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TENETS OF COGNITIVE LINGUISTICS AS A FRAMEWORK FOR TEMINOLOGY RESEARCH

ANUŠKA ŠTAMBUK
University of Split

1. Introduction

Scientific and technical terminology closely follows the development of science. New words are created to name the new concepts, thus providing a possibility not only of expressing the new ideas, but also of building the analytical systems that provide progress from the known thoughts and facts to those as yet unknown. The relationship between sign and concept in this process, is approached in different ways.

In the view of structural linguists, for example, the lexis of science and technology is regarded as strictly monosemous. Thus Coseriu believes that it is essential to distinguish between that which belongs to linguistic meaning and that which belongs to knowledge of the objects. For him, the language of science is not only characterized by monosemy and autosemanticity, but it is simply a nomenclature, and as such not structured on the basis of language, but rather on the basis of objects of the discipline in question. He says:

> Since, in technical usage, the words are really the representatives of the "objects", *signification* and *designation*[1] coincide in this case, whereas in the domain of "natural" language they must necessarily be separated. Therein lies also the reason for the translatability, or better, the substitutability of terminologies, in a 1:1 ratio within the language communities having approximately the same state of knowledge in corresponding sciences. (Coseriu 1981: 48)

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[1] Coseriu explains these terms as follows: "The signification is determined by relationship of *signifiés* to one another ... the designation on the other hand is the relation of the whole linguistic signs to 'objects' of extralinguistic reality" (1981:54).

A similar attitude is taken by the followers of Wüster's school. Galinski, for example, thinks that "as on the surface terminologies resemble the natural language, one may easily be mislead into treating them methodologically like a natural language" (Galinski 1986: 4). Felber believes that terms are assigned to defined concepts, which, on their part, are delimited from other concepts and integrated into a system of concepts. Both the concept and the term are dependent on this system. Following Wüster's theory, Felber argues that "the individual object, the concept and the term are in close connection with each other" (Felber 1982: 325).

According to this view, scientific and technical lexis is reduced to nomenclature and excluded from natural language, thus eliminating from semantic analysis a huge segment of lexical items.

Cognitive linguists, however, contest this view, by rejecting the existence of strictly defined correspondence between linguistic symbols and things in the physical world. Lakoff (1987/1990) rejects the objectivist legacy of viewing rationality as being purely mental, unemotional, and detached of imagination and social functioning; he opposes the belief that science works strictly by the hypothetico-deductive method. Analyzing the biological species from evolutionary perspective he argues that the biological world is not divided up into clearly distinguished natural kinds as objectivist metaphysics requires. He points to problems of objectivist cognition and semantics (Lakoff 1990: 197):

> *The problem for Objectivist Cognition*: Concepts are not internal representation of external reality, since there is no corresponding external reality – there are no *categories* of the right kind of objectively "out there" for the concepts to mirror.
>
> *The problem for Objectivist Semantics*: Symbols (e.g. words) do not match up with *categories* in the world since there are no categories of the right kind in the world for them to match up with.

Lakoff pleads for the approach of "experientialist semantics". Human language is based on human concepts, which are in turn motivated by human (direct and indirect) experience, thus taking experientalist semantics beyond mere symbol-manipulation. He agrees with Putnam about what he called the "linguistic division of labor". Putnam observed that meaning is partly socially determined, by communities of experts to whom we give the authority to say what things are like in technical matters that go beyond most people's direct experience.

He further claims, following Putnam's views, that we are not outside reality, but we are a part of it. However, this does not mean that knowledge is impossible. Instead of absolute and perfect knowledge, from "God's eye point of view", another kind of knowledge is possible, that from a particular point of view, which grants that other points of view can be legitimate. This view does not deny the existence of objective reality, rather it suggests that there is more than one right way of describing it. Lakoff believes that scientific knowledge greatly depends on our ability of perception and understanding, and not on neutral and absolute point of view (Lakoff 1990: 299):

> Knowledge, like truth, depends on our understanding...of experience... What we perceive at the basic level is taken as real and known, pending very good reasons to the contrary. The same is true for scientific theories. They must be coherent with our basic-level perceptions and accepted by the relevant scientific communities in order to be generally accepted as true. Once they are, they become part of our knowledge – again pending good reasons to believe otherwise – because they provide the only socially acceptable understanding available. In this respect, scientific knowledge is like *ordinary* knowledge.

Unlike previous linguistic theories, cognitive linguistics, therefore, described meaning in terms of "the nature and experience of the organisms doing the thinking" and pointed to the absence of strict boundaries in a language. This shed a new light on the language of science and technology. Once it was understood that categories depend not on objects themselves, but on the way we interact with them, the way we perceive them, imagine them, and organize information about them, it became obvious that scientific concepts are not always exactly defined, and that there is not always strict correspondence between these concepts and terms expressing them. It has become clear that scientific lexis is not a nomenclature, and that it can be analyzed in terms of "natural" language. Instead of being excluded from the field of semantics, the terminological lexical items are analyzed within the frame of semantic laws.

2. Prototypical meaning in the language of science

Eleanor Rosch challenged the classical theory of categorization by developing the prototype theory. In a number of experiments she discovered asymmetries among category members. She observed that categories, in general, have best examples called "prototypes", which are judged as being more representative of the category than other members.

Lakoff applies the prototype theory in his description of internal category structure. He believes that prototype effects result from the nature of cognitive models, and argues that concepts can frequently be described not by one model, but by a number of cognitive models, with a prototypical model in the center. He illustrates it by means of a radial structure, in which there is a central model, with less central subcategories around it. He explains it by analyzing the concept 'mother', where the central case includes a mother who is a female, and who gave birth to the child, whereas subcategories, defined as variations on the central case are *stepmother, adoptive mother, foster mother, biological mother, genetic mother*, etc. (see Lakoff 1990: 83).

Langacker also speaks of gradation in terms of centrality of our knowledge of an entity (Langacker 1987: 159):

> The multitude of specifications that figure in our encyclopedic conception of an entity clearly form a gradation in terms of their centrality. Some are so

central that they can hardly be omitted from even the sketchiest characterization, whereas others are so peripheral that they hold little significance even for the most exhaustive description.

Challenging the distinction usually made between a lexicon and an encyclopaedia in the human mind, where the core meaning is assumed to be described by a dictionary, whereas the surrounding non-essential facts are stated in an encyclopaedia of general knowledge, Aitchison speaks of the language of science (Aitchison 1995: 45):

> A well-known philosophical viewpoint is that words do indeed have a fixed, correct meaning, but that only a few experts know it. Ordinary people must consult these experts if they need to know about the essential nature of something. Only a specialist, for example, might be able to specify the true nature of gold or arsenic. The problem here is that specialists sometimes disagree, and sometimes change their minds... Even if the "true meaning" of say, gold, measles or arsenic exists in the minds of experts, it is clear that we non-experts bumble along quite happily with a working approximation of our own for most words, as indeed the philosophers admit. Moreover, even if we are told of an expert's viewpoint, we sometimes choose to ignore it. For example, (when) botanists tell us that an onion is simply a kind of lily...

Aitchison concludes that for the majority of words, meanings in the mind are fuzzy, not fixed.

It is generally assumed that scientific knowledge is categorized in form of conceptual categories. Since language reflects this categorization, concepts can be considered a link between knowledge and lexis. However, understanding of a lexeme or a phrase is closely connected to our background knowledge. The greater a specialist in a particular field, the deeper will be his insight into the meaning of a term. This means that the meaning of a term will change with the amount of our knowledge about it, discovering ever deeper levels of cognition.

This could be illustrated by examples of definitions of a particular scientific term in dictionaries of different levels of specialization, starting from a general language dictionary to highly specialized terminological dictionaries.

Let us take, for example, definitions across dictionaries of one of basic words in electronics terminology, i.e. word *current*:

current 2. the flow of electricity past a fixed point.
Longman Dictionary of Contemporary English (1992)

current The flow of electricity, i.e. the characteristic drift movement of carriers, such as ions, electrons, or holes.
The Illustrated Dictionary of Electronics (1982)

current The rate of transfer of electrons or of positive ions, negative ions, or holes from one point to another, measured in amperes.
Academic Press Dictionary of Science and Technology (1992)

current Any movement of electric charge carriers (electrons, ions, or holes). Electric current in a wire (by electrons) is from negative to positive, although in some contexts the "conventional" direction (positive to negative) is used. Electric current always generates an accompanying magnetic field.
Illustrated Encyclopedic Dictionary of Electronics (1981)

current (1) (general). A generic term used when there is no danger of ambiguity to refer to any one or more of the currents specifically described. *Notes:* (A) For example, in the expression "the current in a simple series circuit," the word current refers to the conduction current in the wire of the inductor and the displacement current between the plates of the capacitor. (B) A direct current is a unidirectional current in which the changes in value are either zero or so small that they may be neglected. A given current would be considered a direct current in some applications, but would not necessarily be so considered in other applications.
(2) (modified by an adjective). The use of certain adjectives before "current" is often convenient, as in convection current, anode current, electrode current, emission current, etc. The definition of conducting current usually applies in such cases and the meaning of adjectives should be defined in connection with the specific applications.
(3) (cable insulation materials). Sum of the polarization and conductance currents.
IEEE Standard Dictionary of Electrical and Electronic Terms (1995)

What can be considered the central meaning in the given definitions? In the first definition we learn that *current* is a flow of electrons. In the second one we go a step further and see that we are dealing with the flow not only of electrons, but also of ions and holes. In the third one we further discover that ions can be positive or negative. The fourth one informs us of direction of *current* and its associated magnetic field, whereas in the fifth one we find out that the term in fact refers to 'one or more of the *currents* specifically described'.

Common to all these definitions is the simplest, surface model ('flow of electrons'), which could be considered the central meaning. By increasing the level of knowledge, we get a more and more precise picture, which eventually takes us to subcategories, i.e. to distinguishing, in the most specific of the given definitions, *conduction current* from *direct current*, etc. It even ventures a linguistic analysis, by pointing out that, if modified by certain adjectives, the word *current* will have specific meanings.

How could this conceptual model be described? Lakoff's model of radial structure would hardly seem appropriate in this case. It seems to us that the prototypical model might here be represented in the form of a cone. At the top of the cone is the central meaning. By increasing the level of background knowledge, this central meaning is constantly being extended by new details. This addition of new information gradually changes the overall picture of the given semantic category, transferring it gradually to deeper levels of cognition. The central meaning is, therefore, not only broadened, but also deepened in concentric circles, thus building the cone from top towards its bottom. In this process, addition of new background knowledge to the central meaning is gradually changing the basic conceptual model in our mind, to the point when, to use Aitchison's comparison, "an onion becomes a lily".

This model, however, does not exclude the existence of subcategories, such as *direct current, alternating current, saturation current, leakage current, idle current*, etc., each of which can in their turn be represented by a conic conceptual model, with a possibility of constant broadening and deepening of their meaning.

It can also be noted that the conceptual structure of most terms is not finished in the given synchronic point, since, with development of science, it is constantly being enriched by new knowledge. This new knowledge can add new semantic features to a conceptual category, but it can also radically change its meaning, discovering deficiencies and even a possible inaccuracy of the existing model. Closely related to the development of science, this diachronic development of certain lexical items is a frequent source of linguistic change in this segment of the vocabulary.

3. Metaphorical characteristics of the language of science

Language categories are described in cognitive linguistics by means of four types of cognitive models (Lakoff 1990: 113-114):

> *Propositional models* specify elements, their properties, and the relations holding among them. *Image-schematic* models specify schematic images, such as trajectories, or long, thin shapes or containers. *Metaphoric models* are mappings from a propositional or image-schematic model in one domain to a corresponding structure in another domain. *Metonimic models* are models of one or more of above types together with a function from one element of the model to another.

In the process of scientific and technological development, the new experience is usually structured by means of metaphors which help us understand it. New concepts that result from our experience are defined in the first place on the basis of their interaction to other concepts. Metaphors are usually structured on the basis of a subconscious pattern, by comparing objects from different semantic fields, which have some minor, but evident characteristics in common.

We shall again illustrate this by examples from electronics terminology. A great number of electronics terms are of metaphorical origin. These are words like *beam, avalanche, threshold, loop, branch, wafer, core, gate*, etc. The very word *electricity* is metaphorical in its origin[2]. These metaphors are created on the basis of resemblance between the concepts, whether in appearance, or in function.

If we compare the given terms to their Croatian equivalents, we shall discover parallel metaphors in a number of cases, for example[3]:

avalanche	–	*lavina*
threshold	–	*prag*
loop	–	*petlja*
branch	–	*grana*
core	–	*jezgra*
gate	–	*vrata*

The two terminological systems can also use different metaphors to describe the same conceptual category. It can be noted, however, that these metaphors usually point to the same, or to similar characteristics of the given conceptual category.

Take, for example, the English lexeme created by metaphorical extension: *lobe*, used in electronics terminology to denote "in an antenna directivity pattern, a figure such as circle or ellipse enclosing an area of intensified response". The corresponding Croatian lexeme is also structured by metaphor. However, Croatian language uses a different metaphor: *latica* ('petal'). If we analyse the conceptual structure of the given English and Croatian metaphorical expressions, we can see that, although different, they are both connected to their respective basic lexemes by the same feature of lobe- or petal-like shape.

Apart from their use in basic terminological lexis, metaphorical models play an important part in conceptualizing and communicating new discoveries in scientific theories. These metaphorical models are frequently based on cognitive and lexical models from some other branch of science. Physical theory thus uses the astronomic planetary model to describe the structure of the atom, genetics uses the linguistic model, whereas linguistics describes the communication process by means of the electronics model.

Thus, Bohr's physical theory pictures the atom in terms of the solar system, with the nucleus (Sun) in the centre and planetary electrons revolving around it.

Molecular biology, on the other hand, describes the flow of genetic information in terms of language. The basic element of this metaphorical model is a *code word*, which consists of letters of *genetic alphabet*. This model is further extended to new concepts. Therefore, *code words* specifying the same amino acid are called *synonyms*, whereas in the process of describing the *translation mechanism*, biologists

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[2] It comes from the Greek word *elektron*, meaning *amber*, due to the fact that, if rubbed by a cloth, it attracts the surrounding particles.

[3] These and other examples of contrastive patterns of electronics terms are taken from *English-Croatian and Croatian-English Dictionary of Electronics*, by Štambuk, A., Pervan, M., Pilkovic, M. Roje, V. (1991) LOGOS, Split.

speak of *translation fidelity*, *ambiguity in translation*, and *translation errors*, where a single error could lead to "error catastrophy" (Smith and Szathmáry 1995: 94).

Linguistic theory, on the other hand, describes the communication process using metaphors from the electronics field. Thus, Shannon and Weaver's model which was elaborated by Lyons (1978), describes human communication in terms of an electronic transmission link: *transmitter, signal transmitted, channel, received signal,* and *receiver,* while Jean Aitchison (1995) uses the metaphor of *complex electric circuitry* to describe our mental lexicon.

It follows from the given examples that, in spite of diversity of codes used in particular branches of science, the models used in scientific communication are closely interrelated, both on cognitive and linguistic levels.

4. Multiword lexical units

Predominant language structures in scientific and technical terminology are linguistic expressions, today commonly called multiword lexical units. A great number of these units, such as, for example, *discrete sound system*, or *binary-to-decimal conversion*, are usually excluded from the domain of grammatical description, since they diverge from predictions of regular compositional rules. In his *Foundations of Cognitive Grammar* (1987), however, Langacker expresses doubts whether this distinction between semantics and pragmatics could ultimately be maintained. Analyzing the hypothetical expression *patriotic pole-climber,* which supposedly obtains a particular meaning in the field of football, he tries to find out how much of its semantic value could be determined from the meanings of its components by regular compositional principles. He decides that nothing in the previously established conventions of English might allow a speaker to deduce what *patriotic pole climber* designates without knowing the situational context in which this expression is a conventional unit. Langacker therefore believes that most of composite expressions have a conventionalized, context-determined meaning, which is more specific than their compositional value, although this value remains an important factor of their meaning. He says (Langacker 1987: 455-456):

> Virtually all linguistic expressions, when first constructed, are interpreted in reference to a richly specified situational context, and much of this context is retained as they coalesce to form established units; this is why most composite expressions have a conventionalized meaning more specific than their compositional value.

Lakoff (1990:148) similarly argues that it is often the case that the meanings of composite expressions are not compositional, i.e. that the meaning of the whole cannot be predicted from the meanings of the parts, although the parts do play a role in the meaning of the whole expression, i.e. they *motivate* that meaning. In cases when compound expressions form chains, like in frequently quoted example of *topless dress, topless waitress, topless dancer,* and *topless bar,* these expressions can be motivated not only by their parts, but by related compounds.

Analyzing lexical combinations in the language of science, Martin points to two parameters that play a predominant role in establishing their kernel, i.e. *communicative situation* (prototypically an expert-expert exchange) and the *semantic domain* (prototypically a restricted and conceptually (well)-organized piece of knowledge). Speaking of conceptual meaning of composite structures, he argues that the "binding" between the elements depends on conceptual slots: 'the more specific the filler of the conceptual slot, the greater the "binding". (Martin 1992: 161)

Take, for example, the English polysemous electronics term *control,* whose particular meanings and submeanings have different equivalents in Croatian:

		1. vodjenje, upravljanje, reguliranje
control	–	*2. nadzor, provjera, kontrola*
		3. upravljačka jedinica (u računalu)

Meanings under 1 are defined as follows:

1. The execution of a system change by manual means, remote means, automatic means, or partially automatic means. We distinguish:
   a. A form of control without feedback (*open loop*).
   b. A type of automatic control in which control actions are based on signals fed back from the controlled equipment or system (*closed loop*).

The broader meaning described under 1. corresponds to Croatian term *vodjenje,* whereas submeanings correspond to Croatian terms a. *upravljanje* and b. *reguliranje (regulacija),* respectively.

If we compare the English composite structures with the noun *control,* to their Croatian equivalents, which have a different word for each meaning of the word *control,* we shall see how different elements in multiword lexical units activate different conceptual slots of the word *control,* thus activating its particular meanings described by the above definitions.

Some modifiers automatically trigger the particular meanings, i.e. *upravljanje* if open loop is implied, or *reguliranje* if closed loop is dealt with:

open-loop control system	–	*upravljanje*
closed-loop control system	–	*regulacijski sustav*
feedback control	–	*reguliranje.*

In other cases, however, the background knowledge is necessary in order to decide which of particular meanings of the term *control* is activated by the given composite structure. We therefore find Croatian lexemes *vodjenje, reguliranje* and *upravljanje* in relation to *control* in the following examples of composite units:

<u>vodjenje</u>

directional control	–	*vodjenje (letjelice) po smjeru*
remote control	–	*daljinsko vodjenje*
manual control	–	*ručno vodjenje*

<u>upravljanje</u>

electric control	–	*električno upravljanje*
device control	–	*upravljanje uredjajem*
ground control	–	*upravljanje sa zemlje*

<u>regulacija</u>

automatic colour control	–	*automatska regulacija boje*
balance control	–	*regulacija ravnoteže*
illumination control	–	*regulacija osvjetljenja*

It is interesting to point out that some composite structures with word *control* motivate completely new meanings, apparently not related to the meanings of their component parts, e.g.

fixed command control	–	*automatska stabilizacija* ('automatic stabilization')
linear control	–	*linearno promjeljivi otpornik* ('linearly changeable resistor').

It follows from the given examples that conceptual relations between elements of multiword lexemes are motivated by their conceptual frame, i.e. their specific field, the knowledge about that field, and the syntactic characteristics of the particular language.

5. Conclusion

We can conclude that the frame provided by the ideas of cognitive linguistics has helped reveal a whole wealth of semantic features in the language of science.

The study of prototypical meaning, as described by cognitive linguists, can be applied to terminological lexis. Dependence of the given semantic category on background knowledge leads to a model of prototypical meaning specific for the language of science.

Metaphorical models abound in the language of science. With their role in structuring the new experience on the basis of the existing one, they play an important part in the development of science, by helping not only to communicate, but also to conceptualize the new knowledge.

Multiword lexical units, disregarded from earlier grammatical theories, now find their place within the frame of cognitive grammar, which rejects distinction between grammar and lexicon and describes lexicon, morphology, and syntax as a continuum of symbolic structures.

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