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ABSTRACT

Cognitive science has recently emerged as a new interdisciplinary field incorporating parts of psychology, computer science, philosophy, neuroscience, and linguistics. Its goal is to bring the theoretical and methodological resources of the contributing disciplines to bear on an integrated investigation of thought, meaning, language, perception, and mentally guided action. The contributing disciplines have begun to converge on a common paradigm, the computational or information processing view. If conceived of and taught as a broad, integrative area of study, cognitive science deserves a prominent place in the liberal arts curriculum, and linguistics merits a central place because language is the most prominent marker of human intelligence. Interdisciplinary cognitive science programs are in various stages of development at about 40 higher education institutions in the United States, most drawing on the resources of previously existing departments and faculty. The study of language provides a testing ground for broad questions about the nature and structure of the mind, and can enrich pedagogical and intellectual work in other disciplines with or without an organized program in cognitive science. (MSE)

LINGUISTICS IN THE UNDERGRADUATE CURRICULUM

APPENDIX 4-I

Linguistics, Cognitive Science and the Undergraduate Curriculum

by

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The views expressed are those of the authors and do not necessarily reflect the position of the LSA or the National Endowment for the Humanities.

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PREFACE

The Linguistics in the Undergraduate Curriculum (LUC) project is an effort by the Linguistic Society of America (LSA) to study the state of undergraduate instruction in linguistics in the United States and Canada and to suggest directions for its future development. It was supported by a grant from the National Endowment for the Humanities during the period 1 January 1985-31 December 1987. The project was carried out under the direction of D. Terence Langendoen, Principal Investigator, and Secretary-Treasurer of the LSA. Mary Niebuhr, Executive Assistant at the LSA office in Washington, DC, was responsible for the day-to-day administration of the project with the assistance of Nicole VandenHeuvel and Dana McDaniel.

Project oversight was provided by a Steering Committee that was appointed by the LSA Executive Committee in 1985. Its members were: Judith Aissen (University of California, Santa Cruz), Paul Angelis (Southern Illinois University), Victoria Fromkin (University of California, Los Angeles), Frank Heny, Robert Jeffers (Rutgers University), D. Terence Langendoen (Graduate Center of the City University of New York), Manjari Ohala (San Jose State University), Ellen Prince (University of Pennsylvania), and Arnold Zwicky (The Ohio State University and Stanford University). The Steering Committee, in turn, received help from a Consultant Panel, whose members were: Ed Battistella (University of Alabama, Birmingham), Byron Bender (University of Hawaii, Manoa), Garland Bills (University of New Mexico), Daniel Brink (Arizona State University), Ronald Butters (Duke University), Charles Cairns (Queens College of CUNY), Jean Casagrande (University of Florida), Nancy Dorian (Bryn Mawr College), Sheila Embleton (York University), Francine Frank (State University of New York, Albany), Robert Freidin (Princeton University), Jean Berko-Gleason (Boston University), Wayne Harbert (Cornell University), Alice Harris (Vanderbilt University), Jeffrey Heath, Michael Henderson (University of Kansas), Larry Hutchinson (University of Minnesota, Minneapolis), Ray Jackendoff (Brandeis University), Robert Johnson (Gallaudet College), Braj Kachru (University of Illinois, Urbana), Charles Kreidler (Georgetown University), William Ladusaw (University of California, Santa Cruz), Ilse Lehiste (The Ohio State University), David Lightfoot (University of Maryland), Donna Jo Napoli (Swarthmore College), Ronald Macaulay (Pitzer College), Geoffrey Pullum (University of California, Santa Cruz), Victor Raskin (Purdue University), Sanford Schane (University of California, San Diego), Carlota Smith (University of Texas, Austin), Roger Shuy (Georgetown University), and Jessica Wirth (University of Wisconsin, Milwaukee).

The last two decades have seen the rise of a new interdisciplinary field which has come to be called **cognitive science**. Incorporating parts of the disciplines of psychology, computer science, philosophy, neuroscience and linguistics, this new field addresses a rich set of questions about the nature of the mind and knowledge that have long been at the heart of intellectual inquiry, both scientific and humanistic. Cognitive scientists seek an understanding of the mental capacities and processes that underly human behavior, and which lie at the heart of what it means to be a human being. The goal of the field is to bring the theoretical and methodological resources of the contributing disciplines to bear on an integrated investigation of thought, meaning, language, perception and mentally guided action.

In recent years it has become clear that the contributing disciplines of cognitive science have begun to converge on a common paradigm, which is usually referred to as the **computational** or **information processing** view. The core of this paradigm can be expressed in three propositions: first, that mental processes can be viewed as the manipulation of formal symbolic structures; second, that the formal structures ultimately bear a representational relationship to the world, or a domain of discourse; and third, that in any functioning mental system, such as a brain or an electronic computer, the symbolic structures must be instantiated in some physical substrate, such as a neural network or an electrical network of solid-state logical components. A full cognitive-scientific analysis of a mental system must characterize it in terms of formal structures and process, representation, and physical implementation.

These ideas are closely related to notions of hardware and software commonly used to describe computing systems. To understand a chess-playing computer, for instance, we deploy several levels of analysis. At the most abstract (representati.nal) level, of analysis, we characterize the functional goals of the chess-playing program. Such a program might contain representations of current and possible board-positions, legal move generators, standard openings, and strategically-guided planning or search processes. At the algorithmic level of analysis, we look at just how the functional components can be implemented as computer programs. At the physical level of analysis, we look at how the program is actually instantiated in a machines made up of solid-state components and electrical signal paths.

Each level of analysis yields its particular insights. The abstract functional analysis gives a clear picture of what the system is designed to do. Certain strengths and weaknesses would be easily characterizable here: to what degree, for example, does the system use standard openings? The algorithmic level gives us a more detailed picture of the symbolic structures and processes. For example, we can tell exactly how a search for future possible moves is represented and carried out. If the search algorithm were inefficiently implemented, we would understand why the system was slow at certain points. The physical level of analysis shows us how it is possible for the functional design and the program -- which are essentially conceptual -- to operate in a physical device. At this level, for instance, we might come to understand how a search process is represented in terms of signal levels in memory chips, and why it is impossible, in terms of physical space-time constraints, to exhaustively search ahead more than a certain number of moves using a particular physical system. Cognitive scientists seek to understand the human mind and to design artificially intelligent systems using this kind of analysis. But it should be noted that such analyses will be much more complicated than the previous example; new computational concepts that are completely foreign to the current world of digital computers may have to be introduced to cope with truly intelligent computation.

The notion of an interdisciplinary computational paradigm, and the terminology used to develop it, are relatively new. But the ideas underlying it are in fact familiar and indeed central to contemporary linguistics and its allied fields. That language -- like other cognitive capacities -- is a system of formal structures and rules, is the central tenet of modern linguistic theories, and the main subject of current linguistic research. The notion that these formal structures are representationally related to the way in which language is actually processed, perceived, produced and used in the world, is the subject matter of much collaboration between linguists and psychologists, as well as philosophers. In collaboration with neuroscientists, linguists explore the question of how language is actually implemented in the brain and nervous system; with computer scientists, linguists ask how (or if) language could be implemented on other kinds of physical devices.

If it is conceived and taught as a broad, integrative area of study, cognitive science deserves a prominent place in the liberal arts curriculum as a whole, and linguistics merits a central place in such a curriculum. Physical science is concerned with the nature of matter and energy; biological science with the material basis of life; social science with the nature of social phenomena. With the nature of mental phenomena as its domain, cognitive science can be placed on a par with these other major branches of inquiry. It can be seen, indeed, as the contemporary embodiment of a large portion of the classical curriculum that has been somewhat out of focus in modern curricula dominated by the natural and social sciences. Questions about the nature of thought, language, knowledge, truth and perception ought to be at the heart of liberal education, and were given more integrated attention in pre-twentieth century curricula; the emergence of a scientific paradigm has significantly revitalized the integrated study of mind.

In addition to these core intellectual issues, cognitive science possesses a number of other characteristics that make it an excellent liberal arts field. It is, arguably, the bridge discipline between the natural and social sciences, giving sustained attention to the relationship between body and mind, knowledge and behavior. Students of cognitive science are introduced to the experimental method, to serious formal study and to current computational theory (without being required to study the conventional physical scientific or mathematical curricula in depth). Thus cognitive science offers an alternative way of training students in scientific and formal methods. Finally, the importance of cognitive development and education in modern societies, and the development of and controversy over artificial intelligence technology have also given cognitive science new practical and ethical dimensions.

Because language is the most prominent marker of human intelligence, linguistics and its allied fields (psycholinguistics, neurolinguistics and computational linguistics) play a vital role in this integrative vision of cognitive science. As we noted earlier, linguists have long been concerned both with the formal analysis of language, and with the implications of their analyses for the nature of the human mind and brain. The study of linguistics, particularly in its contemporary interdisciplinary context, gives students not only direct training in cognitive science itself, but also an appreciation of the intricacy and power of language, general training in precise formal and empirical methods, and an invaluable perspective on crucial policy issues, ranging from the influence of bilingualism on cognitive development to the potential uses and misuses of computers.

Interdisciplinary cognitive science programs are in various stages of development at roughly forty institutions of higher education in the U.S. In nearly every case, these programs draw on the resources of previously existing departments and faculty. The typical college or university already contains a core group of faculty members who are excited about developments in cognitive science, and eager to teach and to do research with faculty in other departments who have complementary training. It is also common to find that the existing core group can be significantly strengthened by one or two new appointments in underrepresented disciplines. In light of the central role of linguistics, every cognitive science program ought to include a linguist if at all possible. Put in another way, cognitive science provides a new and powerful rationale for the inclusion of contemporary linguistics in the undergraduate curriculum, both in its own right and as a vital part of cognitive science as a whole.

Our argument thus far has been general and programmatic. Let us turn now to a more detailed sketch of some of the issues, theories and results that animate contemporary linguistics, and bear on its role as one of the cognitive sciences.

The relationship of language, thought and knowledge, for instance, is an enduring problem of great general interest. Cognitive scientists want to know in what form knowledge is represented, and the character of the processes that mediate and manipulate such knowledge. One common and popular belief is that many aspects of knowledge and thought are directly encoded in linguistic form (i.e., represented in some human language), or in a form that is closely related to language. The introspective experience of "inner speech" (we may seem to hear ourselves talking as we solve problems, or remember facts and events) is suggestive of this view. If this approach is correct, we may wonder to what extent language determines and regulates our thinking, and we may ask whether thought patterns vary across time and culture, as languages appear to do. This form of linguistic determinism (sometimes called the Whorf Hypothesis, after Benjamin Lee Whorf, the linguist who explored such ideas several decades ago) is rather strongly and widely held by the general public, and a fair number of academics; it informs many of our beliefs about cultural differences, the possibility of understanding and communication across cultures, and the ways in which language differences may inform writing, learning and pedagogy in general.

It is interesting that few linguists and cognitive scientists subscribe to this view. Many results in cognitive science suggest that the "language of thought" is quite distinct from the particular natural languages that we speak; and there is considerable support for the position, associated with Noam Chomsky, that the apparently dramatic differences among languages are minor variations on a very general (universal) plan that is part of the fundamental architecture of the mind. On this view, individuals and groups speaking diverse languages are, at the appropriate level of description, far more alike than different. The issue is by no means resolved, but it represents an area in which linguistics, and cognitive science at large, can contribute to our understanding of human nature and human differences, and is one with which a liberally educated individual should be familiar.

Linguistics also plays a special role in the exploration of learning, a fundamental problem for cognitive science. We are surely not born knowing English, or Zulu, or any of the particular properties of the several thousand languages now spoken. The grammars (systems of knowledge) that characterize these properties are highly complex; adult linguists labor mightily to provide adequate descriptions of the generalizations that constitute such grammars. Nevertheless, very young children are able to acquire these systems of knowledge rapidly, easily, and with very little (if any) instruction. Thus, children's acquisition of language is one of the most challenging phenomena for theories of learning. Indeed, some contemporary linguists are of the opinion that there are crucial properties of grammars that cannot be induced by the child from experience (from the language behavior of parents and peers). These aspects of linguistic knowledge may not be learned at all, but rather arise from innate (genetically-specified) characteristics of the mind. Once more, the details are much debated, but the controversy over the genetic basis of human capacities is one which should figure importantly in a contemporary liberal education, and linguistics, in the framework of cognitive science, can provide a fruitful arena in which to explore a well-defined set of questions about the relationship between "nature" and "nurture."

The study of language poses other problems and challenges for cognitive science. Linguists are, for instance, inclined to investigate linguistic structure and language behavior as distinct phenomena. The contemporary integration of linguistics with the other cognitive sciences was initiated by Chomsky's claim that a theory of the structure of language is also a psychological and a biological theory of human knowledge of the rules and principles of sentence-formation, pronunciation and meaning. Such bodies of abstract knowledge, called linguistic **competence**, are theorized to be largely independent of the uses to which the knowledge is put -- in the production and perception of language in actual behavior. This latter domain of domain linguistic **performance** has been investigated jointly by psychologists (psycholinguists) and linguists. The game of chess again provides a useful analogy. A competence theory of chess constitutes an account of the initial arrangement of chess pieces on the game board, the legal moves and conditions for terminating a game. A performance theory of chess, by contrast, characterizes actual game strategies and procedures. A chess performance theory must somehow take the competence theory into account, since the rules for legal movement must be obeyed in formulating strategies. For example, the performance theory might assume that the rules of chess are represented in a distinct knowledge base which is consulted by strategy generating processes. Does the same hold true for language? Some psycholinguists hypothesize that a separate representation of abstract linguistic rules is recruited by the strategic performance processes that operate during the perception and production of language. The investigation of this hypothesis requires work at the intersection of linguistics, psycholinguistics and neuroscience. For example, one piece of positive evidence comes from the study of neurological patients whose brain damage has led to aphasia, a deficit in the ability to produce or perceive language. Some aphasic patients retain the ability to make judgments about the grammaticality of sentences, and the proper pronunciation of words, even though their ability to use words and sentences is severely impaired. These patients may be said to suffer a disruption of their performance mechanisms that is independent of their underlying linguistic competence. If this view is correct, is it a unique property of language (perhaps a function of the special way in which language is represented in the brain), or are there other domains of cognition that reflect a similar division of mental labor? Linguistics thus plays a crucial collaborative role not only in our understanding of mental processes, but also in our investigation of how mental systems are instantiated in the human brain.

The study of language provides a testing ground for other broad questions about the nature and structure of the mind. One compelling view of the mind is that it is a powerful, general information processor with a largely homogeneous structure operating over different types of information (linguistic, visual and so forth) with common strategies and processes. Much work in the field of artificial intelligence, for example, proceeds from this kind of assumption. By contrast, other cognitive scientists view the mind as a set of separate, largely independent modules with distinct properties and mechanisms. Linguistics and psycholinguistics figure centrally in this important debate. The problem of language understanding provides an illustration. When we hear utterances in a discourse, we potentially have access to a great deal of information: the linguistic properties of the utterance (its pronunciation, its sentence structure, the meaning of its individual words and so forth) and also information about the speaker (his or her background, emotional state, beliefs and related information), about the context of the utterance, and shared knowledge about the world at large. On the non-modular view, we might well expect any and all of this information to be recruited, perhaps simultaneously, as we attempt to understand what the speaker means. Many "language-understanding" systems for computers rely on assumptions of this sort. But if language understanding is organized modularly, it might be the case that we first assign a grammatical structure to utterances independently of non-linguistic factors like context or general knowledge. Non-linguistic knowledge might ultimately be brought to bear on the problem, but as a separate mental process. There is a large body of experimental psycholinguistic data that bears on this issue. Some of the evidence supports a view of language understanding in which linguistic structure is assigned by a modular process, independent of other information. There have also been attempts to apply the modular approach to natural language understanding on computers, in which linguistic grammars play a crucial special role in the initial analysis of incoming sentences. The debate over the modularity of mind illustrates again that work within linguistics can be synthesized with work in related fields to address some core problems within cognitive science -- problems that are of interest not only to the student of language, but also to the student of mind in general.

Some may find the debate over modularity surprising. Much like our beliefs about the relationship between language and thought, we often feel that our language is so inextricably bound up with other aspects of our mental lives and our behavior that modularity theory would be ruled out on common-sense grounds But hypotheses in cognitive science, as in any branch of science, are tested against experimental and observational data, and are not judged by their consistency with our everyday beliefs. This illustrates the way that linguistics and cognitive science bring the methods and framework of formal scientific inquiry to bear on questions about human language, human mind, and human nature that are too often addressed only casually and informally by undergraduates.

Linguistics is not exclusively concerned with matters that fall within the central purview of cognitive science, of course. Questions about the social uses of language -- e.g. the ways in which linguistic variation reflects and helps to regulate social structures, or the political role that language-group identity plays in ethnic conflict -- are of deep interest to anthropology, social psychology, political science, and sociology. Indeed, such questions may be viewed as a potential interface between the cognitive and the social sciences. The cognitive nature of linguistic aesthetic experience, also little studied, can provide for exciting connections between linguistics, cognitive science, and literary studies. Finally, as we have suggested, linguistics raises some important questions for the biological sciences: the claim that language learning has a specific genetic basis; the question of how (and where) linguistic knowledge and processes are represented in the brain and nervous system; and general questions within cognitive science about the evolutionary pressures that have given rise to particular architectural properties of the mind (e.g., modularity).

It should be emphasized that linguistics can serve to enrich pedagogical and intellectual work in connection with these other curricular areas even in the absence of an organized program or major in cognitive science. Interdisciplinary courses involving linguists and psychologists, computer scientists, philosophers, or neuroscientists can clearly address deep substantive issues fruitfully, even when such courses are not part of a larger program. More than that, one might say that linguistics, and linguists, have a strong natural tendency toward interdisciplinary interaction. It appears to be in the nature of the subject matter for insights and results to spill into other fields, and to encourage both research and teaching interactions. Linguistics also has considerably less of the kind of departmental history and tradition that may mitigate against intellectual cooperation and interaction. In this sense, linguistics can be regarded as a seed discipline that has the potential to spark the kinds of interaction that will lead to pressure for the development of a multidisciplinary program in cognitive science.