CENTER FOR RESEARCH IN LANGUAGE

February 1987 Vol. 1, No. 3

The monthly newsletter of the Center for Research in Language, University of California, San Diego, La Jolla CA 92093. *(619) 534-2536*; electronic mail: *crl @ amos.ling.ucsd.edu*

• • •

CONTENTS

TALKS & EVENTS OF INTEREST

Terry Sejnowski, Johns Hopkins;
Analyzing Signals and Symbols with Neural Networks
Wednesday, February 11, 2 pm
1105 Basic Sciences Building (Garren Auditorium, Med. School)

David Touretzky, Carnegie-Mellon University;
BoltzCONS: Representing and Transforming Recursive Objects in a Neural Network
Friday, February 27, 10 am
CHIP Conference Room
Psychology & Linguistics Annex, 3rd floor

Henry Hamburger, George Mason University;
A Fragment of English as an Authoring Tool
Wednesday, February 25, 12 noon
125 Media Communication Center

Henry Hamburger, George Mason University;
On the Second Consecutive Complex Modifier in this Title
Friday, February 27, 12 noon
125 Media Communication Center

WORKSHOP IN SYNTACTIC THEORY

February 21- 22, 1987
Department of Linguistics, UCSD

Saturday, Feb 21

12:30 pm Welcoming Remarks

1:00 pm - 5:30 pm: **THE SYNTAX AND SEMANTICS OF REFLEXIVES**

Speakers:

Richard Kayne, MIT
"The HAVE-BE Alternation"

Peter Sells, CSLI, Stanford University
"Theoretical Issues in the Analysis of Reflexives"

Judith Aissen, U.C. Santa Cruz
"Evidence for Multiattachment in Mayan"

Discussants:

David Perlmutter, U.C. San Diego
Eduardo Raposo, U.C. Santa Barbara

8:30 pm:PARTY at David Perlmutter's
3505 28th St., San Diego

Sunday Feb 22

9:30 am - 2:30 pm: **SYNTACTIC REPRESENTATIONS**

Speakers:

Hilda Koopman, U.C.L.A.
"Clausal Structure"

Timothy Stowell, U.C.L.A.
"Specifiers and X-bar Theory"

Grant Goodall, University of Texas, El Paso
"Theories of Coordination and Phrase Structure"

Discussants:

Peggy Speas, U.C. San Diego
Mark Johnson, Stanford University
Lauri Karttunen, Stanford University

JOB ANNOUNCEMENT

The Department of Linguistics at the University of California, San Diego seeks to fill a tenure-track Assistant Professor position in the area of syntax/semantics, beginning September 1987. Annual salary is $29,800-$37,200. The Ph.D. in linguistics is required. The candidate should have a cross-theoretical and cross-linguistic perspective. Send letter of application, curriculum vitae, names of 3 referees, and 1 representative publication, to:

Search Committee
Department of Linguistics, C-008-C
University of California, San Diego
La Jolla, CA 92093

Application materials must be received no later than March 17, 1987. The University of California is an equal opportunity, affirmative action employer.

MEETING ANNOUNCEMENT

Special Interest Committee in Natural Language Processing meets regularly the first Monday of each month at 6:30 pm in Room 3118 (CRL Conference Room) of the Psychology and Linguistics Building, Muir Campus, UCSD. For details, contact Beth Sundheim (sundheim@ trout.nosc.mil).

EDITOR'S NOTE

Beginning with this issue of the **CRL** Newsletter, and on an occasional basis, we will publish brief articles or notes of interest to **CRL** members and friends. We welcome contributions from readers. Pieces should be brief (1 to 10 pages) and preferably submitted in electronic form. Address correspondence to:

Center for Research in Language,
Mail Code C-008
University of California, San Diego
La Jolla, CA 92093
(619) 534-2536
electronic mail: crl@amos.ling.ucsd.edu

The Cognitive Perspective

Ronald W. Langacker
University of California, San Diego

For the past quarter century, theoretically oriented linguistic research has been dominated by transformational grammar and its descendants. Despite the diversity of theory and opinion within this tradition, it is not grossly unfair to speak of a "generative grammar world view": a body of received wisdom and default-case assumptions that linguists in this tradition tend to adopt unless they have specific reasons to believe otherwise. Central components of this view include the modularity of linguistic knowledge, the autonomy of syntax (with respect to meaning in particular), and the viability for natural language of some type of truth-conditional semantics modeled on formal logic.

In recent years, an alternative perspective has emerged and begun to coalesce as a comprehensive, coherent, and self-conscious alternative to the generative world view. My own work in "cognitive grammar" (a.k.a. "space grammar") over the past decade is only one of the many strands of research involved, both in linguistics and in related disciplines. The purpose of this brief report is to offer a succinct survey of this "cognitive perspective" and to comment on its coherence and potential.

The term "cognitive perspective" is adopted mainly for lack of a better option. Since generative grammarians loudly proclaim the psychological relevance of their work, concern with cognitive issues is not per se what distinguishes the two outlooks. Rather they differ in their conceptions of the nature of linguistic knowledge, how it relates to other facets of cognitive organization, and what kinds of theoretical models are appropriate for language and for cognition in general. Thus, in speaking of the cognitive perspective, I am referring to one of two broadly-contrasting approaches to these issues. It does however imply a far more immediate and intimate connection between linguistic investigation and specific developments in other branches of cognitive science than is suggested by the generative world view.

This is most obvious in the case of semantics, for the whole point of truth-conditional semantics is to avoid any postulation of mental constructs in the characterization of semantic structure. In accordance with its origin in logic and empiricism, truth-conditional semantics is by nature *objectivist;* the meaning of an expression is taken to be the set of conditions under which it is true--it is specifically *not* equated with any kind of conceptualization or cognitive processing. This outlook places stringent limitations on both the phenomena examined and how they are treated. Excluded, for example, are figurative language, any semantic contrasts that do not reduce to differences in truth conditions, and those aspects of the meaning of complex expressions that are not strictly compositional (e.g. anything contributed by appreciation of the context or by "extra-linguistic" knowledge).

Whether these restrictions are justifiable, and whether truth-conditional semantics is revelatory within its chosen domain, are issues that we need not address. What does concern us is the emergence and rapid growth, within the last decade, of a movement known variously as "subjectivist", "conceptualist", or "cognitive semantics". Many different theories and approaches can be subsumed under these rubrics; what they share is the notion that meaning is a mental phenomenon which must ultimately be described as such, and that natural-language semantics is far richer than logic-based models would lead us to suspect. Here, of course, I can offer only the briefest description of the scope of cognitive semantics and some of its basic ideas and results.

One enterprise is to characterize certain aspects of mental structures on the basis of linguistic evidence. By positing "mental spaces" whose elements are linked by correspondences, Fauconnier (1985) has provided a unified and elegant solution for many classic problems (pertaining to opacity, referentiality, presupposition, etc.) of truth-conditional semantics. I myself *(to appear b)* have tried to spell out explicitly the many parameters along which the construal of a conceived situation can vary (e.g. level of specificity, scope of predication, relative prominence of substructures, background assumptions and expectations, perspective), and to show the linguistic import of each construct. A rather different example is Wierzbicka's attempt (e.g. 1972, 1980, 1984) to build up subtle and elaborate characterizations of word meanings out of a small inventory of conceptual primitives.

A related enterprise is the extensive, fine-grained investigation of particular semantic domains, which has led to surprising and significant results. For instance, a careful examination of "force dynamics" (Talmy 1985b; Sweetser 1982, 1984) has revealed that notions of force, energy, resistance, etc. figure in the meaning of a vastly wider range of expressions than one would anticipate, and are crucial even in abstract areas such as epistemic modality. A great amount of work has been done on the semantics of locative expressions, both here (Casad 1982; Casad and Langacker 1985; Hawkins 1984; Lindner 1981, 1982; Vandeloise 1984, 1985, 1986) and elsewhere (Brugman 1981; Brugman and Macaulay 1986; Herskovits 1982, 1985; Talmy 1975, 1977, 1978, 1983, 1985a). Among the important discoveries emerging from this research are the following: (i) a small number of elemental concepts (e.g. contact vs. separation; bounded vs. unbounded path; origin vs. terminus) neatly accommodate the meanings of English prepositions, insofar as these are spatial and geometric. (ii) To a substantial extent, however, even the meanings of "spatial" prepositions depend on considerations of function and interaction (e.g. contents/container; bearer/burden). (iii) Language-specific regularities are observable in the lexical "packaging" of configurations involving spatial motion (e.g. *float* [along a path] vs. Spanish *ir flotando).* (iv) Languages manifest radical differences in how spatial relationships are construed and portrayed; even in this basic domain, semantic structure is non-universal and exact translation often impossible. (v) Locative elements are typically polysemous, showing a multiplicity of alternate senses related non-arbitrarily to one another, but not in general displaying any "core meaning" valid for them all.

A major concern of cognitive semantics is the nature of categorization (Lakoff *in press).* Studies of lexical polysemy have demonstrated the inadequacy for natural language of the classic "criterial attribute" model of categorization, and supported the alternative "prototype" model recently developed in psychology (Rosch 1973, 1975, 1977, 1978). Most linguistic categories are complex, having a range of alternate values that are connected to one another to form a network anchored by the category prototype. A growing body of research shows that these networks are anything but random or arbitrary: they develop from the prototype by specific mechanisms of semantic extension (e.g. metaphor, schematization, domain shift, profile adjustment), which tends to follow universal and language-specific patterns. Though the precise array of values subsumed by a network is subject to conventional determination, its growth and structure is highly principled, and any given relationship is motivated.

The structure of a semantic network is the synchronic reflex of what, in diachronic terms, is recognized as semantic change. Cognitive semantics is thus providing important insights concerning semantic shift, and fostering a renaissance in diachronic semantics. For example, Sweetser (1984) has added a new dimension to the study of Indo-European etymologies by noting recurrent patterns of metaphorical extension leading from the physical to the mental domain. Nikiforidou (1986) has traced the history of the Indo-European genitive, showing that a particular cluster of values are consistently among those constituting the semantic network for this case, and that their relationships to one another are motivated by metaphors whose productivity can be established on independent grounds. Traugott (e.g. 1982, 1986) has studied the process of abstraction by which lexical items acquire grammatical, discourse, or expressive uses, and I have argued (1986) that the frequent extension of 'go' to indicate futurity is the joint product of three very common types of semantic shift. By meticulously examining the history of certain lexemes in Dutch, Geeraerts (1983) has supported the network conception of lexical semantics based on prototypes.

Metaphor is recognized by cognitive semanticists as a critical aspect of meaning in natural language, and is now an object of intensive study. Sentences totally devoid of metaphor are probably a small minority, and a motivated boundary between "literal" and "figurative" expressions is impossible to draw (Lindner 1981; Rumelhart 1979). Lakoff and Johnson (1980) demonstrated that metaphor is typically not a property of individual sentences. Instead, one cognitive domain is used systematically to structure another--regular correspondences are established between their elements, and the same set of correspondences provides the basis for an open-ended family of mutually-reinforcing metaphorical expressions. The linguistic research on metaphor dovetails with psychological work on the use of analogy in problem-solving (e.g. Gentner 1983; Gentner and Gentner 1983; Gentner and Toupin 1986), and informs philosopher Mark Johnson's study (*in press*) of the grounding of our conceptual world in bodily experience. A classic paper by Reddy (1979) details an all-pervasive metaphorical system employed in English to talk about language itself; facets of this system underpin widespread but dubious theoretical assumptions.

For example, we talk about linguistic expressions as if they were "containers" for a "substance" called meaning. Since containers have clear boundaries and limited volumes, this encourages the doctrine that linguistic and extra-linguistic knowledge are sharply distinct, that "dictionary-type" definitions are adequate to characterize the meanings of words, and that the meaning of a sentence is obtained simply by combining discrete word meanings according to certain rules. This runs directly counter to experience in machine translation and artificial intelligence, which indicates that open-ended, essentially "encyclopedic" knowledge systems must be invoked for the semantic analysis of even the simplest, most straightforward sentences (e.g. *The pen is in the box).* Cognitive semanticists have argued on more narrowly linguistic grounds the arbitrariness of the semantics/pragmatics dichotomy and the need for an encyclopedic conception of linguistic semantics. Though terminology varies, there is wide agreement that the meanings of both fixed and novel expressions are construed with reference to "frames", "scenes", "cognitive domains", "folk models", "scripts", "schemas", or "idealized cognitive models", which are essential to their characterization (Fillmore 1982; Haiman 1980; Lakoff *in press*; Langacker *in press a*, *to appear a*).

I have provided a fair amount of detail (see also Lakoff 1986a), since many linguists remain unaware of the scope, vitality, coherence, and results of cognitive semantics (most textbooks still take pains to explain why meaning cannot be considered a mental phenomenon). The works I have cited merely sample the large and steadily increasing volume of research, in linguistics and other disciplines, that is contributing to the emergence of a viable and realistic account of natural language semantics from the cognitive perspective. It has revitalized the investigation of classic issues (e.g. metaphor, and the relation between language and thought--cf. Langacker 1976, Lakoff *in press*, Silverstein 1979), and laid the foundation for re-assessing the relation between meaning and grammar.

The principles and discoveries of cognitive semantics support a conception of grammar that is quite at odds with its treatment in the generative tradition as an autonomous, self-contained system. I have pointed out (*to appear a*) that standard arguments for the autonomy thesis either presuppose objectivist semantics or else mistakenly assume that autonomy is established by the inability to predict all aspects of grammatical form on the basis of meaning or other independent factors (cf. Newmeyer 1983). This latter assumption confuses two issues that are in principle distinct: *the nature of grammatical units*, and *the predictability of their behavior*. It is perfectly coherent to maintain, as I do (*to appear d*), that grammatical patterns are conventional and must be listed, but to claim that all the units which figure in their characterization have both semantic and phonological import--i.e. grammatical structure is inherently *symbolic*.

My own conception of "cognitive grammar" posits only three kinds of linguistic units: semantic, phonological, and symbolic. Symbolic units accommodate both lexicon and grammar, which are seen as forming a gradation divided only arbitrarily into separate "components". Because a symbolic unit embodies a particular way of construing and portraying conceptual content, the choice between alternative lexical items or grammatical constructions (e.g. active vs. passive) necessarily has semantic consequences (even if there is no difference in truth conditions). The theory is highly restrictive, arbitrary constructs being precluded: nothing is permitted other than units which occur overtly, schematizations of such units, and relationships of categorization; "rules" are simply schematic representations of the expressions they account for. This view of linguistic structure is certainly non-standard, but it is intrinsically desirable by virtue of conceptual unification and theoretical austerity.

I have tried to show that a model of this sort is workable in principle (*in press a*, Part III) and revelatory when applied to specific grammatical phenomena. For instance, I have developed (*to appear c*) a fully general account of grammatical composition (based on semantic and phonological correspondences), which affords a natural characterization of such pivotal notions as "head", "modifier", and "complement", and explains the typical correlation between morphological layering and "semantic scope" (cf. Baker 1985, who struggles with this in the context of generative theory). I have employed these compositional principles for a full and explicit analysis of the English passive (1982); it attributes to each "grammatical" morpheme a semantic value motivated by its other uses, and indicates precisely how passive sentences differ semantically from the corresponding actives despite their truth-functional equivalence. I have provided an account of "raising" constructions (1984), showing them to be just special cases of mundane phenomena observable in virtually any sentence. Further, I have proposed (*in press b*) a conceptually-grounded characterization of the noun and verb classes, demonstrated the exact parallelism of their major subclasses (count vs. mass nouns, perfective vs. imperfective verbs), and shown how the analysis accounts for a wide range of semantic and grammatical properties. More recently (*manuscript*), I have sketched the cognitive grammar approach to such problems as grammatical relations, transitivity, and case.

Much additional grammatical research is being conducted from a cognitive perspective; I can only cite some representative examples. Bolinger has long insisted on the meaningfulness of so-called "grammatical morphemes", the semantic consequences of any difference in grammatical form, and the treatment of grammatical constructions as complex categories (i.e. families of construction types) that grade into one another (1961, 1971, 1977). The general prediction that some semantic difference should always be discernible between two constructions, even when one is derived from the other in generative treatments, has been shown by Tuggy (1980) to be correct for the specific case of "possessor ascension" in Spanish. Lindner (1981, 1982) has demonstrated that English verb-particle constructions (e.g. *pass out*, *turn up*) are virtually always semantically analyzable, and that there are systematic relationships among the meanings of a given particle. Janda (1984) has successfully employed the network model to describe the meanings of certain verb prefixes in Russian. Smith (*in progress*) is describing the semantic contrast between dative and accusative case in German, and how its specific value differs across constructions. Van Oosten (1986) has analyzed the notions "subject" and "topic" in terms of the prototype model of categorization, and investigated the semantic differences among constructions in which their value is non-prototypical. Lakoff (*in press*) has treated *there*-constructions as a complex category and shown that many grammatical properties of the various construction subtypes are semantically predictable; he has also demonstrated that the coordinate-structure constraint cannot be handled in purely syntactic or structural terms (1986b), and is working with others at UC Berkeley to develop a general "construction theory".

These approaches are closely related to a large body of research that attempts to account for grammatical structure in "functional" terms (cf. Giv\'on 1979, 1984; DeLancey 1981; Nichols 1984; Foley and Van Valin 1984). Descriptive and functional analysis are complementary: the former is responsible for laying out the specific details of grammatical systems, whereas the latter investigates the many factors--including discourse, acquisition, iconicity, cognitive processing, and language change--which interact to shape such systems and determine their prototypical organization. In particular, considerable effort has been devoted to explicating grammatical structure in terms of its discourse function (e.g. Giv\'on 1983; Hopper and Thompson 1980, 1984), while Haiman (1983, 1985, 1986) has led the way in demonstrating its extensive iconicity. Although the grammatical patterns of a language are not determined in any mechanical or fully predictable way from functional considerations, they are never arbitrary, and always represent a way of resolving the varied and often conflicting constraints that these factors impose.

Scholars can honorably disagree about the validity and importance of the grammatical research outlined above, just as they disagree about the insight and significance of grammatical theories in the generative tradition. My point is simply to indicate that the most basic issues concerning the nature of grammatical structure and its proper analysis are far from being resolved, and that a conception of grammar differing radically and fundamentally from generative orthodoxy may nevertheless prove capable of offering a coherent view of linguistic organization and achieving significant theoretical and descriptive results.

Supporting this assessment are developments in related disciplines. With respect to cognitive psychology, I have already mentioned the growing acceptance of the prototype model of categorization, whose implications for all facets of linguistic structure are only beginning to be realized. The emergence of imagery as an active field of rigorous investigation (Block 1981; Kosslyn 1980; Shepard 1978) is worth noting if only because textbooks continue to repeat objectivist platitudes concerning its irrelevance to semantics and the impossibility of mental constructs being studied scientifically. But rather than listing additional trends congenial to the cognitive perspective in linguistics, I will focus on one particular development that merits the label "revolutionary" by virtue of its fundamental character and sweeping implications.

I speak of "connectionism", which represents a distinctive philosophy in the computer modeling of cognitive processing. Although the connectionist program is still quite young, and naturally controversial, few informed scholars would dispute that the issues it raises are of vital significance, and that its apparent potential deserves to be thoroughly explored. It is already having a strong impact on cognitive science and artificial intelligence, and will certainly be a major (if not predominant) force for years to come. A recent issue of *Cognitive Science* (vol. 9.1, 1985) was devoted entirely to connectionist models, which have become a pre-eminent topic of discussion at cognitive science and AI meetings. The publication of Rumelhart and McClelland's massive foundational work *Parallel Distributed Processing* is bound to give the movement even greater impetus.

>From the outset, both computer technology and the view of cognitive processing it metaphorically inspired have been based on the classic von Neumann architecture, which involves the serial execution of algorithmic programs. In sharp contrast, connectionist models are "neurally inspired", taking the brain rather than the digital computer as their guiding metaphor. They posit extremely large arrays of simple "units" (analogous to neurons), each of which has numerous excitatory and/or inhibitory connections to other units, and at any given moment displays a certain level of "excitation". An individual unit merely sums the input it receives from others, which determines (in accordance with some function) whether it will "fire", thus tending to excite or inhibit the additional units with which it "synapses". Each connection

between two units has a certain "weight", which controls the strength of the signals transmitted across it. Connection weights are continually adjusted according to some "learning" function (e.g. the co-excitation of two units might strengthen the connection between them to a specified degree). All information is stored in the connection weights--there is no separate program or data base.

The processing in such a system is massively parallel rather than serial, and each computational decision (i.e. whether or not to fire) is based on purely "local" considerations instead of being centrally directed. One might think that systems of this kind would be severely limited in their capacities, but they have in fact been shown to be extremely powerful, and to be endowed with properties that are quite desirable from the standpoint of cognitive modeling. They can learn and associate patterns. They can capture and exploit the regularities discernible in structured input. They can generalize, extract features, restore degraded inputs, and form the conception of a category prototype. The influence of context is inherently accommodated. Moreover, connectionist models have been applied with considerable success to linguistic tasks, such as speech recognition (Elman and McClelland 1984, 1985, 1986; McClelland and Elman 1986a, 1986b) and the learning of English past-tense verb forms (Rumelhart and McClelland 1986b). An important consideration in all this research is whether the learning and subsequent behavior of the system match the experimental data obtained from human subjects on comparable tasks. The convergence is often striking. For example, in learning past-tense verb forms the system, like children, went through a stage of overgeneralization, and made similar patterns of errors.

In short, connectionism is an inherently plausible approach to the modeling of mental processes, and shows considerable promise of empirical adequacy for both language and other aspects of cognition. It accommodates behavior that would normally be considered "rule-governed", as well as phenomena that do not lend themselves to such a characterization. Crucially, however, a connectionist model makes no use whatever of explicit rules, nor is the information responsible for "rule-governed" behavior separately or discretely represented. All the system’s "knowledge" lies distributed in connection weights, which collectively determine what coalitions of units are likely to participate in stable patterns of activation. There is no difference in this regard between general and specific knowledge, i.e. no qualitative distinction between rules and their instantiations. Furthermore, "computation" in connectionist terms does not involve the step-by-step execution of an algorithm--it is simply a matter of the system "relaxing" into a stable activation pattern.

If all this seems exotic or impossible to linguists, it is mainly because linguistic theory in the generative tradition presupposes the von Neumann architecture, accepting without question the need for discrete and explicit rules couched in some "propositional" format, and which constitute an algorithm specifying the sequential manipulation of abstract strings of symbols. By contrast, cognitive grammar (at least my own formulation of it) is basically compatible with the connectionist philosophy. First, cognitive grammar makes no qualitative distinction between rules and their instantiations--rules are simply schematized expressions; moreover, the "schemas" in question are thought of as being "immanent" to their instantiations, not as separate or discrete structures. Second, only elements with semantic and/or phonological content are permitted, and they are characterized directly in terms of such content, not in a propositional format. Third, analyses are based on the overt form of expressions; derivation from abstract, "underlying" representations is precluded, as is any sort of algorithmic computation. Finally, a linguistic system is viewed as simply an inventory of "cognitive routines", which are interpretable as recurrent patterns of activation that are easily elicited by virtue of connection weights; the construction of complex expressions reduces to the co-activation of appropriate routines and "relaxation" into a pattern of activation that simultaneously satisfies all constraints (Langacker *in press a*, Part III).

The rise of connectionism coincides with some important developments in neuroscience and the philosophy of mind. These are elegantly summarized by Patricia Churchland in her landmark book *Neurophilosophy*. Churchland maintains that neuroscience is essential to the philosophy of mind, which has generally downplayed its relevance on the basis of either dualism or the "functionalist" doctrine that the brain is "hardware" and the mind "software" (with the same software capable of being run on many different machines). She argues compellingly against this view, and in favor of a kind of "eliminative materialism" (cf. Thagard 1986; Paul Churchland 1984). Among her central theses are that (i) mental processes are brain processes; (ii) the philosophy of mind is currently based on categories ("belief", "thought", etc.) that descend from folk psychology (as reflected in language), and have no necessary validity as basic scientific constructs; (iii) the ultimate reduction of mind to neurological processing will involve the replacement of the current folk psychology with the conceptual framework of a matured neuroscience; and (iv) one casualty of this revision will be the common notion that human information processing consists in the manipulation of propositional representations (i.e. sentences in some "language of thought"--cf. Fodor 1979). The connectionist challenge to the von Neumann architecture for the modeling of cognition can be interpreted with reference to point (iv), as can the cognitive alternative to generative theory.

Churchland thus envisages the integration of neuroscience with theories of mind and cognitive processing. As examples, she cites not only connectionism, but also "tensor network theory", which offers a way of making sense--in functional terms--of some important discoveries by neuroscientists. The brain proves to have an abundance of topographical maps (i.e. areas where neurons form a kind of "map" of some region of the body), and of relation-preserving interconnections between such areas. A pattern of activation over a topographic map (or some other assembly of neurons) can be represented mathematically as a "vector", and a "tensor" is a mathematical function transforming one vector into another. Tensor network theory hypothesizes that topographic maps and relation-preserving interconnections solve a fundamental functional problem for the brain: to coordinate processes involving different representational systems (e.g. to coordinate visual input and motor activity in picking up an object). Specifically, the interconnections effect a kind of matrix multiplication, whereby representations in one array of neurons are related systematically to representations in another.

Tensor network theory is a highly promising way of bridging the gap between the low-level study of neurons and neural pathways on the one hand, and that of higher-level cognitive processes on the other. It bears a natural relationship to connectionism, since matrix multiplication is readily implemented by systematic connections between two populations of neurons, with the weights of these connections determining the specific values of the mapping function. Moreover, a relation between tensor network theory and linguistic concerns is not at all fanciful. Lakoff is actively exploring the hypothesis that certain conceptual primitives critical to linguistic semantics consist of invariants in topographic mappings; this would provide a direct neurological explanation for some essential linguistic constructs. Also, tensor network theory is relevant to the linguistic notion of "correspondences", which is fundamentally important in numerous areas. I will mention just three: (i) Fauconnier’s account of opacity, reference, presupposition, etc. is based on correspondences between the elements of different mental spaces. (ii) The Lakoff-Johnson theory of metaphor hinges on systematic correspondences between two domains. (iii) My own analysis of grammatical composition (both semantic and phonological) requires correspondences between elements of the component structures.

In this survey of the "cognitive perspective", I have tried to emphasize several points. First, it encompasses a vast amount of research in linguistics and other disciplines. Second, despite their different emphases, the various research programs involved are synergistically related, and offer the genuine prospect of a coherent, well-integrated account of language in relation to cognitive processing. Third, the difference between the cognitive perspective and the generative world view is not a trivial one, but a matter of immense intellectual significance--the issues at stake are fundamental to our conception of both language and mind.

References

Baker, Mark. 1985. ’The Mirror Principle and Morphosyntactic Explanation’. *Linguistic Inquiry* 16.373-415.

Block, Ned (ed.) 1981. *Imagery*. Cambridge, Mass. and London: MIT Press/Bradford.

Bolinger, Dwight. 1961. ’Syntactic Blends and Other Matters’. *Language* 37.366-381.

-----. 1971. *The Phrasal Verb in English*. Cambridge, Mass.: Harvard University Press.

-----. 1977. *Meaning and Form*. London and New York: Longman.

Brugman, Claudia. 1981. ’The Story of *Over*’. Berkeley: University of California masters thesis.

-----, and Monica Macaulay. 1986. ’Interacting Semantic Systems: Mixtec Expressions of Location’. *BLS* 12.315-327.

Casad, Eugene H. 1982. *Cora Locationals and Structured Imagery*. San Diego: UCSD doctoral dissertation.

-----, and Ronald W. Langacker. 1985. ’"Inside" and "Outside" in Cora Grammar’. *IJAL* 51.247-281.

Churchland, Patricia Smith. 1986. *Neurophilosophy: Toward a Unified Science of the Mind-Brain*. Cambridge, Mass. and London: MIT Press/Bradford.

Churchland, Paul M. 1984. *Matter and Consciousness*. Cambridge, Mass. and London: MIT Press/Bradford.

DeLancey, Scott. 1981. 'An Interpretation of Split Ergativity and Related Phenomena'. *Language* 57.626-657.

Elman, Jeffrey L., and James L. McClelland. 1984. 'Speech Perception as a Cognitive Process: The Interactive Activation Model', in Normal Lass (ed.), *Speech and Language*, vol. 10, p.337-374. New York: Academic Press.

-----. 1985. 'An Architecture for Parallel Processing in Speech Recognition: The TRACE Model'. *Bibliotheca Phonetica* 12.6-35.

-----. 1986. 'Exploiting Lawful Variability in the Speech Wave', in J. Perkell and D. Klatt (eds.), *Invariance and Variability in Speech Processes*, p.360-385. Hillsdale, N.J.: Erlbaum.

Fauconnier, Gilles. 1985. *Mental Spaces: Aspects of Meaning Construction in Natural Language*. Cambridge, Mass. and London: MIT Press/Bradford.

Fillmore, Charles J. 1982. 'Frame Semantics', in *Linguistics in the Morning Calm* (ed. by the Linguistic Society of Korea), p.111-137. Seoul: Hanshin.

Fodor, Jerry A. 1979. *The Language of Thought*. Cambridge, Mass.: Harvard University Press.

Foley, William A., and Robert D. Van Valin, Jr. 1984. *Functional Syntax and Universal Grammar*. Cambridge: Cambridge University Press.

Geeraerts, Dirk. 1983. 'Prototype Theory and Diachronic Semantics: A Case Study'. *Indogermanische Forschungen* 88.1-32.

Gentner, Dedre. 1983. 'Structure Mapping: A Theoretical Framework for Analogy'. *Cognitive Science* 7.155-170.

-----, and Donald R. Gentner. 1983. 'Flowing Waters or Teeming Crowds: Mental Models of Electricity', in Dedre Gentner and A. L. Stevens (eds.), *Mental Models*, p.99-129. Hillsdale, N.J.: Erlbaum.

Gentner, Dedre, and Cecile Toupin. 1986. 'Systematicity and Surface Similarity in the Development of Analogy'. *Cognitive Science* 10.277-300.

Givón, Talmy. 1979. *On Understanding Grammar*. New York: Academic Press.

----- (ed.) 1983. *Topic Continuity in Discourse: A Quantitative Cross-Language Study*. Amsterdam and Philadelphia: John Benjamins.

-----. 1984. *Syntax: A Functional-Typological Introduction*, vol. 1. Amsterdam and Philadelphia: John Benjamins.

Haiman, John. 1980. 'Dictionaries and Encyclopedias'. *Lingua* 50.329-357.

-----. 1983. 'Iconic and Economic Motivation'. *Language* 59.781-819.

----- (ed.) 1985. *Iconicity in Syntax*. Amsterdam and Philadelphia: John Benjamins. Typological Studies in Language 6.

-----. 1986. *Natural Syntax: Iconicity and Erosion*. Cambridge: Cambridge University Press.

Hawkins, Bruce W. 1984. *The Semantics of English Spatial Prepositions*. San Diego: UCSD doctoral dissertation.

Herskovits, Annette H. 1982. *Space and the Prepositions in English: Regularities and Irregularities in a Complex Domain*. Stanford: Stanford University doctoral dissertation.

-----. 1985. 'Semantics and Pragmatics of Locative Expressions'. *Cognitive Science* 9.341-378.

Hopper, Paul J., and Sandra A. Thompson. 1980. 'Transitivity in Grammar and Discourse'. *Language* 56.251-299.

-----. 1984. 'The Discourse Basis for Lexical Categories in Universal Grammar'. *Language* 60.703-752.

Janda, Laura A. 1984. *A Semantic Analysis of the Russian Verbal Prefixes ZA-, PERE-, DO-, and OT-*. Los Angeles: UCLA doctoral dissertation.

Johnson, Mark. In press. *The Body in the Mind: The Bodily Basis of Reason and Imagination*. Chicago and London: University of Chicago Press.

Kosslyn, Stephen Michael. 1980. *Image and Mind*. Cambridge, Mass.: Harvard University Press.

Lakoff, George. 1986a. 'Cognitive Semantics'. Berkeley Cognitive Science Report No. 36. To appear in Umberto Eco (ed.), *Meaning and Mental Representation*.

-----. 1986b. 'Frame Semantic Control of the Coordinate Structure Constraint', in Anne M. Farley *et al.* (eds.), *Papers from the Parasession on Pragmatics and Grammatical Theory*, p.152-167. Chicago: Chicago Linguistic Society.

-----. In press. *Women, Fire, and Dangerous Things: What Categories Reveal About the Mind*. Chicago and London: University of Chicago Press.

-----, and Mark Johnson. 1980. *Metaphors We Live By*. Chicago and London: University of Chicago Press.

Langacker, Ronald W. 1976. 'Semantic Representations and the Linguistic Relativity Hypothesis'. *Foundations of Language* 14.307-357.

-----. 1982. 'Space Grammar, Analysability, and the English Passive'. *Language* 58.22-80.

-----. 1984. 'Active Zones'. *BLS* 10.172-188.

-----. 1986. 'Abstract Motion'. *BLS* 12.455-471.

-----. In press a. *Foundations of Cognitive Grammar*, vol. 1, *Theoretical Prerequisites*. Stanford: Stanford University Press.

-----. In press b. 'Nouns and Verbs'. *Language* 63.

-----. To appear a. 'An Overview of Cognitive Grammar', in Rudzka-Ostyn.

-----. To appear b. 'A View of Linguistic Semantics', in Rudzka-Ostyn.

-----. To appear c. 'The Nature of Grammatical Valence', in Rudzka-Ostyn.

-----. To appear d. 'A Usage-Based Model', in Rudzka-Ostyn.

-----. Manuscript. 'Transitivity, Case, and Grammatical Relations: A Cognitive Grammar Prospectus'.

Lindner, Susan. 1981. *A Lexico-Semantic Analysis of English Verb-Particle Constructions with UP and OUT*. San Diego: UCSD doctoral dissertation.

-----. 1982. 'What Goes Up doesn't Necessarily Come Down: The Ins and Outs of Opposites'. *CLS* 18.305-323.

McClelland, James L., and David E. Rumelhart (eds.) 1986. *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, vol. 2, *Psychological and Biological Models*. Cambridge, Mass. and London: MIT Press/Bradford.

McClelland, James L., and Jeffrey L. Elman. 1986a. 'Interactive Processes in Speech Perception: The TRACE Model', in McClelland and Rumelhart, p.58-121.

-----. 1986b. 'The TRACE Model of Speech Perception'. *Cognitive Psychology* 18.1-86.

Newmeyer, Frederick J. 1983. *Grammatical Theory: Its Limits and Its Possibilities.* Chicago and London: University of Chicago Press.

Nichols, Johanna. 1984. 'Functional Theories of Grammar'. *Annual Review of Anthropology* 13.97-117.

Nikiforidou, Kiki. 1986. 'The History of the Genitive: A Case Study in Semantic Change and Semantic Structure'. Manuscript.

Ortony, Andrew (ed.) 1979. *Metaphor and Thought*. Cambridge: Cambridge University Press.

Reddy, Michael J. 1979. 'The Conduit Metaphor--A Case of Frame Conflict in Our Language about Language', in Ortony, p.284-324.

Rosch, Eleanor. 1973. 'On the Internal Structure of Perceptual and Semantic Categories', in Timothy E. Moore (ed.), *Cognitive Development and the Acquisition of Language*, p.111-144. New York: Academic Press.

----. 1975. 'Cognitive Representations of Semantic Categories'. *Journal of Experimental Psychology: General* 104.192-233.

-----. 1977. 'Human Categorization', in Neil Warren (ed.), *Studies in Cross-Cultural Psychology*, vol. 1, p.1-49. London: Academic Press.

-----. 1978. 'Principles of Categorization', in Eleanor Rosch and Barbara B. Lloyd (eds.), *Cognition and Categorization*, p.27-47. Hillsdale, N.J.: Erlbaum.

Rudzka-Ostyn, Brygida (ed.) To appear. *Topics in Cognitive Linguistics*. Amsterdam and Philadelphia: John Benjamins.

Rumelhart, David E. 1979. 'Some Problems with the Notion of Literal Meaning', in Ortony, p.78-90.

-----, and James L. McClelland (eds.) 1986a. *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, vol. 1, *Foundations*. Cambridge, Mass. and London: MIT Press/Bradford.

-----. 1986b. 'On Learning the Past Tenses of English Verbs', in McClelland and Rumelhart, p.216-271.

Shepard, Roger N. 1978. 'The Mental Image'. *American Psychologist* 33.125-137.

Silverstein, Michael. 1979. 'Language Structure and Linguistic Ideology', in Paul R. Clyne *et al.* (eds.), *The Elements: A Parasession on Linguistic Units and Levels*, p. 193-247. Chicago: Chicago Linguistic Society.

Smith, Michael B. In progress. *The Semantics of Dative and Accusative in German: An Investigation in Cognitive Grammar*. San Diego: UCSD doctoral dissertation.

Sweetser, Eve. 1982. 'Root and Epistemic Modals: Causality in Two Worlds'. *BLS* 8.484-507.

-----. 1984. *Semantic Structure and Semantic Change: A Cognitive Linguistic Study of Modality, Perception, Speech Acts, and Logical Relations*. Berkeley: University of California doctoral dissertation.

Talmy, Leonard. 1975. ’Semantics and Syntax of Motion’, in John Kimball (ed.), *Syntax and Semantics*, vol. 4, p.181-238. New York: Academic Press.

-----. 1977. ’Rubber-Sheet Cognition in Language’. *CLS* 13.612-628.

-----. 1978. ’Figure and Ground in Complex Sentences’, in Joseph H. Greenberg (ed.), *Universals of Human Language*, vol. 4, *Syntax*, p.625-649. Stanford: Stanford University Press.

-----. 1983. ’How Language Structures Space’, in Herbert Pick and Linda Acredolo (eds.), *Spatial Orientation: Theory, Research, and Application*, p.225-282. New York: Plenum Press.

-----. 1985a. ’Lexicalization Patterns: Semantic Structure in Lexical Forms’, in Timothy Shopen (ed.), *Language Typology and Syntactic Description*, vol. 3, *Grammatical Categories and the Lexicon*, p.57-149. Cambridge: Cambridge University Press.

-----. 1985b. ’Force Dynamics in Language and Thought’, in William H. Eilfort *et al.* (eds.), *Papers from the Parasession on Causatives and Agentivity*, p.293-337. Chicago: Chicago Linguistic Society.

Thagard, Paul. 1986. ’Parallel Computation and the Mind-Body Problem’. *Cognitive Science* 10.301-318.

Traugott, Elizabeth. 1982. ’From Propositional to Textual and Expressive Meanings: Some Semantic-Pragmatic Aspects of Grammaticalization’, in Winfred P. Lehmann and Yakov Malkiel (eds.), *Perspectives on Historical Linguistics*, p.245-271. Amsterdam and Philadelphia: John Benjamins.

-----. 1986. ’From Polysemy to Internal Semantic Reconstruction’. *BLS* 12.539-550.

Tuggy, David. 1980. ’|Ethical Dative and Possessor Omission Sí, Possessor Ascension No!’ *Work Papers of the Summer Institute of Linguistics, University of North Dakota* 24.97-141.

Vandeloise, Claude. 1984. *Description of Space in French*. San Diego: UCSD doctoral dissertation.

-----. 1985. ’Au-delà des Descriptions Géométriques et Logiques de l’Espace: Une Description Fonctionnelle’. *Lingvisticae Investigationes* 9.109-129.

-----. 1986. *L’Espace en Français*. Paris: Editions du Seuil.

van Oosten, Jeanne. 1986. *The Nature of Subjects, Topics and Agents: A Cognitive Explanation*. Bloomington: Indiana University Linguistics Club.

Wierzbicka, Anna. 1972. *Semantic Primitives*. Frankfurt: Athenaum Verlag.

-----. 1980. *Lingua Mentalis*. Sydney and New York: Academic Press.

-----. 1984. ’Cups and Mugs: Lexicography and Conceptual Analysis’. *Australian Journal of Linguistics* 4.205-255.