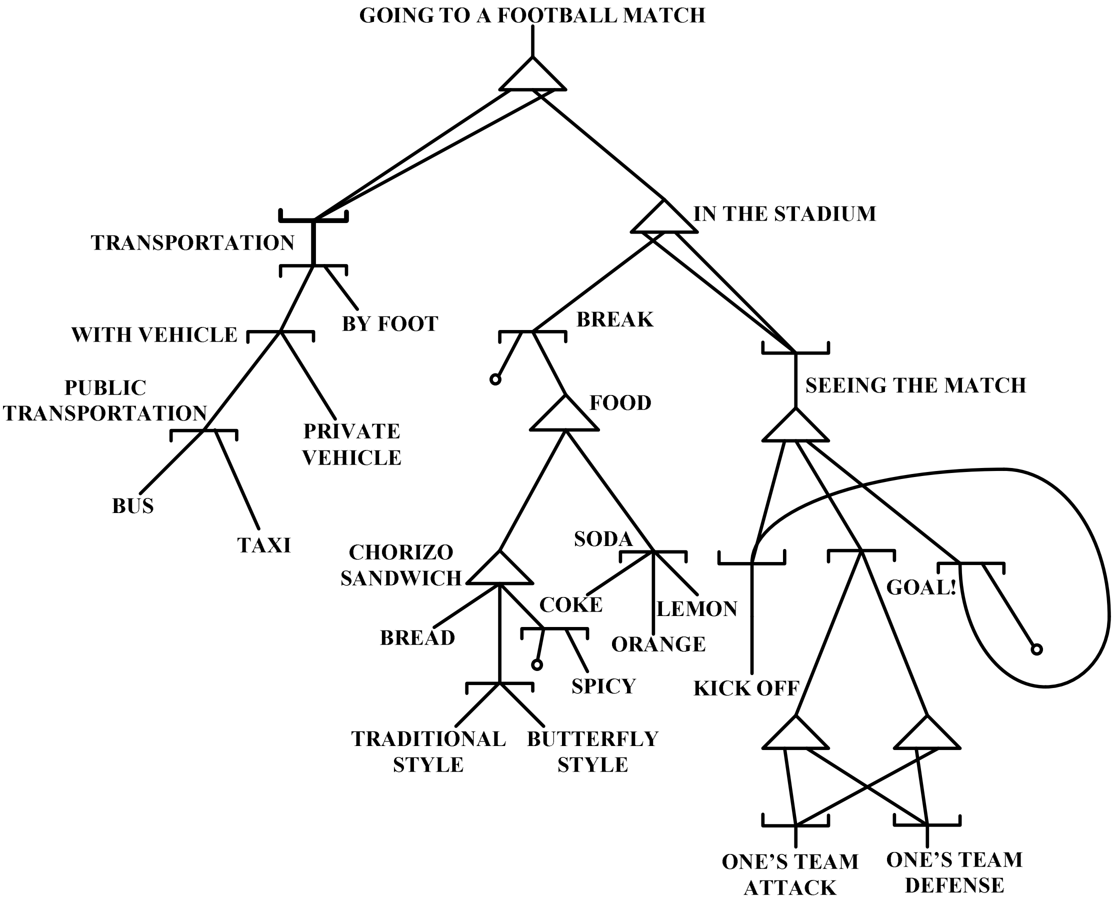

Figure 6: Going to a football match in Argentina

A great part of our knowledge of the world is of people and their institutions, which are based on social groups. We may now ask whether such knowledge also consists of relationships of the type that have been represented in Figures 4 and 6. Lamb (1999: 150-1) considers that the family can be interpreted as the social group which perhaps serves as the conceptual prototype for social groups in general. Figure 7 is a representation of the prototypical family in many Western cultures. It shows the family node above the nodes for its members, in keeping with the upward-downward convention that have been useds in the linguistic subsystems: Higher level nodes for what are larger units in the extra-mental world. Lamb explains that for the family node there is an ordered 'and' in keeping with the releatively prototypical situation in which the married couple comes first, before the children. It also shows children as optional, multiple children as coming in sequence (ordered 'and') and every one after the first as optional.

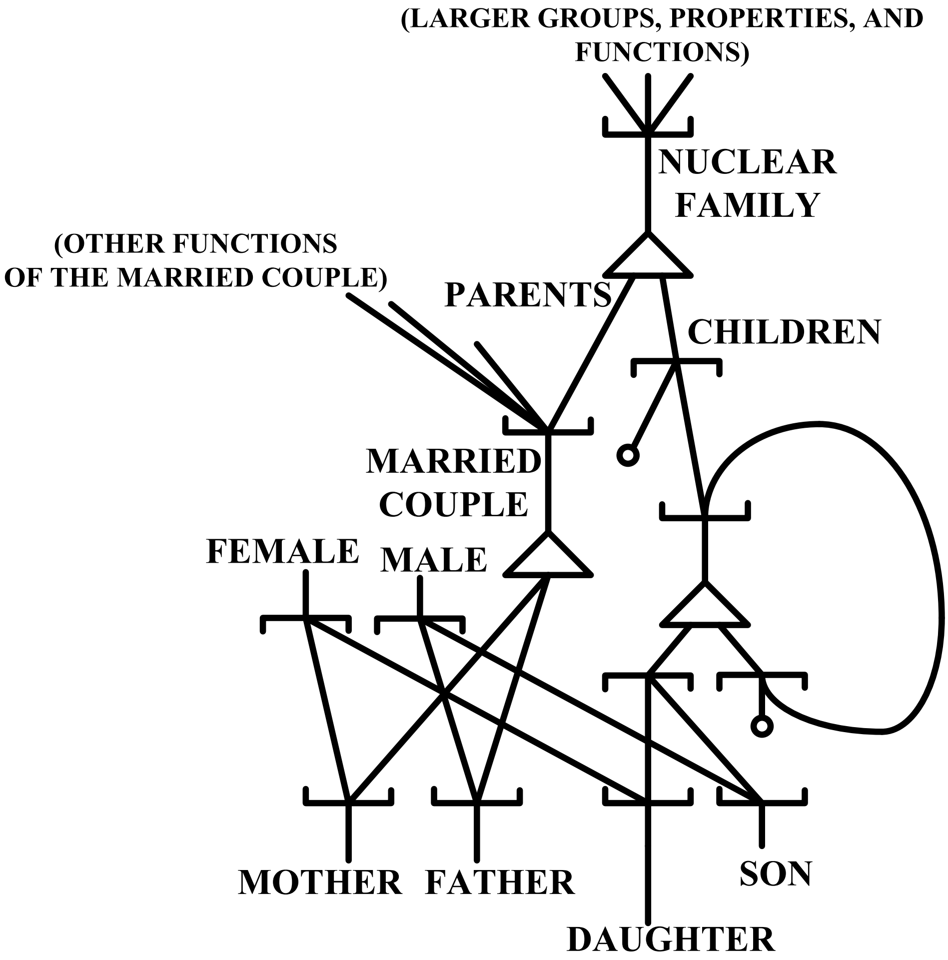

Figure 7: Steoreotypical Western family (slightly adapted from Lamb 1999: 150)

In conclusion, it seems that (some) semiotic relationships can be treated by relational networks, which are also to account for linguistic information (like Figure 3). It can be emphasized that a crucial property of a semiotic network is that none of its nodes can be described without an account of its relationships to various other nodes. It seems that that everything which is "social", "cultural", "semiotic", can be represented in relational terms in the highly complex cognitive system of an individual. In other words, here we have a biological basis for the semiotic realm, because the cognitive systems are located in the brain. Within this context, Neurocognitive Linguistics allows us to begin to see how we can find some definite relationships between the semiotic realm and the natural realm.

I would like to provide a last example in order to illustrate how semiotic information can be represented in the cognitive system of an individual. It deals with the concept of "global coherence" (Van Dijk 1981, 1985; Van Dijk and Kintsch 1983), and it is strongly related to many of the concepts that have been considered before. In order to understand a text "as a whole", the interpreter makes use of the previous knowledge of stories. We may consider the following example, which was narrated by Sue to a group of friends (Lamb 2002: 282):

0. There's some guy … we
1. we heard a story a couple of weeks ago

2. of this… family
3. and there was a young child in the family
4. a young boy
5. and he was having tremendous problems in the school
6. he was a very difficult child
7. he was too active
8. and he was always getting in trouble
9. a long lost relative came into this family
10. who had been to India
11. and studied with some of the Eastern mystics
12. and… so he suggested to this child
13. that he stuff cotton, up the right side of his nose
14. and so they stuffed cotton up the right side of his nose
15. and his personality completely changed
16. he became this very passive, nice, docile, child…

This story, if remembered, will be registered in the cognitive system as a new entity, as a member of the category of the stories, although differing from other members in various manners: The narrator was Sue, and it has certain characters and events. In this case, the most relevant fact is that the story will be related not only to the category STORY, but also to the semotaxis of narratives, i.e., to the canonical structure or "superstructure" of the narrative (Van Dijk 1981), where we may find ordered constituents such as FRAME, MIDDLE and END.

Van Dijk has proposed a general scheme for narratives whose structure can be interpreted in neurocognitive terms as the semotaxis represented in Figure 8. These schemes or frameworks are "superstructures", and are considered to be cognitive frameworks which allow the interpreters to understand the text as whole. Figure 8 illustrates the SEMOTAXIS OF STORY (CATEGORY), independently from this concrete story or any other one: It does not represent some specific story but the huge category of texts than can be considered stories. Upward lines in the upward "or" node for STORY, and the sets of downward lines in downward "or" nodes at the bottom of Figure 8 simply indicate that there are connections to instances of specific stories, like the one narrated by Sue.

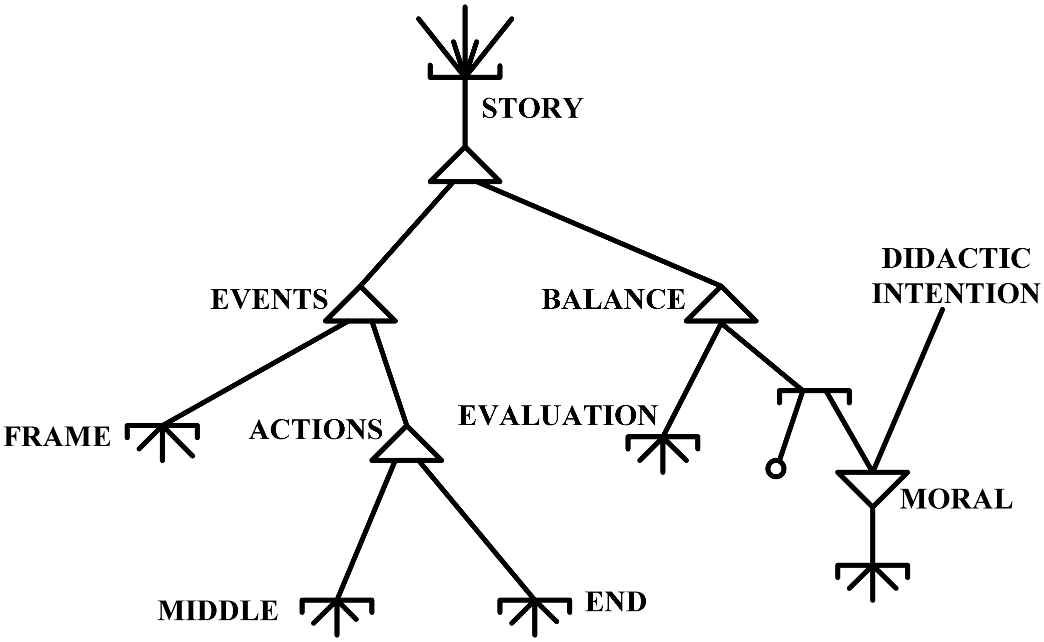

Figure 8: Semotaxis of STORIES

Interpreters may apply some cognitive strategies mapping sequences of propositions of the text on sequences of "macropropositions" at more abstract, general, or global levels of meaning. Such mappings are operations that select, reduce, generalize, and construct propositions into fewer, more general, or more abstract propositions (Van Dijk 1985: 116). For instance, an interpreter could "reduce", "generalize", and "construct" in order to create the following macrostructure of the story told by Sue:

A macrostructure of the story told by Sue

1. FRAME: In a certain family, there was a very hyperactive and problematic child.
2. MIDDLE: Thanks to a suggestion given by a long-lost relative, the other members of the family stuffed cotton up the right side of the child's nose.
3. END: The child became passive, nice, and docile.
4. EVALUATION 1: Nasally treatment of hyperactivity was effective.
5. EVALUATION 2: Yoga can help people to live better.
   EVALUATION n: ….

According to Van Dijk, "macrostructure" is a specific semantic realization of a superstructure. Macropropositions are the result of applying macrostrategies ("reduce", "generalize", and "construct"). There is one macroproposition for each terminal element of Figure 8. There is no MORAL in this story if you consider that thet text does not have any didactic intention.

Global coherence assignment can be considered as a relevant aspect of text comprehension. Interpreters are capable of understanding "the text as whole" because they have complex representations in their cognitive systems, for example, the representation of what a narrative is, maybe in the terms of a particular semotaxis like the one that has been sketched in Figure 8.

4. Neurological plausibility of relational networks

Lamb proposes a definite meaning for the term 'realistic' in the context of his neurocognitive research (Lamb 1999, 2006). A 'realistic' theory of language should go beyond the analysis of the products of verbal behavior (i.e., texts), and should account for the linguistic system in relation to actual human beings. With a view to doing that, a realistic linguistic theory will have to satisfy the following three requirements (Lamb 1999: 293-294):

(1) *Operational plausibility:* A realistic linguistic theory has to provide a plausible account of how the linguistic system can be put into operation in real time to produce and understand speech.
(2) *Developmental plausibility:* A realistic linguistic theory needs to be amenable to a plausible account of how the linguistic system can be learned by children.
(3) *Neurological plausibility:* A realistic linguistic theory has to be compatible with what is known about the brain from neurosciences.

There is a good amount of neurological evidence for relational networks. However, there is no direct experimental evidence because of the following reasons:

i. Brain images are too rough for the study of microscopic levels (Cherchi 2000, Lamb 2004b).
ii. The experiments with living brain tissue of animals are not done with humans for obvious ethical reasons.
iii. The experiments with living brain tissue of animals deal with visual, auditory, and somatosensory perception of cats and monkeys (Hubel and Wiesel 1962, 1968, 1977; Mountcastle 1997, 1998), and these animals do not perform linguistic processing.

On the other hand, there is a good amount of relevant indirect evidence for the neurological plausibility of relational network theory. For example, Hubel and Wiesel (1962, 1968, 1977) discovered that visual perception in cats and monkeys works in the ways that would be predicted by the relational network model, and the nodes of visual network are implemented as cortical columns. "The nodes are organized in a hierarchical network in which each successive layer integrates features from the next lower layer and sends activation to higher layers" (Lamb 2005: 168).

The eminent neurologist Vernon Mountcastle discovered and characterized the columnar organization of the cerebral cortex. In his book *Perceptual Neuroscience: The Cerebral Cortex* (1998), he explains that the basic unit of the mature neocortex is the cortical *minicolumn*, a narrow chain of neurons that extends vertically across cellular layers II-VI. Each minicolumn contains about 80-100 neurons and all the major phenotypes of cortical neural cells. Mountcastle's general hypothesis is that the minicolumn is the smallest processing unit of the neocortex, and he also claims that "every cellular study of the auditory cortex in cat and monkey has provided direct evidence for its columnar organization" (1998: 181). For example, a nerve-regeneration experiment in the monkey provides evidence for columnar organization of the somatic sensory cortex. A recording microelectrode was passed nearly parallel to the pial surface of the cortex of the postcentral somatic sensory cortex, through a region of neurons with the same modality properties. Neurons in adjacent minicolumns are related to adjoining and overlapping peripheral receptive fields, and the transitions between minicolumns pass unnoticed. Results obtained in the same animal in a similar experiment after section and resuture of the contralateral medial nerve showed a misdirection of the regenerating bundle of nerve fibers, innervating then the glabrous skin of the hand. Sudden displacements of receptive fields, which occur at intervals of 50-60 microns, reveal the minicolumns and their transverse size (Kaas et al. 1981, cited by Mountcastle 1997: 708, 1998: 173).

Since speech perception is a higher-level perception process, it is permissible to suggest the following extrapolation: Each node in the neurocognitive system of an individual can be implemented as a cortical column. Within the linguistic system, every node/cortical column has a highly specific function. For example, there may be a node/cortical column corresponding to a single lexeme like *hard* in Figure 3.

Now, we see that the relational network model requires (*before* considering its neurological plausibility) the following types of connectivity among its nodes, and the following types of properties for its connections (Lamb 2005: 170):

1. Connections can have varying strengths.
2. Connections are strengthened through successful use (the learning process).
3. Connections of given strength carry varying degrees of activation.
4. Nodes haves varying thresholds of activation.
5. The threshold of a node can vary over time (part of the learning process).
6. Connections are of two types: excitatory and inhibitory.
7. Excitatory connections are bidirectional, feed-forward and feed-backward.
8. Excitatory connections can be either local or distant.
9. Inhibitory connections are local only.
10. Inhibitory connections can connect either to a node or a line, the blocking element attaches to a line.
11. In early stages (pre-learning) most connections are very weak (latent).
12. A node (at least some nodes) must contain an internal wait (delay) element, needed for sequencing, for example of the part of a syllable or of the constituents of a construction.

The examination of evidence shows that minicolumns and their interconnections have every one of these properties. For example, the internal delay element (Number 12 in the above list) is implemented by means of axon fibers which branch off from the axons of pyramidal cells within a column and connect vertically to other cells in the same column. “[F]rom layer VI they project upwards and from upper layers downward. This circulating activation among the pyramidal cells of a column keeps activation alive until it is turned off by inhibitory neurons with axons extending vertically within the same column. Such inhibitory cells are called double basket cells” (Lamb 2005: 170).

There are also relevant considerations about the number of minicolumns that an individual would need in order to represent linguistic information. For example, when estimating the huge number of minicolumns in Wernicke’s area, Lamb (2005: 172) suggests that there could be approximately 2,800,000 minicolumns in that area. This number could allow an individual to represent all the information needed for phonological perception.

On the basis of previous remarks, we can provide an argument for the neurological plausibility of relational networks:

Argument for the neurological plausibility of relational networks

i. Nodes represented in relational networks are implemented (with an important level of abstraction and generality) as minicolumns.
ii. Connections represented in relational networks are implemented (with an important level of abstraction and generality) as fibers.
iii. Minicolumns and fibers integrate real cortical connections.
iv. Therefore, relational networks represent (with an important level of abstraction and generality) real cortical connections.

5. Conclusions

I have intended to provide an alternative to the semiotic assumption according to which signs are conceived as concrete constituents within the cognitive systems of a person.

1. By means of relational networks, Neurocognitive Linguistics helps us to understand that the signs are *products* (and *inputs*) of cognitive systems. Consequently, signs are very different from the structure of cognitive systems.

2. In other words, the means by which signs are created and interpreted are very different from the external signs, which can be represented by the conceptions of Peirce or Saussure, for example.

3. The internal cognitive systems are integrated only by nodes and connections.

4. There is no “internal semiotics”. Semiotics can be conceived as the study of every type of sign, and signs can be interpreted as external re-constructions made by the cognitive systems. Strictly speaking, signs do not exist as external objects: Signs happen.

5. Meanings are represented in the real cognitive systems of an individual (and such systems are the structures which allow an individual to interpret any external object as a sign).

6. If signs happen, if they do not have existence as concrete objects, the interaction between our cognitive systems and the extenal world *creates* signs.

7. And, finally, what is the relationship between the biologic and semiotic realms?

    (a) Every social phenomenon which is considered “semiotic” evokes some kind of meaning.

(b) If something evokes some kind of meaning, it is interpreted by some cognitive system.
(c) Every cognitive system (from perceptual systems like vision to conceptual systems and planning) must have its basis in the brain.
(d) Meanings can be represented in neurocognitive relational networks.
(e) Neurocognitive relational networks are neurologically plausible.
(f) Therefore, the representation of meanings in neurocognitive relational networks constitutes a first step to account for the relationships between the semiotic and the biological realms.

This perspective could also help us to support a traditional idea on the bases for the so called social sciences: According to Ernest Nagel (1961), social transcultural laws will be found in some layer of reality which has not been reached by social research yet. This unknown layer could be found in the human brain.

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