

THEORETICAL FOUNDATIONS OF LINGUISTICS
AND AUTOMATIC TEXT PROCESSING *

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ABSTRACT

Texts are viewed as purposeful transactions whose interpretation requires inferences based on extra-linguistic as well as on linguistic information. Text processors are viewed as systems that model both a theory of text and a theory of information processing. The interdisciplinary research required to design such systems have a common center, conceptually, in the development of new kinds of lexical information, since words are not only linguistics objects, they are also psychological objects that evoke experiences from which meanings can be inferred. Recent developments in linguistic theory seem likely to promote more fruitful cooperation and integration of linguistic research with research on text processing.

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and

AUTOMATIC TEXT PROCESSING

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It is awfully important to know what is and what is not
your business.

Stein, Lectures in America, 1935

I gotta use words when I talk to you.

Eliot, Sweeney Agonistes, 1933

A. Introduction

Committing myself to produce a paper with a title containing the expression "theoretical foundations of linguistics" was an act of madness that I hereby attempt to redeem. I see no way to reduce my topic to manageable size without drastic surgery to accommodate my own limitations as well as limitations of time and space. Therefore this paper is not a survey but a rather personal perspective on the relationship of theoretical linguistics to methodological problems in automatic text processing (ATP).

I propose to look at text processing as a special kind of information processing in which the input is in the form of a natural language and in which further information about that language plays an essential role in the processing. In a larger sense, I take the enterprise of automatic text processing to be the construction of theories of text as well as the design of processors (computer systems) that model and test those theories. The principal question to be addressed here is:

How much of that enterprise is the business of linguistics?

The problem in answering the question is that there is a large area in which the study of what language is engages the study of how language is used to serve human purposes. To put it another way, knowledge of a language as a code is associated with knowledge about the language, including the motives for and the effects of its use. Views diverge widely as to how much of the study of language is, strictly speaking, linguistic and how much belongs to other areas of psychology or sociology or cultural anthropology--or, indeed, any of the other disciplines into which we have divided the study of the world and of ourselves.

Having raised the problem, I would like to defer its discussion and stipulate at this point a difference between linguistic theories and theories about language. Roughly speaking, I intend 'linguistic' theory (description, knowledge, etc.) to mean the theory of the syntactic forms of a language and their relation to truth-conditional meaning. A generative grammar is one representation of such a theory. A theory of 'language' will be considered as a broader theory that includes linguistic theories along with much else that is germane to the use of language, such as theories of speech acts, conversational principles and commonsense reasoning.

On the basis of the proposed distinction, the contributions of linguistic theory to a theory of texts can be more precisely delineated. It is important to understand the limitations of those contributions in order to understand the need for complex interactions of a linguistic component with the other components of text theories; that is, to understand why the linguistic component representing knowledge of the language must interact with components representing knowledge about the language and with other extralinguistic knowledge; why there must be a theory of the interactions themselves, and why theories of linguistics are not autonomous with respect to theories of their interactions with other components. The extralinguistic components are sometimes spoken of as representing knowledge of the world; however, language is in the world too, and what we know of it is part of what we know about it.

The first section presents a broad view of the nature of texts and text processing. It points out that texts cannot profitably be considered as linguistic objects solely; that they are better understood as purposeful transactions whose interpretation requires inferences based on extralinguistic information as well as on linguistic form and truth-conditional meanings. Consequently, text processors that can interpret text must provide for interactions of components representing many areas of expertise. I view such processors as 'intelligent' systems that model both a theory of text and a theory of information processing. Although the research required to design such models is interdisciplinary, I will propose that it has a common center, conceptually, in the development of new kinds of lexical information -- the information associated with words -- because words are not only linguistic objects with syntactic and semantic co-occurrence properties, they are also psychological objects that evoke our experiences with the world, from which meanings can be inferred.

The second section discusses the relationship of theoretical linguistics to the research required for developing text theories and ATP systems. It outlines some divergent views concerning the scope and aims of linguistic research, suggests a way of reconciling them and then traces the relationship between one major paradigm of linguistic research, that of transformational grammar (TG), and the development of natural-language processors. The final section points to recent changes in transformational theory that shift its concern from narrow preoccupation with autonomous syntax and logical form to consideration of the larger system in which they are interactive components.

B. On Processing Texts

1. The Nature of the Input

In Cohesion in English, Halliday and Hasan say that a text is "any piece of language that is operational, functioning as a unity in some context of situation...(p. 293)." I will use the word in this sense, realizing that it begs many theoretical questions when one tries

to apply it to particular candidates. A closely associated term is 'discourse'. Dijk [1972] uses 'discourse' for what I will call 'text' and defines 'text' as the formal abstract linguistic unit that "manifests itself" in discourse [p. 3]. I propose to ignore the differences in terminology, and note rather that in both treatments there is agreement that coherence (continuity, cohesiveness) is an essential property of the pieces of language under consideration. It is also agreed that the coherence of a text is basically semantic, although, not surprisingly, it is often signaled in various ways in the linguistic forms it comprises. These signals systematically relate the text to an environment in which it is to be interpreted.

So far, this informal definition of texts suggests that they are rather static objects, existing as wholes at the moment they are to be processed. This is misleading. They are better conceived of as joint creations of producers of pieces of language (speakers, writers) and interpreters (hearers, readers). (Cf. Ricoeur 1971.) Judgments affirming that a piece of language is or is not a text are not based solely on the language itself; they are evaluations of its potential for coherent interpretation. No matter if the intended meaning of its producer is coherent; if coherence cannot be perceived, the piece will not make sense and therefore cannot be processed as an operational unit, regardless of how grammatical and truthful its individual sentences may be. However, it may later become a text for an interpreter who rejected it on a former occasion if it is recalled along with some hitherto missing bits of information. Thus we may recall a puzzling utterance years later and suddenly understand it because we now possess the relevant experiences to be evoked by its words.

The transactional aspect of text creation is obscured by a tendency to associate "text" with written monologues, whose linguistic forms exist as wholes before we begin to interpret them.* This tendency may be vanishing, now that spoken monologues and dialogues are easily recorded for later interpretation. One may also participate in a

* Rubin (1978) provides a relevant framework for analyzing the effects of the medium of communication on the receivers of messages.

dialogue by means of electronically linked terminals, so that dialogue is no longer closely associated with either speech or face-to-face context sharing. Thus, the relevant distinction to make with regard to text processing is the distinction between 'batch processing', in which a completed piece of language is available at the time processing begins, and 'interactive processing', in which the language to be interpreted continues to grow. An even more useful distinction is between 'single initiative' and 'mixed initiative' in producing the text. In a monologue, only one participant in the creation of the text plays the role of producer; in a dialogue, both (all) participants play producer as well as interpreter roles. Consequently, a dialogue participant who is unable to give a coherent interpretation to a text at some point during its creation can become a producer and ask for clarification. If it is forthcoming, textual status is maintained. If not, the piece of language is no longer operational as a text for that participant at that time.

With this view of the nature of texts in mind, let us look at a hypothetical interactive query system, which I shall call ATP¹. Like TQA, PHLIQA [see Petrick *infra*], and many others, ATP¹ has a syntactic component, a semantic component, and a data base. It is designed to process texts that are English interrogative sentences presented in order to obtain information from the data base. Its output is neither an analysis nor an interpretation of the input. It is a response. For example, to the input:

How many Palo Alto residents own foreign cars?

it might respond: 10,015.

Now if we interpret the input as a question, we may conceive of the output as an answer to that question. In that case, is the output itself part of a growing text, an ongoing dialogue?

Not everyone is willing to call this kind of interaction with

a machine a dialogue.* However, if we examine the transcript of a sequence of exchanges between a user and a well-debugged query system, it may be indistinguishable from exchanges with another person. It is especially likely to appear coherent if enough is known about the domain of the data base to infer the motives of the user for asking what he asks, as well as the plans he is following in eliciting the information he wants. The aims imputed to the user provide the sense of unity, while the plans we discern as being relevant to those aims provide the skeletal structure.

If we ourselves are the users, then of course we already know our aims and plans without having to infer them. As long as we receive reasonable responses that appear to be relevant to our purposes in using the system, we may find ourselves acting as if we were engaged in a linguistic performance with a fully competent partner, perhaps unconsciously taking it for granted that it is one who "understands" our purposes and is "cooperating" with us.

These possibilities lead on to some interesting speculations about artificial intelligence and intentional systems [Dennett 1971]. They also lead one away from viewing texts as purely linguistic performances. Linguistic considerations play a necessary part in the production of texts and in the inferences needed for their interpretation but the introduction of the understanding of aims brings in psychology with it--including knowledge of motives and commonsense reasoning. We infer the motives that underlie texts on the basis of our knowledge of people. It is this kind of knowledge that allows us to interpret sentences-in-use as direct or indirect speech acts and to respond with relevant answers and actions to questions and requests [Hobbs and Robinson 1978]. This is not linguistic knowledge in the previously stipulated sense of 'linguistic'. Neither is it simply knowledge about the use of language. It is knowledge about purposeful

* Of course there might be responses that we could not conceive of as answers; "red or black," for instance; or "10,015.68," or "\$100.15." We could give different reasons for rejecting each, but basically it is because all three remind us that we are dealing with an automaton rather than with a person and we sense the machinery behind these responses.

behavior. Using language is one kind of such behavior and we understand a text as an instance of it.

2. Texts as Coherent Actions

Suppose we see a man get out of his car. We observe him looking at its tires. We observe that one of the tires is flat. We then see him looking around. Subsequently, he crosses the street and enters a telephone booth. We can interpret his actions broadly. We can assume he is calling for assistance or perhaps calling to inform someone that he will be late for an appointment. At any event, we grasp his actions as forming a coherent, meaningful sequence. If, instead of approaching the telephone booth, he had leaned against his car and lighted a pipe, his action would not appear irrational, but it would appear less coherent with respect to his previous action; their connection would be more tenuous. Now suppose that, on a different occasion, we answer our doorbell in response to a ring and find a stranger on our doorstep. He says, "May I use your telephone? My car has a flat tire." Again, we judge his actions to be reasonable, coherent and meaningful, but now his actions include producing a text.

On the first occasion, we interpreted what the man was doing by constructing reasons for his actions; we could infer his intentions from observations of those actions in a context by marshalling the relevant knowledge of the world--of cars and their uses, of people and their needs and strategies for coping with problems. In doing so, we may even employ the Gricean principles [Grice 1975]; e. g., we assume his actions are 'sincere', that he is not trying to delude an observer. The same holds true for the second occasion, but on that occasion, what he was doing was talking; he used words to evoke the scene. Fillmore [1978], in relating case theory to interpretation, adopts the slogan: Meaning is relativized to scenes. His slogan applies to both occasions described above. Interpretation of what the stranger said still depends on knowledge of the world, but now it is words and not our eyes that have focused our attention on that part of all our knowledge that provides the relevant scene for inferring his intentions. Note that we cannot infer his intentions solely from the grammatical

arrangement of his words and identification of their referents, not even with an appeal to the possible ellipsis of some overt connecting word. "May I use your telephone because my car has a flat tire" seems a bit odd. "May I use your telephone? The reason for my request is that my car has a flat tire" seems stilted. In either case, the same kinds of inferences are required to grasp the connections. One infers that the speaker has a plan for solving a problem and that the telephone is instrumental to his plan. In effect, the meanings we assign to his actions and his text are relativized to plans.

From all this it is clear that linguistic analysis coupled with truth-conditional semantic interpretation is not enough for complete text processing. The purposes that motivate the production of texts must also be interpreted, and these lie outside linguistics. But it is also clear that producing a text is an action, and that the motives for the action can be inferred from knowledge of language and knowledge of the world generally.

Words bridge these two kinds of knowledge. Knowing a word involves a great deal more than knowing its phonology, morphology, spelling, and syntactic category. Miller's "minimal list" of the kinds of information a person must have about a word includes knowing its permitted syntactic contexts, knowing the concept it expresses and the relation of that concept to others, knowing its appropriate semantic contexts, and knowing its pragmatic relations to general knowledge and to discourse contexts [Miller 1978]. Because of the richness and diversity of the information associated with them, words evoke knowledge of the world as perceived, categorized, and talked about by a linguistic community. When designating objects, events, situations, attitudes, ideas, and the like, they evoke further knowledge of the properties and relations stereotypically associated with what they designate. This further knowledge both constrains and supplements purely linguistic interpretations of texts. Bar-Hillel's frequently cited example, "The baby is in the pen", demonstrates the constraints imposed by knowledge of the sizes of the objects designatable by 'baby' and 'pen'. 'Flat tire' and 'telephone' evoke knowledge of culturally familiar situations

and actions, to constrain and supplement the meaning of the stranger's two-sentence text.

It may seem that in emphasizing the role of the lexicon I am ignoring an essential aspect of the nature of texts, namely that they have global structures transcending the structures of sentences and their expressed propositions. Is it a step backwards from 'text linguistics' [see various articles in Dijk and Petofi 1977] to emphasize words rather than groups of sentences as the linkage between the linguistic properties of texts and the inferences that lead to their interpretation? I think not. Proposing an interface between knowledge stored in a lexicon and a component containing knowledge of how to draw plausible inferences is not to deny the importance of also drawing inferences on the basis of the use of particular syntactic arrangements of words and sentences. On the contrary, it is an acknowledgment that the linkages among the various components needed for comprehending and producing texts are likely to be complex and that words afford a clear example of text elements that are linked to both linguistic and extralinguistic components.

All this suggests the broader conclusion that any attempts to construct generative text grammars by expanding only the linguistic capabilities of sentence grammars are doomed to failure on both theoretical and empirical grounds. Evidence for this conclusion comes also from empirical investigations of how people interpret texts. They "rarely confine their interpretations to information conventionalized in text" [Olson 1977]. Labov and Fanshel [1977] even go so far as to propose, paradoxically, that "there are no connections between utterances [*italics theirs*]." The rules they found necessary to account for the coherence of the conversations they analyzed are not linguistic, although they have linguistic reflexes; they are rules for coherent speech acts. The design of processors as well as grammars must take account of these findings.

3. Clever and Intelligent Processors

Texts are instances of the use of language to convey meaning. Many useful and interesting formal operations on texts can be automated with little or no semantic interpretation, others--such as the retrieval of relevant answers to specific questions from stored information whose form does not directly match the input--typically demand very sophisticated interpretive processing. In carefully constrained environments and for carefully limited purposes, ATP systems can use the linguistic properties of an input to serve those purposes without having to represent its meaning. Up to a point, the output of such systems can even produce appropriate responses in a dialogue with a user without generating those responses from representations of meaning [cf. Weizenbaum 1967].

However, I believe there is a fundamental distinction to be made between these 'clever' systems and what I call 'intelligent' systems. It is not feasible to draw a sharp line between the two kinds, but to the extent that a system is intelligent, it is a model of a theory of text within a theory of information processing. Ideally, an intelligent system contains representations of the kinds of knowledge people use: grammatical knowledge, knowledge of words, of the world, of each other, of the situation, of logical inference and commonsense reasoning, and strategic knowledge about how and when to use the other kinds. It contains procedures for applying representations of these various kinds of knowledge in order to interpret an utterance and it responds on the basis of that interpretation rather than on the basis of superficial cues. Its procedures will be especially complex if, unlike our earlier example, ATP1, its interpretation is not restricted to truth-conditional semantics but also includes consideration of presuppositions, implicatures, and the intentions of the user. This broader kind of interpretation is necessary, for example, if the system is designed to respond to questions by giving information that is both true and relevant. Such complex processing poses its own theoretical problems in the designing of control structures for allocating computing

resources among the procedures that apply the various representations, and for combining and coordinating their application.

Although we are far from having systems capable of the kind of interpretation sketched above, we are making progress in developing systems that are to some extent intelligent. All of them also have to be fairly clever in constraining the input and bridging gaps where no theory exists or existing theory is imprecise. And although a system may have components that are not analogues of the theory and the theory may have components that are not modeled in the system, there is nevertheless a coupling between them so that developments in text theory can guide those in ATP while developments in ATP can be used to test the text theory.*

Assuming, then, that ATP systems partially model theories of text and of information processing, we can now ask: What part can linguistic theory be expected to play in guiding and contributing to work in ATP?

C. Theoretical Linguistics

1. Aims and Methodologies

Posing this question plunges us immediately into the current debate over the methodology of linguistic research, its scope and its aims. The debate reflects a dichotomy in the study of language that appeared earlier in de Saussure's distinction between 'langue' and 'parole', or, more generally, between form and function. The debate

* As Hesse [1967] points out, "Almost any model or interpretation carries some surplus meaning. ...There is always a negative analogy that is implicitly recognized and tacitly ignored. We can therefore make a distinction between the model as exhibited by the familiar system and the model as it is used in connection with the theory. The latter is a conceptual entity arrived at by stripping away the negative analogy, and it is only this that can plausibly be identified with the theory." While it is true that an intelligent system will have components and operations that are unrelated to the partial theory of text it is intended to model, these can be ignored, conceptually, and the remainder will be a positive and easily recognized analogy to the theory.

concerns the focus of linguistic research; i.e., whether it should be focused primarily on form, or on function, or on both equally. In short, what is its business?

Until recently, the predominant position has been the one advocated by Chomsky and held by many though not by all transformationalists. Chomsky emphasizes form. For him, the primary object of study is the competence of an idealized speaker; the primary goal is to model this competence in a grammar and, beyond that, to discover the formal conditions that a grammar of any natural language must meet. He expects the study of formal grammars to reveal ultimately the innate structures in the human mind that are responsible for language. In pursuing this study, 'competence' is to be distinguished from 'performance'. Performance includes 'extralinguistic' information about the context of actual use and "operates under constraints of memory, time, and organization of perceptual strategies that are not matters of grammar" [Chomsky 1972, p. 116]. In Chomsky's view, performance provides data for the study of competence, and the study of performance should embed a grammar that models an idealized speaker's competence, but a theory of performance is outside the scope of linguistic research.

This rejection of the study of performance within linguistics, which narrows linguistic theory to a theory of grammar, is claimed to be necessary on very general methodological grounds. "In general, we would expect that in studying the behavior of a complex organism, it will be necessary to isolate such essentially independent [italics mine] underlying systems as the system of linguistic competence, each with its intrinsic structure, for separate attention" [p. 117].

Such an 'isolating' view is reasonable, but the prospects that those who hold it will develop an adequate theory depends on their correctly identifying an essentially independent system that can in fact be isolated from the complex behavior of language users. Transformationalists themselves have developed divergent theories of the independence of syntax from semantics and of the scope of semantics, and

there is currently considerable debate over whether syntax is an autonomous system and whether semantics includes the speaker's meaning as well as truth-conditional meaning.

Other linguists totally reject the competence/performance distinction. For Halliday [forthcoming], the separation of form and function is not simply unnecessary or undesirable--it is impossible. He does indeed distinguish two aspects of language, calling them 'language as code' and 'language as behavior', but insists that they are not independent. He speaks of their "interpenetration", claiming that the form of the code has evolved and its evolution has been determined by patterns of use, "so that the system is organised internally on a functional basis." A linguistic theory that ignores behavior "ends up by painting itself into a corner."

This holistic view is also reasonable, but progress may still require identifying some coherent range of phenomena for study, analyzing them into subsystems, and specifying the representation of each subsystem and its interaction with the others to form the whole. Otherwise the theory may be difficult to develop coherently; it will be diffuse.

I have gone on record elsewhere [Robinson 1975] as agreeing basically with the holistic view, but I also think the isolating view makes a valid point. The two positions can be reconciled and modified to provide a methodological stance that is general and reasonable for linguistics, ATP, and many other disciplines. The proposed modification is:

In studying the behavior of a complex organism, it is a good strategy at the outset to analyze the organism for the purpose of isolating each relatively independent system, with its intrinsic structure, for separate attention. It is to be expected that there will be disagreement over the analysis, over what systems to propose for independent study, where to draw their boundaries, and whether some are to be studied before others because they are more central or more important. As work progresses, it is to be expected that new analyses will be made and to the extent that these new analyses appropriately reflect the structure of the organism, it will

become progressively more feasible to study the functional relationships and dependencies among the systems that the analyses have suggested.

Let us call this an integrating view. It is not so much a static position as it is a way of proceeding. It sets forth a very general research strategy, one that is recursively applicable at many levels for analyzing complex phenomena or organisms into simpler components without reducing the whole to the sum of its parts. It is also a strategy that promotes both intradisciplinary and interdisciplinary cooperation. At the same time, it avoids taking so broad a view of the phenomena that no formalisms can be developed for any part or for the whole.

One justification for the isolating view, voiced today principally by those who defend the concept of autonomous syntax, is that it is necessary because it alone affords the possibility for formalization. The capability for being formalized is important. There are obvious advantages to having a formalism rather than an informal description for representing the insights of a theory in an automatic processor. But there is no reason to believe that formalization requires adhering tenaciously to an approach that isolates components completely; in fact, there is some reason to believe that such a limitation makes it impossible, as Lakoff has said, to develop a coherent theory at all [Lakoff 1974, as cited in Culicover et al. 1977]. However, we need not conclude, as Lakoff does, [op. cit., p. 5], that "at this time in history, a description of language that adheres to some formal theory will not describe most of what is in language....the time has come for a return to the tradition of informal description...."

A possible reason both for the insistence on autonomy and for Lakoff's reaction against formalization is the failure of the generative semanticists' attempt to accommodate within a single formal mechanism all the knowledge and processes people use in producing and understanding texts. A research strategy that focuses research on semi-autonomous systems and also on problems of their interactions can

provide for breadth and coherence without sacrificing formality. Informal descriptions have provided valuable insights -- and providing them is important at any stage -- but I see no reason to assume that we must return to them exclusively, abandoning formal descriptions. (I admit to a belief that a good description will lend itself to formalization, but perhaps this is an article of faith or a stipulation of the meaning of the expression "good description.")

2. Formalization, Abstraction, and Computers

Very likely it was the formalism of the theory of transformational grammar (TG) that led in large part to its early acceptance and rapid rise to become the dominant paradigm for almost two decades. At the outset, TG offered a theory that appeared congenial to the tasks of computer analysis and interpretation of sentences in texts. Part of its appeal lay in the elegant way in which certain semantic regularities observable in sentences with different structures (e. g., actives and passives, affirmatives and negatives, declaratives and interrogatives) were accorded an explicit and formal syntactic representation. In spite of the difficulty of analyzing sentences by performing inverse transformations to recover their underlying 'kernel' structures, the notion of first generating relatively simple structures by formal phrase-structure rules and then generating more complex structures by transformations afforded the hope that the problems of relating syntactic analysis and semantic interpretation would become more tractable. However, those who expected a natural cooperation to arise between theoretical linguists and those computational linguists who were writing explicit rules for application to texts were ultimately disappointed.

There are probably several reasons for this disappointment. One of them may stem from the fact that the only intersentential relationship captured by TG is the paraphrase relation. While the availability of paraphrases makes it possible to arrange the propositional content of sentences into coherent sequences, the

paraphrase relation is not itself a cohesive device. In fact, a sequence of paraphrases like:

My car has a flat tire, and one of my car's tires is flat
and there is a flat tire on my car.

is not a coherent text in spite of the presence of many of the cohesive devices described in Halliday and Hasan (1978).

Another reason may stem from the methodological position of TG theorists. In limiting the theory to a study of competence and insisting on autonomy, TG not only isolated competence from the rest of linguistic phenomena, it tended to insulate it from data other than the idealized introspection of linguists working within the paradigm. This approach reinforced a tendency to place a high value on the creation of abstract structures very remote from surface structures, as if their abstractness made them more universal and less subject to the idiosyncrasies of performance. By the time Chomsky's Aspects of the Theory of Syntax [1965] appeared, kernel sentences had given way to 'deep structures', which became increasingly abstract as time went on. The generative-semantics model of TG, with its decomposition of words, added still further to the computational complexity of analyzing even the simplest of sentences.

As deep structures became more remote, the transformations required to derive sentences from them necessarily became more numerous and more complicated. It also became necessary to provide complex traffic rules for their application. Abstractions that lead to simpler ways of articulating a complex problem domain and generating the necessary complex structures in it are usually welcome, but the combination of abstractness with baroque complexity in the generative semanticist's models of TG offered no simplifying insights for ATP and the early enthusiasm for the theory as a guide to ATP waned. At the same time, transformationalists showed no interest in testing their formal claims by computer, even though it was made easily possible [Friedman 1973]. In addition, after one large effort by a group at UCLA

[Stockwell et al., 1973] to collect and reconcile various rules that had been independently proposed, transformationalists stopped writing large bodies of coherent rules in the style of Lees [1960] and Rosenbaum [1965]. The attitude arose that effort spent on constructing extensive grammars with explicit rules was unlikely to produce any results of theoretical interest and was therefore simply a waste of effort. [See Postal 1972.]

As this attitude became prevalent, it was not surprising that few transformationalists were sympathetic to the aims of ATP. ATP must cope with performance, obviously, and if a grammar is to figure in an ATP system of any generality, that grammar must be extensive. But to many theorists in TG, the whole enterprise was a misguided attempt to handle raw, intractable data, impossible to analyze until after a theory of competence had been more or less fully specified. Dialogue between theorists in linguistics and theorists in text processing virtually ground to a halt.*

D. Recent Changes

There have been many deep-seated disagreements among TG theorists, especially over the relation of deep and surface structures to each other and to semantics. From the perspective of this paper, however, it is less important to delineate the disagreements than it is to note changes in attitude toward the construction of explicit, testable grammars, on the one hand, and toward computers as sources of tests, models, and metaphors that are relevant to linguistic theory, on the other hand.

As a sign of the first kind of change, we find Bresnan [1976] disavowing "a conception of linguistic research that has become widespread among generative grammarians"--the concept expressed by Postal [1972] when he "described the construction of grammars as an

* The lack of effective interaction between theoretical linguistics and ATP was apparent by 1970 and commented upon by Walker [1973] and Damerau [1976] in their surveys for the Annual Review of Information Science and Technology.

unrealistic and 'naive' goal for contemporary generative linguistic research." In a similar vein, Bach [1977] complains that after the appearance of Chomsky's Aspects, linguists no longer felt obligated to provide "reasonably rich fragments" of explicit syntactic, semantic, or lexical rules. To Postal's request for evidence that writing rules provides insights not provided by other means, Bach replies, "But there can't be any evidence for this concept, because it is simply a postulate as to what linguistics is all about. No rules, no grammars. No grammars, no theory."

Signs of the second change are to be found in the discussions about the problem of 'psychological reality'. Although the expression 'psychologically real grammar' is not defined, the concept is that different grammars for a language imply different degrees of difficulty in learning and processing that language.

Attempts to validate the psychological reality of the transformational model have not been successful. More recently, evidence has accumulated to show that children initially acquire representations of linguistic structures that are more closely related to surface structures than to the deep structures from which the surface structures are theoretically derived [Maratsos 1978].

One effect of the accumulating evidence has been to breach the artificial barrier between competence and performance. If there is evidence that some deep structures proposed on grounds of explanatory adequacy are not used, then why postulate them? Concomittantly, the question is raised as to whether transformational analysis is a necessary or optimum way of accounting for semantic/syntactic generalizations. A second effect has been to reexamine the role of surface structure relative to semantic interpretation, placing increased emphasis on the importance of words for relating syntactic and semantic information.

The current position is that semantic interpretation is performed in part on surface structures. In Reflections on Language [1975],

Chomsky points out that the active-passive pair

a. beavers build dams

b. dams are built by beavers

do not have the same meaning. The first ascribes the property of dam building to beavers, which is true of beavers generally, whereas the second ascribes the property of being built by beavers to dams, which is clearly a false generalization. In accounting for the difference in meaning, one must take into account the difference in surface structures. However, to account for the similarity in meaning, one must know that while "dams" is the subject of the sentence in (b), it is also in the same functional relation to the verb as it is in (a). Chomsky speaks of it as being the subject in one sense, but also the object of the verb "and hence not the subject, in another sense." He proposes to account for its double role through a theory of annotated surface structures in which traces are left to mark a position from which some constituent has been shifted by a movement transformation. In terms of 'trace theory', the passive sentence has a structure something like

dams are VP[built t by beavers]

But why should we view the active sentence as the structure to which a transformation has not applied and the passive sentence as one in which an NP has been moved by a transformation? One could just as well say that transitive verbs like "build" are semantic predicates with two arguments, an agent and a theme. These verbs occur in the active voice with the agent as the subject NP and the theme as the direct object NP. In the passive voice the theme is the subject NP and the agent (if present) is the object NP of the preposition "by" in the verb phrase complement. The information can be supplied as attributes or features in the lexical entry for verbs and then be preserved by annotating the phrase structure in which they are constituents.

This latter treatment is currently being implemented in SRI's DIAMOND system. (A. Robinson [1978] gives an overview of the design of the DIAMOND system and its current state.) DIAMOND uses lexical information to encode the possible syntactic ordering of predicates and arguments. The semantic predicate/argument relations are represented after parsing as part of a partitioned semantic net with labeled arcs,

rather than as an essentially syntactic phrase form with a canonical linear order.

A similar approach is found in Marcus' theory of syntactic recognition [Marcus 1978]. Marcus sets forth the hypothesis that the underlying predicate/argument structures of sentences can be recovered by a deterministic parsing procedure applied without backup to a grammar that provides an annotated surface structure. The annotations introduce trace elements to indicate the 'underlying' positions of 'shifted' NPs (where 'underlying' and 'shifted' are labels carried over from transformational terminology). The grammar also annotates syntactic nodes by labeling them with sets of features. As Marcus points out, a properly annotated surface structure makes it possible to encode in the same formalism "both deep syntactic relations and the surface order needed for pronominal reference and...other phenomena" such as focus, theme, and scope of quantification [p. 132].

While Chomsky himself does not subscribe to an account that eliminates or severely reduces the transformational component of a generative grammar, this appears to be the direction many transformationalists are now taking. In the new Extended Lexical Model proposed by Bresnan [1978], all but a few transformations are eliminated, including the Passive Transformation. That transformation is replaced by a table-lookup interpretive rule that identifies the syntactic relations of noun phrases and prepositional phrases to verbs, on the basis of information stored in the lexical entries of the verbs. The lexical entries also supply semantic information in association with the syntactic information. While the strict subcategorization and selectional features of the older model provided similar information, the innovative step in (ELM) is the use of this information to eliminate all bounded transformations, leaving only those like the WH Movement Transformation, which move elements over unbounded lengths. As a result, the formality of a generative grammar is retained while the functions of transformations are being re-evaluated. In contrast to the earlier autonomous model of TG, the new model (ELM) suggests, in

Bresnan's own words, "the cooperating interaction of separate information-processing systems." In making it clear that the psychological reality of a grammar is to be judged in part by its computational efficiency, Bresnan states the assumptions on which she bases her proposed revisions to TG in terms that are unmistakably computational as well as psychological.

First, I assume that the syntactic and semantic components of the grammar should correspond psychologically to an active, automatic processing system that makes use of a very limited short-term memory. ...Second, I assume that the pragmatic procedures for producing and understanding language in context belong to an inferential system that makes use of long-term memory and general knowledge. ...Finally, I assume that it is easier for us to look something up than it is to compute it. It does in fact appear that our lexical capacity--the long-term capability to remember lexical information--is very large. (p.14)

The proposed new orientation of TG that makes it more psychologically real also makes it more adaptable to automatic processing techniques--a change that seems obviously advantageous for developing ATP systems. This is welcome. But even more important is the shift from a narrow concentration on isolated syntax and logical form to consideration of the larger system in which they are components, accompanied by a sense of their place in "an active, automatic processing system."

In an earlier section of this paper, I advocated an integrating view of the scope and aims of linguistic research, presenting it as a desirable synthesis of the isolating and holistic views. I have also suggested throughout that the lexical component is central to the enterprise of text processing as a whole, since words furnish both linguistic codes for indicating part of the meaning of a text and clues for inferring the remainder. If, as I believe, Bresnan's statement is indicative of the dominant trend in linguistic theory, then an integrating view is now emergent which emphasizes the lexicon. In the future, we can expect to see an increased preoccupation with determining

both the nature of the components that an adequate theory of text processing requires and the nature of the interactions and functional dependencies that hold among them. We can also expect that the business of each component, including the linguistic component, will be better understood when the role of each is defined as part of the complex process of using words to talk.

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