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Metaphor in the language of science

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In the process of knowledge development a new experience is frequently conceptualised and structured by means of metaphors which help us understand it. A great part of the language of science and technology is, therefore, metaphorical in nature. Modalities of metaphorical patterns used in scientific lexicon are discussed. Simplified lexical models are analyzed in the light of the *wrong analysis* theory which explains the creation of particular conceptual prototypes on the basis of limitations of scientific knowledge in the given synchronous moment. The comparison of English metaphorical models with the Croatian ones has shown that the two languages frequently use the same metaphor. However, in some cases the two languages apply different metaphors to point out certain (usually the same) features of the conceptual category. The comparison of these metaphors reveals some traits of the fundamental conceptual mechanism of metaphorical mappings in the scientific lexicon. Metaphors also play an important role in constituting the scientific theories, by providing a vehicle both for communicating the new knowledge and for stimulating new understanding and new discoveries within a metaphorical model.

I. Introduction

In the process of establishing links between the world and the language of science, metaphors play a very important role. They are considered to be the main mechanism through which we comprehend abstract concepts and perform abstract reasoning. Analogy and metaphor are therefore frequently described as "central to scientific thought" (cf. Gentner and Jeziorski 1996:447).

New concepts issuing from our experience are structured in the first place on the basis of their interaction with other concepts. Lakoff sees metaphor not as a figure of speech, but as a mode of thought defined by a systematic mapping from a source to a target domain, and characterized by:

1. Systematicity in the linguistic correspondences.
2. The use of metaphor to govern reasoning and behavior based on that reasoning.
3. The possibility for understanding novel extensions in terms of the conventional correspondences (1996:210).

Over the centuries, however, many great thinkers have banned metaphor from scientific use. Empiricist philosophers suggested that metaphorical use of language might lead to imprecision and ambiguity, thus misleading and distorting the judgment. This view is based on empiricist belief that the scientific concepts are acquired through accurate sense perceptions in such a way that they correspond to strictly defined entities in the world. Consequently, scientific language was believed to deal only with strictly defined categories. Application of analogy and metaphor was therefore considered to blur the accuracy of knowledge representation.

Structural linguists, similarly, regard the lexicon of science as being strictly monosemous. Thus, Bloomfield asserts that "We can define the meaning of a speech form accurately when this meaning has to do with some matter of which we possess scientific knowledge" (1933:139). Coseriu's view is even more restrictive. He believes that technical vocabulary is simply a nomenclature and as such not structured on the basis of language, but rather on the basis of extralinguistic reality, namely the objects of the discipline in question. He claims:

> Since, in technical usage the words are really the representatives of the "objects", *signification* and *designation* coincide in this case whereas in the domain of the "natural" language they must necessarily be separated. (1981:48).

Current cognitive science, however, has opposed the empiricist view of linguistic precision by developing the theory of nondefinitional reference. Thus, Boyd argues that there is no such thing as linguistic precision; there are rational strategies for avoiding referential ambiguity, but they are not a reflection of rules of linguistic usage as the empiricist theory suggests. He argues that knowledge would not be possible if our language and our conceptual categories were not accommodated to the changing facts of the world:

> Thus, if reference is the relation between language and the world which explains the role of language in the acquisition and communication of knowledge, *nondeterminate referential connections between words and features of the world are essential components of reference* (1996:504).

Accommodation of scientific language to the development of science is a continuous process. The meanings of terms constantly change as the amount of knowledge about them increases, discovering ever deeper levels of cognition. Similarly, scientific theories are constantly being replaced by more revealing and more accurate theories.

Once we have discarded the empiricist theory of linguistic precision, including the precision of scientific language, we can also discard the empiricist view that metaphor might distort the scientific thought by conveying wrong ideas and lead to imprecision

and vagueness due to its conceptual open-endedness. Quite to the contrary, metaphor is today accepted not only as a figure of speech, but also as a mode of thought and a valuable, even indispensable vehicle for conceptualizing and conveying new knowledge. Thus, Boyd claims:

> The use of metaphor is one of many devices available to the scientific community to accomplish the task of accommodation of language to the causal structure of the world. By this I mean the task of introducing terminology and modifying usage of existing terminology (1996:483).

Lakoff develops the "experientialist" account of knowledge, claiming that we structure our reality by our conceptual schemes. In this process some kinds of experience are structured preconceptually. However, in domains lacking such preconceptual structures, we understand experience via metaphor. Lakoff finds that "much of rational thought involves the use of metaphoric models," and that "any adequate account of rationality must account for the use of imagination" (1990:303). By mapping properties from source to target domain, metaphors conceptualize new knowledge. However, they have another important function: they also reveal aspects of reality as yet unseen, thus influencing our thought process.

A variety of metaphor types are encountered in the language of science. We shall try to describe their patterns by analyzing examples from terminology of electrical and electronics engineering. We shall also compare the respective metaphorical models of English and Croatian terminology, in order to point out the mechanism of structuring the metaphorical models across languages.

II. Metaphorical expressions in the lexicon of electrical engineering

The analysis of electrical engineering lexicon will show that a great number of the terms are of metaphorical origin. These metaphors are predominantly based on correspondences in our experience. In some cases they are also based on image similarity. Thus, Lakoff speaks of "image metaphors", defining them as "isolated one-shot mappings from a single conventionalized mental image onto another conventionalized mental image." (1993:29).

Take for example the word *electricity*. Six hundred years BC a Greek philosopher noted that when amber (*elektron* in Greek), is rubbed with cloth, it attracts light particles. This phenomenon remained a curiosity for full twenty-two centuries, but in the seventeenth century, when scientists started studying the forces acting between certain materials, the phenomenon got its name after amber. A century later concepts of *positive* and *negative* electricity were introduced, again using metaphors.

Trying to create the Croatian term for *electricity,* Bogoslav Šulek, a great Croatian lexicographer, in his Croatian-German-Italian Dictionary of Science, published in 1874, suggested the lexeme *munjina (lightning).* Again, this word is created by metaphorical extension, due to the fact that a century earlier Benjamin Franklin discovered

that lightning was a form of electricity. Thus, in Šulek's dictionary *condenser* is called *kupilo munjine (lightning collector), electromagnet* is *munjomagnet (lightning magnet),* and *electric field* is *munjokrug (lightning circuit).* These terms were used for some time in Croatian electrical engineering terminology, but they did not last long, and were soon replaced by internationalisms such as *elektricitet, elektromagnet, električno polje (electric field),* etc.

If we continue observing the lexeme *electricity,* we shall see that today it has several meanings, one of which is synonymous with the lexeme *electric current,* or shorter *current.* Here is another metaphor among the basic lexemes of electrical engineering science, created in analogy to the *current* of water, or *current* of air, on the basis of common characteristics of motion, since *electric current* basically involves the motion, or *flow* of electric charges.

Such metaphorical expressions, according to Anderson's definition "involve the application of a word or expression that properly belongs to one context to express meaning in a different context because of some real or implied similarity in the referents involved." (1964:53). Some authors express doubts whether such expressions might be nothing more than cases of catachresis, i.e. using expressions to fill in the gaps in the lexicon (cf. Black 1996:25). However, the converse view seems to prevail. Thus, speaking of *catachresis* as "the use of metaphors to introduce theoretical terminology where none previously existed", Boyd (1996:482) claims that "these metaphors possess several (though not all) of the characteristics which Black attributes to interaction metaphors." Paivio and Walsh (1996:307) consider that "semantic productivity must be regarded as a salient design feature of metaphorical language, just as syntactic productivity of language in general", and Miller claims that "the danger he sees in regarding the metaphorical use of a word as merely an extension of that word's meaning, is that it tempts us to oversimplify our view of metaphor." (1996:397).

Our examples from the lexicon of electrical engineering have shown that other metaphors are frequently structured around the basic metaphorical expressions, thus creating a set of correspondences between source and target domains. In our example of *electric current* we shall further have *current source,* (a point from which the current flows), *current drain,* (the amount of current a circuit draws from a power supply), *ripple,* (the presence of an alternating current component in a direct-current signal), *leakage current,* (the unwanted stray current that flows across the surface on an insulator or an insulating material), etc.

In the process of the development of science we can encounter a number of terms to which the *wrong analysis* theory could be applied. This theory suggests that children, who do not have a full (adult) knowledge of the existing system of categories, create their own system, limited by their experience and perception. They pick their own prototypical model, and if they find an object showing sufficient agreement with the features of the prototype, they assign the new object to the same category. For example, since children are usually irresistibly attracted by sources of light, one of the first words in their vocabulary will be a word for it. In Croatian it is the word *žiža* (a child's expres-

sion for *lamp,* probably shortened from *žižak (wick)*). Almost invariably, when they see the moon, by the analogy of illuminated state and the circular form, they will use the same word (*žiža*) to name it.

Psychologists say that children form their perceptions and generalizations of the world through a *mental fog* (cf. Aitchison 1995:173). In a similar way, scientists, whose knowledge is limited by the level of the existing scientific discoveries, and consequently by the current conception of scientific truths in the given field, frequently create conceptual categories and words expressing them, through a similar kind of mental fog. With the development of science, these words are usually lost, as we have seen with the example of the word *munjina*. However, a number of these simplified lexical models enter long-term use, despite their maladjustment to changes of conceptual models resulting from new knowledge. An example of such a primitive lexical model which has become generally accepted, in spite of its maladjustment to current knowledge, might be the very word *electricity*.

III. Contrastive analysis of metaphorical models in English and Croatian

III. a. Parallel mappings

Speaking of the experiential base of metaphor which stimulates the discussion raised in connection with the arbitrary vs. motivated dichotomy, namely the relationship between language on the one hand and culture and environment on the other, Taylor argues:

> Since, on the one hand, certain experiences are presumably common to all normal, healthy human beings, while others are strongly conditioned by culture and environment, it comes as no surprise that we find both considerable cross-language similarity in metaphorical expression, as well as cross-language diversity. (1995:141).

Thus, if metaphorical models in the English electrical engineering lexicon are compared to the Croatian ones, a number of equal mappings will be found in the two languages. If we take, for example, the above described metaphorical model of *current* and the lexemes grouped around it, we find that most of them have parallel metaphors in the two languages:

current flow - *protok struje*
current source - *izvor struje*
current drain - *odvod struje*
leakage current - *struja otjecanja*
ripple current - *struja mreškanja.*

A number of parallel metaphorical expressions can also be found in electronics lexicon in the two languages:

field	-	*polje*	*wave*	-	*val*
bundle	-	*snop*	*bridge*	-	*most*
head	-	*glava*	*loop*	-	*petlja*
node	-	*čvor*	*shell*	-	*ljuska*
fiber	-	*vlakno*	*grass*	-	*trava, etc.*

If we look at dictionary definitions of the given lexemes, we shall see that their conceptual and linguistic productivity is based on analogy. One or more features of the source concept are integrated to produce a new concept and its expression, e.g.:

grass (trava) - the pattern produced by random noise on an A-scope; it appears as closely spaced, sharp, constantly moving pulses on the base line.

shell (ljuska) - a group of electrons having a common energy level that forms part of the outer structure of an atom.

In the first example the metaphor is created on the basis of similarity between grass and closely spaced, sharp, constantly moving pulses. In the second example, however, the mediator between the source and the target concepts is the metaphorical model of atom, in which the groups of electrons associated to the *nucleus* are logically described as *shells.* This is even more obvious in Croatian, where the lexeme used for *nucleus* is *jezgra (core, kernel).*

III. b. Loan metaphors

In a number of the given examples of parallel mappings we can talk of metaphorical transfer or "migration" of metaphors from one language to another, in this case from English to Croatian scientific terminology. This phenomenon can predominantly be observed in the fields of telecommunications and computer science, in which most concepts were first created and named in English-speaking parts of the world. In the process of accepting these concepts in Croatian science, metaphors are frequently borrowed from the source language and parallel metaphorical mappings are used:

mouse	-	*miš*	*stack*	-	*stog*
window	-	*prozor*	*trap*	-	*zamka*
thimble	-	*naprstak*	*bucket*	-	*vjedro*
descendant	-	*potomak*	*handshake*	-	*rukovanje*
orphan	-	*siroče*	*widow*	-	*udovica, etc.*

III. c. Divergent metaphorical models in the two languages

Contrastive analysis of metaphorical models in English and Croatian electrical and electronics engineering lexicon has shown that a large number of metaphors have parallel structures in the two languages. However, closer examination will reveal that a particular metaphorical model rarely overlaps in all its parts. Thus, in a number of ex-

amples the given metaphorical model was found to be more consistently applied in English than in Croatian.

In English, for example, we find a metaphorical model in which the characteristics of human beings are attributed to electric charges, as seen in the following statements:

Electrons reach sufficient speed *to escape* from the surface of the conductor.

Electrons acquire sufficient energy to *break the bonds and jump into* the conduction band.

Electrons detach themselves and *wander at random* within the crystal lattice.

The number of electrons *released* depends on frequency.

When an electron moves randomly about in the crystal, the possibility is that it will *meet* a hole.

When an electron *meets* a hole, the broken *bond* is re-established.

In Croatian translation, however, a great part of the metaphorical component is lost. Thus, in Croatian, for example, electron does not *wander at random*, but it *moves chaotically (giba se kaotično),* it does not *escape*, but *leaves (napušta)* the surface of the conductor.

The given examples illustrate the case when one language uses the metaphor where another language uses it less consistently, or does not use it at all.

In a number of cases we shall find another type of divergence in metaphorical structure of the two languages. Both languages use metaphors to describe a conceptual category, each language, however, using a different metaphor. Thus we have examples of lexemes in electrical engineering lexicon of the two languages:

elbow	-	*koljeno (knee)*	*lobe*	-	*latica (petal)*
horn	-	*lijevak (funnel)*	*reed*	-	*listić (little leaf/thin sheet)*
pin	-	*ušica (eye of a needle)*	*beat*	-	*treptaj (flicker).*

If we analyze the conceptual structure of the given lexemes, we shall discover that, although different, metaphors in the two languages usually point at the same or at similar features of the conceptual category. Thus, in metaphorical lexemes *elbow* and *koljeno (knee),* defined as a 90-degree bend in a waveguide, it is the feature of BENDING that establishes the interactive link among concepts and decides about the use of these lexemes in the lexicon.

Lexemes *reed* and *listić (litle leaf* or *thin sheet)* defined as a "thin bar located in a narrow gap and made to vibrate electrically, magnetically, or mechanically by forcing air through the gap", are structured on the basis of the fact that something is THIN and VIBRATING.

The feature of being WIDENED at one end is the basis of parallel metaphorical lexemes *horn* and *lijevak (funnel)*: "a radiating device that is essentially a cylindrical or rectangular pipe whose surface flares from a narrow entry to a wide exit."

Lexemes *lobe* and *latica (petal)* are created with reference to the feature of a PARTICULAR SHAPE. They are used to denote "in an antenna directivity pattern, a figure such as circle or ellipse enclosing an area of intensified response."

If we accept the view that the semantics of a word may be defined as a combination of different types of meaning, including conceptual, grammatical, collocational and associative meaning (cf. Vliet 1994:217), we could say of the above pairs of metaphorically created English and Croatian lexemes that they have the same conceptual, but different associative meanings, since they are structured by different metaphors.

IV. Metaphor in scientific theories

The role of *theory-constitutive* scientific metaphors (cf. Boyd 1996) is essential in the process of both structuring and communicating newly created knowledge. All metaphors serve as a vehicle for activating new understanding and providing a new insight into the given conceptual models, but this is particularly true of theory-constitutive metaphors. Providing a more or less explicit metaphorical model to describe otherwise fuzzy and not yet fully shaped theoretical claims creates a cognitive frame which is precious not only for communicating the new discoveries, but also for stimulating exploration of new similarities and analogies within the model, helping to discover those not yet discovered and to understand those not yet fully understood.

It should be pointed out that almost all branches of science include examples of theory-consititutive metaphors, which help communicate the new knowledge and stimulate further development of the given science (cf. Štambuk 1998).

V. Conclusion

Once we have rejected the empiricist conception of linguistic precision, and accepted the dependence of scientific knowledge on our interaction with the world, we can embrace the idea of a vital function of metaphors in scientific thought as a basic mechanism which helps us to understand abstract concepts by means of concrete concepts.

In the process of structuring our experience, metaphors help us to structure categories, concepts, and terms that will serve as vehicles of thought and will both enable communication of existing knowledge, and encourage further research and new discoveries.

Analysis of a part of scientific lexicon has revealed a great number of expressions of metaphorical origin, belonging to different metaphor types, according to patterns of their conceptual and semantic features.

Since conceptual categories and their expressions are frequently created in the environment of *mental fog*, due to limitations of the current level of perception of scientific truths, a number of metaphorical expressions become inadequate with the development of science. With the introduction of new knowledge, some of these mappings are lost and replaced with new ones, whereas some of them survive as primitive lexical models, despite their maladjustment to the new knowledge.

The comparison of English and Croatian metaphorical models has revealed patterns of similarities and differences between the two languages on this level. The analysis has shown that most metaphorical models have parallel mappings in the two languages. However, a closer examination reveals that there is rarely a consistent overlapping of all elements of a metaphorical model in both languages.

In another type of divergence the two languages use different metaphors to conceptualize the same experience. The comparison of these metaphors reveals some traits of the fundamental conceptual mechanism of metaphorical mappings in the scientific lexicon.

Metaphorical models are also used to formulate scientific theories. Providing a conceptual frame for theoretical insights, these metaphors frequently help to constitute scientific thought, inciting the exploration of new similarities and analogies within the model, and leading to new theoretical perspectives.

The examples of metaphorical patterns used in scientific lexicon have shown that in the process of creating metaphorical mappings, there is a rich interaction between the language and the world. This interaction could be adequately expressed by the question put by Kuhn:

> "Does it obviously make better sense to speak of accommodating language to the world than of accommodating the world to language? Or is the way of talking which creates that distinction itself illusory? Is what we refer to as 'the world' perhaps a product of a mutual accommodation between experience and language?" (1996:541/542).

Whatever the answer, it is obvious that language, with all its complexity and the mystery of its manifold mappings, provides a key which helps us unlock, one by one, the doors of cognition.

REFERENCES

Aitchison, Jean (1995). *Words in the Mind.* Oxford, Cambridge Mass.: Blackwell Publishers.

Anderson, C.C. (1964). "The psychology of the metaphor," *Journal of Genetic Psychology* 105: 53-73.

Black, Max (1996). "More about metaphor," A. Ortony, ed., *Metaphor and Thought* (Cambridge University Press) 19-41.

Bloomfield, Leonard (1933). *Language.* London: George Allen and Unwin Ltd.

Boyd, Richard (1996). "Metaphor and theory change: What is 'metaphor' a metaphor for?," A. Ortony, ed., *Metaphor and Though.* (Cambridge University Press) 481-532.

Coseriu, Eugeniu and Horst Geckeler (1981). *Trends in Structural Semantics.* Tübingen: Gunter Narr Verlag.

Fillmore, Charles J. (1982). "Frame Semantics," The Linguistic Soceity of Korea, ed., *Linguistics in the Morning Calm* (Seoul: Hanshin Publishing Co.) 111-137.

Gentner, Dedre and Michael Jeziorsky (1996). "The shift from metaphor to analogy in Western science," A. Ortony, ed., *Metaphor and Thought* (Cambridge University Press) 447-480.

Kuhn, Thomas S. (1996). "Metaphor in science," A. Ortony, ed., *Metaphor and Thought* (Cambridge University Press) 533-542.

Lakoff, George (1990). *Women, Fire and Dangerous Things*, Chicago and London: The University of Chicago Press.

Lakoff, George (1993). "The Syntax of Metaphorical Semantic Roles," James Pustejovsky, ed., *Semantics and the Lexicon* (Dordrecht, Boston, London: Kluwer Academic Publisher) 27-36.

Lakoff, George (1996). "The Contemporary theory of metaphor," A. Ortony, ed., *Metaphor and Thought*, (Cambridge University Press) 202-251.

Langacker, Ronald W. (1987). *Foundations of Cognitive Grammar.* Vol. I. Stanford: Stanford University Press.

Miller, George A. (1996). "Images and models, similes and metaphors," A. Ortony, ed., *Metaphor and Thought* (Cambridge University Press) 357-400.

Ortony, Andrew ed. (1996). *Metaphor and Thought.* Cambridge University Press. First published 1979. Second, revised and extended edition 1993.

Paivio Allan and Mary Walsh (1996). "Psychological processes in metaphor comprehension and memory," A. Ortony, ed., *Metaphor and Thought* (Cambridge University Press) 307-329.

Štambuk, Anuška, M. Pervan, M. Pilković, V. Roje (1991). *Englesko-hrvatski i hrvatsko-engleski rječnik elektroničkog nazivlja.* Split: LOGOS.

Štambuk, Anuška (1998) . Metaphor in Scientific Communication. *META.* Montreal, 43: 3, 373-379.

Šulek, Bogoslav (1874, 1875). *Rječnik znanstvenog nazivlja hrvatsko-njemačko-talijanski.* Zagreb.

Taylor, John R. (1995). *Linguistic Categorization.*Oxford: Oxford University Press. First published 1989.

Vliet, Henry (1994). "Conceptual Semantics for Nouns," Willy Martin et al., eds. *Euralex 1994 Proceedings,* 216-225.

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METAFORA U JEZIKU STRUKE

Tijekom razvoja znanosti novo se iskustvo često konceptualizira i oblikuje s pomoću metafora koje nam pomažu u njegovu razumijevanju. Stoga je jezik struke u velikoj mjeri metaforičan po svojoj prirodi. Na primjerima elektroničkog leksika u članku se raščlanjuju konceptualne i semantičke karakteristike različitih tipova metafora. Govori se o pojednostavnjenim leksičkim modelima u svjetlu teorije *krive analize* čime se objašnjava stvaranje određenih konceptualnih prototipova ograničenih trenutačnom razinom percepcije znanstvenih istina. Usporedbom engleskih i hrvatskih metaforičkih modela otkrivaju se sličnosti i razlike između dvaju jezika na ovoj razini. Raščlamba je pokazala da većina metaforičkih modela ima paralelne oblike u dva jezika. Međutim, također se očituju i razlike između dvaju navedenih jezika, uporabom različitih metafora za konceptualizaciju istog iskustva. Usporedbom ovih metafora otkrivaju se neke od temeljnih osobina konceptualnog mehanizma metaforičkog preslikavanja u znanstvenom leksiku.

Metaforički se modeli također upotrebljavaju za oblikovanje znanstvenih teorija. Pružanjem konceptualnog okvira za teorijska saznanja, ove metafore često potiču oblikovanje i razvoj znanstvenih teorija, potičući istraživanja novih sličnosti i analogija unutar metaforičkog modela.