METHOD AND TACTICS IN COGNITIVE SCIENCE

Edited by

Walter Kintsch
James R. Miller
Peter G. Polson
University of Colorado

LAWRENCE ERLBAUM ASSOCIATES, PUBLISHERS
1984 Hillsdale, New Jersey London

8 Theoretical and Methodological Issues in Cognitive Science: A Psycholinguistic Perspective

David Swinney
Tufts University

Introduction

The fundamental concern of cognitive science is to understand the nature of both the structural and functional properties of intellectual capacity and intellectual operation. And in so far as such a goal is maintained as a central focus in each of the various fields comprising cognitive science it will follow that roughly the same set of general theoretical issues and methodological approaches will be at stake in each. However, it is equally clear that any *real* catholicity of theory and methodology across disciplines can only exist when these fields (including, at least, aspects of psychology, linguistics, philosophy, neuroscience, and artificial intelligence) share *in detail* the same underlying assumptions about the nature of these issues and their possible solution sets. Thus, it is impossible to overstate the importance that such (typically unstated) assumptions play in constraining theoretical and practical approaches to any issue and in making approaches incorporating one constellation of assumptions *un*intelligable to those with a slightly different constellation.

It is obvious that some fields within cognitive science share more basic goals and approaches than do others, and it is certainly true that the interaction of some of these fields has produced a growing tendency for the development of mutually held theoretical assumptions. (Psychology and linguistics are prime examples: since its inception, psycholinguistics has borrowed extensively from linguistic theoretical foundations and, particularly in the past few years, linguistics has tended to expand its explanatory domain to include data on the *use* of linguistic knowledge.) However, there are great differences in the underlying approaches and basic theoretical goals in even these mutually assimilative areas, differences

that have inevitably led to misunderstandings and a subsequent failure of those in one discipline to successfully use and appropriately apply knowledge gained by those in the other.

In what follows I examine a number of basic issues and assumptions underlying work in one domain of cognitive science, that of cognitive psychology. The goal of this presentation is to make explicit some of the considerations involved in a cognitive psychological approach to issues so that a reasonable basis for valid incorporation of data from this domain into other fields of cognitive science may he established. Further, as cognitive psychology is itself a diversified field, I focus discussion on a number of theoretical considerations (and their related methodological concerns) in one area of cognitive psychology-psycholinguistics. This focus on language processing seems appropriate in as much as a great many of the fundamental concerns in cognitive psychology have received their most extensive examination in the past decade from work in psycholinguistics.[1] However, it is my contention that the issues of perception and production discussed here are not different in kind front issues of perception and production in any other aspect of cognitive psychology, and thus the material presented here is taken to he representative of a fairly general set of concerns in and approaches to cognitive science.[2]

The discussion of theoretical and methodological issues in psycholinguistics is followed by an illustration of the issues at stake through an extended example of work in a specific area of language comprehension-lexical processing. Following this, a short discussion of the validity of utilizing such data to support claims in fields not sharing assumptions under which the data were gathered, is made.

BASIC THEORETICAL AND METHODOLOGICAL CONSIDERATIONS IN PSYCHOLINGUISTICS

The central concern of any theory of language perception is to establish the manner in which we assign interpretations to acoustic or visual language stimuli (i.e.. understand words and sentences). Such a theory must, at the very mini-

[1]The reasons for this are fairly obvious: language has proven to be a somewhat more accessible domain for study than some others in cognitive psychology, and the systematic classification and observation brought by linguistics and philosophy to language have provided a convenient initial stepping stone for the investigation of the psychological properties underlying *human* language perception and production.

[2]It is worth noting that the issues that will be discussed all have human intelligence as their target of inquiry. This goal is shared by most, but certainly not all, approaches in cognitive science and provides a limiting criterion on all such work. The distinction between those fields that focus on human capacity and operation (to whatever degree) and those that entertain data from 'other' types of intelligent behavior appears to be that with perhaps the most profound consequences for mutual interdisciplinary understanding.

mum, detail the distinct sources of information that are involved in comprehension (including both the representational structure and the content of such information) and the processes by which this information is organized and integrated. As such, what distinguishes such psycholinguistic examination from many other approaches to language is its focus on the fact that language understanding (like many other cognitive functions) is a dynamic *process*. That is, theoretical descriptions of language from a *psychological* point of view must incorporate the fact that language understanding involves operations (on various sources of knowledge) that are distributed over time. A number of important issues, most of which are highly interrelated, follow from this point:

1. *Real-time vs. static analysis of language*. The first of these is that *static* models of putative language structure are of questionable (and, at best, indeterminent) importance in the enterprise of understanding language performance. Models can he classified as static on two grounds: the first of these can he seen in the distinction drawn between those mental processes involved in real-time language perception (the *process* of understanding a sentence) and those involved in various post-perceptual language functions (recall, recognition, paraphrase, or some other such manipulation of already-perceived sen(ential/propositional material). Not only do quite different mechanisms likely underly perceptual and post-perceptual processes, but data taken from one of these two sources may not legitimately reflect processes in the other. Thus, it is important to distinguish between theory relevant to (and data derived from) on-line processes as compared to post-perceptual processes. The latter can, at best, provide an underdetermined model of language performance. The importance of the meld of theory and methodology is critical here and, if our goal is one of understanding language use, then we must look at that use appropriately ---as it occurs in time.[3]

The second way in which models may he considered 'static' is when temporally independent analyses of language torn the inferential base for positing mental processes. Traditional formal linguistic description, for example, represents structures independently of temporal constraints, a fact that is likely to void the relevance of at least sonic linguistic descriptions to the enterprise of psychological explanation. Further, the data on which such linguistic models are based-linguistic intuitions and observation of distributional characteristics-are clearly post-perceptual; they are simply not direct reflections of the processes involved in real-time language comprehension. At the very least, such intuitional data is filtered through whatever cognitive process is involved in bringing unconseious knowledge to consciousness; and, it has been amply demonstrated that

[3]Note that on-line processes in language are assumed here to provide a segmental analysis that yield a roughly literal interpretation and structural description of a given proposition/sentence, whereas post-perceptual processes involve evaluation or other manipulation of the basic structural description in light of world knowledge, processing demands, or other higher order information sources.

most unconscious events are opaque to conscious access. Overall, if we are to achieve any substantive understanding of language as a psychological process it will be necessary to examine the microstructure of this process as it occurs *in real time;* an adequate psychological description of language must incorporate specification of the availability, structure, and content of the various levels of representation throughout the temporal course of language performance.

2. *Issues of modularity, auronony, and interactivity*. The above considerations lead to a related and equally critical issue in language (and other cognitive) processing---the degree to which the system is decomposable into independent, internally consistent, specifiahle suhprocesses. Because our perceptual models require that some basic invariant unit of analysis he posited, the concept of modularity exists to sonic degree in most models of language. However, we have neither an account of: (1) what distinct processing modules (sources of information) are functional in language understanding; nor (2) an account of the degree to which these operate independently of each other.

With respect to the first issue, whereas systematic observation in linguistics has allowed for the characterization of a number of sources of information in formal linguistic analysis-phonetic, morphemic, syntactic, and so on-such descriptions are based on the rules and constraints of linguistic description and few have yet to be shown to have anything but an indirect (or indeterminant) relationship to the types of information that are *functional* in the ongoing process of language comprehension. Such observations do, however, provide a strong prima facie case for the 'functional reality' of these information types, and as such are important stepping stones in the search for functional properties of the system. Similarly, evidence from language pathology has given us hints as to functional modules in the language system. However, establishing psychologically relevant characterizations of the sources of information involved in language processing can only he accomplished by empirical examination.

The second issue---hotly contested in the past few years-concerns the basic nature of the integration of information that occurs during language comprehension. This issue contrasts two models of language processing: a maximally interactive system (in which any type of contextual information can affect processing of any other piece of information) and a highly modular system (a system comprised of autonomous suhroutines in which contextual information does not affect processing internal to any subroutine). At the outset, it can be noted that language comprehension, like most other cognitive processes, is clearly "integrative" in nature. To understand an utternace we must, in some fashion, retrieve information about the words in that utterance, discover the structural relationships and semantic properties of those words, and interpret these in the light of the various pragmatic and discourse constraints operating at the time. Further, we know that all of this takes place at a remarkably rapid pace, a fact (along with much post-perceptual data) that has led some theorists to view the

comprehension system in general as being a maximally interactive, 'top down' process. The modularist view of such integration, however, is that the subcomponents comprising the comprehension process constitute autonomous levels of processing, each of which may operate with its own unique temporal and distributional characteristics. It is only the outputs of these processes that interact (by providing inputs to other subprocesses); the internal operation of any one process is not changed by information derived from another (see, e.g., Garrett, 1978).

Resolution of the issue of whether the system in general is a modular or an interactive one is perhaps the most important key to establishing a viable psychological model of perceptual processing. Certainly, it is clear that a system that supports the nearly infinite variability in processing that is inherent in any *maximally* interactive model requires a significantly more powerful underlying mechanism to be posited than one which consists of relatively autonomous, context free, internally consistent routines. Failure to provide clear definition of (and detail of constraints on) the nature of information integration almost guarantees that we will posit either far too powerful or far too weak an underlying mechanism as the basis for language behavior, a failure that may well be a critical one in our attempts to understand the process.

It should be noted that the question of autonomy of processing levels, that has been presented here as a means for delineating the micro-structure of the language faculty, has a macro-level counterpart. It is, in fact, important that we determine the extent to which mental operation in general is comprised of independent, domain-specific systems (e.g.,--language, imagery) as opposed to domain-general functions. For example, to what degree do general memory functions or automaticity factors penetrate our structural and functional descriptions of the language system? And (taking another view) to what extent are the models of language processing that we develop distorted by various 'output' functions that recruit both world knowledge, situational constraints and (possibly) domain-general processing strategies in their operation? In both micro- and macro-level cases, as will he denionstratcd in pact below, the weight of the evidence appears to favor the modular approach. However, the critical link in our ability to detail the relevant independent structures and processes, and the nature of their interaction, is our ability to bring appropriate empirical methodology to bear on the issue. This ability hears discussion.

3. *Methodological Considerations.* Let us begin with an obvious but nonetheless important observation: how we characterize information sources and (their) procedures is intimately tied to the assumptions we make about the nature of the experimental techniques used to reveal them. There is simply no passive window that allows for the examination of mental processes without affecting those processes to some extent. Thus, the representational characterization of these information types, the processes involved in their interaction, and the

processes by which we attempt to examine these interactions must all be modeled simultaneously. Each of these constrains our ability to examine and model the other. It is, therefore, essential to stress that adequate models of our empirical tasks are a critically important part of our attempt to understand mental representation. Although it is encouraging to note that some experimental techniques have undergone extensive critical examination (witness the study of phoneme monitoring over the past 6 years), far too little is known of even the most basic characteristics of most of these techniques.

There are at least two corollary issues that are of importance here. The first relates to the critical need for discovering and testing new experimental techniques. Given that much of the problem in understanding language comprehension is best resolved by empirical examination of the real-time characteristics of language processing, we are in need of experimental techniques that are sufficiently flexible to examine such processing on-line and, simultaneously, that are as non-intrusive into the process under study as possible. Further, we are in need of tasks that are differentially sensitive to different *levels* of analysis in language processing (e.g., acoustic/phonetic, lexical, syntactic, inferential, etc.). It is important that the examination of mental processes he seen to be a mufti-leveled enterprise. We need to discover the nature of each of the several putative levels of processing as they are computed during the on-going perceptual analysis of language. To do this, it will he necessary to develop batteries of 'on-line' tasks, each of which has known properties that reflect different aspects of the mental process under study.

The second corollary issue concerns the need for determining the relationship that holds between conscious and unconscious processing as well as the role of autontaticity in such processing. Itecause language is a highly overlearned, automatized system, until we understand the manner in which automaticity affects our ability to interrupt, examine, and have intuitions about language, we will have little idea of the value of the information we gather from such experimental tasks. Further, as it is generally only the final result of any perceptual process that can he brought to the conscious awareness of a listener, any task involving conscious decisions by the listener as to the nature of (he material he has heard is likely not to give a direct reflection of the series of tuconscious, automatic stages involved in that perceptual process.

It has been argued (appropriately, I believe) that support for nearly any theoretical position can be obtained if the 'right' experimental task is used (Foster, 1979). One can, for example use tasks which will 'demonstrate' that context either does or does not have an effect on subsequent processing. The problem is that not only does any one task bring with it its own particular set of required strategies, each task also has a different degree of sensitivity to different mental processes. Although it is clear that we cannot have the ideal situation-one in which the task would add none of its characteristics to the process under study and would also be maximally sensitive to underlying processes - some of

the tasks that have been used appear to approach that ideal more closely than others. One key factor appears to be the *point of application* of the experimental tasks during the comprehension process. As suggested previously, tasks that attempt to examine a process only after it is completed (post-perceptually) reflect quite different aspects of processing than do tasks that occur with more temporal immediacy to the process under study. Minute differences in the degree of temporal separation of the experimental task from the occurrence of the particular process one wishes to study, can cause major differences in the results obtained, as will be seen in the next example.

A final methodological issue relates more to the experimental situation than to the tasks used. In general, it is the case that the environment in which a particular operation is examined will influence the characteristics discovered. If, for example, one is interested in lexical processing in fluent language comprehension situations, then the process must he examined in a fluent language environment, and not in 'isolated' lexical tests (for the obvious reason that the cognitive/linguistic operations involved in these different task situations will, themselves, differ). Similarly, if the target of inquiry is *speech* comprehension, we must be wary of drawing conclusions from the processing of written material. Although some underlying operations are undoubtedly shared across performance situations, it is not a trivial chore to determine which of the inferences that we make about cognitive processes are best attributable to 'underlying' processes and which are best attributable to superficial or task-related operations. Results from some task situations undoubtedly reflect more of how subjects can perform given constraining (and often complex) experimental situations than of' what subjects normally do during language comprehension. (Obviously, when sufficient evidence from different 'task' sources coincide, we have the basis for arguments about underlying representations, however, that situation is not a common one.) Thus, because the task a subject sees himr or herself as having--the *query* he or she poses to his or her cognitive system--may determine the cognitive strategies employed in that situation, a conservative position may well be the best one to adopt in research. In doing so, some relevant evidence will undoubtedly be overlooked, but the model we sketch will not he forced to account for much of what may be irrelevant or inappropriate data.

Information Interaction during Lexical Processing-An Illustrative Example

The point of the argurtrentation thus far has been to delineate a number of issues that are critical to understanding the psychological processes underlying language. The issues that have been elaborated constitute concerns that, in some cases, form the more unique contributions of psycholinguistics to this enterprise and, in others, represent concerns shared by a larger subset of cognitive psychologists (including questions of modularity, automaticity, autonomy, functional

information sources, the role of consciousness in experimental investigation, and the penetration of domain-general processes into the examination of putatively independent cognitive faculties). In some cases an obvious stance has been taken on these issues, but in others the necessary information is simply not available for such a posture. It is the case, however, that the only viable approach to resolving most of these issues is the careful empirical examination of the microstructure of the language process through the appropriate match of experimental technique to the questions of interest.

In what follows an extended example of methodological approaches to some of the problems raised earlier is presented. The example is intended to provide both an illustration of the problems involved in evaluating experimental approaches to these issues and (ultimately) to provide evidence for a particular characterization of the cognitive system in man.

The general issue motivating the research reported here is the question of the degree to which we can characterize comprehension as being a highly interactive (as opposed to an autonomous, modular) system. The approach my colleagues and I have taken in this enterprise has been to examine the nature of the influence of prior contextual information upon the processing of subsequent material during sentence/discourse comprehension. In this, we have attempted to map the temporal characteristics, of such contextual effects. As argued previously, although we know that 'context' exerts sonic influence upon the interpretation of language, the important question is where and how such influence takes place. The work discussed here takes the domain of lexical processing as the testing ground for examination of this issue. This choice has been made for a number of reasons. First, words are perhaps the most likely candidates for being truly functional sources of information during language processing (word recognition is acknowledged to play a role in nearly every psychological and linguistic account of language). In addition, lexical representation and processing are commonly considered to be (the) major points of intersection of acoustic-phonetic, syntactic, semantic, and discourse information in language. Thus, it is a logical realm within which to examine information interaction.

The work to he examined focuses on the effects of prior-occurring 'higher' order contexts upon lexical access and interpretation. In this, the interactionist/modularisl issue corresponds to a distinction between what have been labeled the Contextually Predictive and (lie Contextually Independent models of lexical processing. Under the Contextually Predictive theory, contextual information constrains and directs all of the various stages of lexical processing, whereas under the Contextually Independent model, higher order context will only act oil the output of the lexical access process. Thus, the problem can be characterized as one concerning whether or not lexical *access* is independent of contextual constraint.

The overwhelming proportion of the evidence on this issue comes from studies that have examined the effects of contexts upon the interpretation of poly-

semous words. The reasons for this are straightforward. The meanings of lexical ambiguities can be differentiated rather easily, and thus the selective effects of higher order contextual constraints upon the functional activation of these meanings are relatively available to empirical examination. Further, not only are lexical ambiguities arguably as common as unambiguous words in language use, but nearly all words exhibit some type of indeterminacy in characterizations of their meanings. Thus, ambiguous words provide a useful and well founded vehicle for examining the effects of context upon lexical processing. Given a sufficiently sensitive task, one should be able to determine whether strongly biasing (higher order) contexts constrain the various stages of lexical processing by examining which meanings of the ambiguities are functionally activated in the presence of these contexts.

Most of the early studies on this issue utilized the so-called 'ambiguity effect' in their investigations. The principle behind this effect rested on evidence that the presence of a lexically ambiguous word caused increased processing difficulty (when compared to an unambiguous word) in sentence comprehension. Thus, the absence of this 'effect' in the presence of a prior context was taken as an indication that the context had simplified the access process. Holmes, Arwas, and Garrett (1977), for example, demonstrated that time to classify a sentence as meaningful is increased by the presence of a lexical ambiguity and, also, that the number of words recalled in a rapid serial visual presentation task is fewer in the presence of an ambiguity. MacKay (1960) demonstrated that the presence of ambiguous words in sentence fragments causes sentence completion times to be slower. And, in an approach that we will examine in slightly more detail, Foss and his colleagues (Cutler & Foss, 1974; Foss, 1970; Foss & Jenkins, 1973) as well as Cairns and Kamennan (1975) and Cairns and Hsu (1979) demonstrated that monitoring for a phoneme takes longer following an ambiguous word (compared to an unambiguous word). Further, this effect was shown not to diminish even in the presence of a prior biasing context.

The phoneme monitoring task operates on the following principle: in any finite capacity processing device in which two competing tasks are being performed simultaneously (e.g., listening for a prespecificd target phoneme (monitoring) and comprehending the sentence). changes in difficulty in one task should he reflected in speed or accuracy of performance changes in the other. Thus, the experimental finding that phoneme monitoring took longer following an ambiguous word than an unambiguous control word in these sentential materials, even in the presence of a prior biasing context, was interpreted as demonstrating that such prior context did not affect lexical access. Unfortunately, this interpretation constituted support for the Contextual Independence hypothesis solely by virtue of *failing* to find support for the Contextual Interaction hypothesis (i.e., failure to find a reduction in monitoring latency). The problem with this experimental inference became apparent when the work of Swinney and Hakes (1976) demonstrated a reduction in the phoneme monitoring latency fol-

lowing ambiguities in the presence of very strong biasing contexts. However, the Swinney and Hakes research (and its apparent support for the Contextually Interactive Hypothesis) was also doomed to reinterpretation, but for an entirely different set of reasons, many of which have been suggested earlier. In all of the work using phoneme monitoring, the phoneme target, of' necessity, occurs "downstream" from the ambiguity that is being examined (it usually begins the word following the ambiguity). The temporal gap between occurrence of the ambiguity and detection of the phoneme target in a following word is, thus, fairly extensive relative to the magnitude of the latency effects reported with this task. Thus, whereas claims deriving from monitoring data all contain the key assumption that the task actually treasures lexical access and not some process that occurs following access, the phoneme monitoring task may well only reflect some type of post-access decision process. If so, in situations where a prior biasing context was not very strong this post-access decision process that incorporates context might take a relatively long time to complete, long enough so that the phoneme-monitoring decision is engaged while this process is still at work, thus producing no evidence of contextual interaction. However, in the presence of a very strong biasing context (the Swinney & Hakes study) this post-access decision process could occur rapidly enough so as to reduce the processing load caused by the ambiguity prior to the lime when the phoneme monitoring task comes into play. In short, it seems likely that the phoneme monitoring task was not actually reflecting the real-time access of information for ambiguous (or other) words preceding the phoneme target but, rather, was reflecting post-access processing (see Cairns & Hsu, 1979; Swinney, 1982, for related arguments). Thus, despite appearing to be an 'on-line' measure, the monitoring task may not be capable of yielding data appropriate to the examination of the hypotheses under question.

In order to he able to provide more relevant evidence for the hypotheses under question, an experimental task was needed that was capable of directly reflecting the access of each of the several meanings of an ambiguous word as well as being capable of pleasuring lexical access immediately (with no temporal delay) during on-going sentence comprehension. To these ends, a task the cross modal lexical priming technique (CMLP) was devised which coupled the auditory presentation of an ambiguous sentence with a visual, lexical decision task. This technique utilizes the existence of automatic semantic printing (response facilitation) to detect the activation of word meanings during sentence comprehension. It has been demonstrated that lexical decisions (word/nonword judgments) are facilitated when the target word is semantically related to a previously presented word (see, e.g., Meyer. Schvaneveldt, & Ruddy, 1975; Neeley, 1977). This effect has been demonstrated to hold cross-modally, where the lexical decision is made to a visually presented letter string and the related word is presented auditorily as one of the words in a sentence (Swinney, Onifer, Prather, & Hirshkowitz, 1979). It is the fact that printing can be driven front words in sentences that makes the task of

interest here. Not only is the task flexible (the 'primed' visual word can be presented at any point during which a subject is listening to a sentence), but it has also been demonstrated o reflect the relative degree of activation of the target word in a sentence as a function of the amount of facilitation obtained for the lexical decision. (The amount of priming for an experimental word is determined by comparison to an unrelated, but otherwise equivalent, control word presented at the same point in the sentence). There are three additional aspects of this task that are worth noting. First, processing of the sentence is relatively natural, at least until the appearance of the visual stimulus (that occurs immediately *after* the subjects hear the critical word in the sentence). Secondly, the task does *not* require subjects to try to manipulate the sentence or consciously relate the visual material to the sentence in any way, and thus the task is considerably less intrusive into the natural process than several other on-line tasks seem to be. Finally, when there is a sufficiently low ratio of materials in which the visually presented word is (as compared to 'is not') related to some other word in the sentence, subjects rarely report noting this critical relationship and, in fact, rarely appear to try to do so after the first few practice trials.

Thus, given a task that is an index of the degree of activation of word meanings in sentences, the rationale for its use in the examination of the effects of context upon the access of ambiguous words is no doubt apparent. If prior contexts constrain or predetermine lexical access, then one should only expect to find priming for visual words related to the contextually relevant meaning of an ambiguity; if context prevents the inappropriate meaning from being accessed and activated there can be no basis for a priming response from that meaning. On the other hand, if access is an autonomous (and exhaustive) process one would expect *all* meanings of a particular acoustic/phonetic word form to be accessed, and thus visually presented words related to all meanings, (contextually appropriate or not) should be primed, at least momentarily.

The initial experiments (Swinney, 1979) examined the effects of local lexical-semantic contexts upon the access of meanings for unsystematic ambiguities, utilizing a set of materials from which subjects listened to sentence pairs such as the following (where the material in parentheses constitutes the context manipulation):

> Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several (spiders, roaches, and other) bugs in the corner of his room.
>
> 

Visual lexical decisions were required for words related to the contextually appropriate meaning of the ambiguity [ANT], for words related to the contextually inappropriate meaning of the ambiguity [SPY], and for unrelated control words [SEW]. These materials were presented both at a point immediately following occurrence of the ambiguity 1 and at a point three syllables later 2.

The results clearly supported the Contextual Independence model of lexical access; significant facilitation occurred for lexical decisions to visual words related to each meaning of the ambiguity, even in the presence of a strong, constraining lexical-semantic context, when tested immediately following the ambiguity 1. Importantly, at the delayed test point A, significant facilitation was obtained only for lexical decisions made to words related to the contextually relevant meaning and not the contextually inappropriate meaning. This result strongly supports the concept that an independent post-access decision process takes place that utilizes context to determine the appropriate meaning for the word. The result of this process is that activation is maintained for the appropriate meaning but the other, inappropriate, meanings of a word are allowed to rapidly decay (or, perhaps, be suppressed). These results also provide strong support for the assumption that this task is sensitive to the processing of words throughout the time-course of sentence comprehension.

The experimental work aimed at examining the autonomy and interactionist hypotheses of lexical processing has been presented in a fair amount of detail in order to demonstrate several of the methodological issues inherent in attempts to examine the nature of representation and processing involved in real-time cognitive operations. As demonstrated, with sufficiently fine-grain analysis techniques one can hope to find reasonably definitive answers to questions about autonomy and modularity in cognitive processing. Obviously, however, convincing evidence for modularity is not supplied by a single demonstration. While the data presented thus far support the argument that lexical access takes place independently of any biasing effects of lexical/semantic context in sentential environments, claims of true autonomy require demonstration that other types of context also fail to affect lexical access. A number of relevant investigations have been undertaken in the past 2-3 years in our laboratory and in other research Facilities. It has been shown, for example, that the presence of various types of local and globel cues as to the syntactic (structural) role that must be played by subsequent lexical material also do not constrain lexical access. In a series of experiments employing categorical ambiguities (e.g., cross, watch) in sentential contexts with prior occurring cues as to their grammatical role (e.g., "... *the battered cross . , .*", ". . . *to quickly cross . . .*"), it has been shown using CMLP that *both* noun and verb interpretations of the ambiguity are momentarily accessed (Prather & Swinney. I977; see also Tanenhaus, Leiman, & Seidenberg, 1979).

Similarly, again usurg CMLP, preliminary evidence supports the position that lexical access is independent of effects from higher-oirder discourse constraints (including contest provided by 'picnic' and 'given' information in discourse). In all, lexical access appears to he an exhaustive procedure that operates independently of existing contextual information; such information only has its effects after the interpretations for a word are computed.

Separate evidence about the process that incorporates contextual information

independently of (and following) lexical access has been obtained using real time processing techniques (CMLP) on a specific diagnostic population of subjects-chronic schizophrenics. The motivation for this work rested in the fact that the schizophrenic population is known for a tendency to ignore contextual information in processing (contextually independent, bizarre, associations are a major diagnostic for this disorder). It was reasoned that if contextual effects on word interpretation are independent of lexical access, and if the cognitive disruption involved in schizophrenia affects the use of context but *not* the underlying perceptual access process, then data from schizophrenic patients should be able to provide evidence confirming (or refuting) the modularity claims made above. Using sentences containing polarized lexical ambiguities (words with one very likely and one very infrequent meaning) it can he predicted that if the perceptual access process is intact for schizophrenics both the high and low frequency meanings should be activated immediately 1 after occurrence of the ambiguity, regardless of the contextual bias of the sentence. (This is, of course, the result already reported for 'normal' subjects.) However, when the test point is delayed 2 thus allowing sufficient time for the posited post-access decision process to have taken place, it can he predicted that a departure from the pattern for normal subjects should he found (reflecting a disruption in the post-access contextual integration module). This was precisely the result obtained. In the delayed text condition 2, only the *most* frequent meaning for the ambiguity was activated, even when the contextual information in the sentence dictated that the *less* Frequent interpretation was the correct one. (As expected, for normal control subjects only the contextually appropriate, *less* frequent, meaning was activated in this condition.)

Thus, whereas the research has certainly not exhausted the inventory of possible higher order constraints on access, the range of data that does exist strongly suggests that access of lexical information is unconstrained by higher order contexts during sentence comprehension. Lexical access appears to he a contextually independent process operating on a bottom-up principle of analysis, a fact that is not, however, represented in a number of influential theories of lexical processing (e.g.. Forster. 1970: Morton, 1909) that were developed based on data taken from post-perceptual or non-sentential examinations of lexical processing.

It is interesting to note that This modular characterization of the language srstenn has been somewhat mirrored in an entirely different domain-the processing of visual figures. Prather (1980), using a speeded decision technique *during* the processing of complex visual figures, has found evidence that even for very young children pore than one possible organization for the lines comprising the figure are elaborated during the course of visual perception (even if the figure has one obviously correct and 'recognizable' organization). These data, taken from on-line perceptual analyses of visual processing, stand in contrast to the

standard arguments about visual perception (i.e., that only one perceptual organization is perceived at a time) which, again, were obtained from post-perceptual report data (see e.g., Elkind, Anagnostopoulou, & Malone, 1970).

Just as distinguishing between on-line and post-perceptual analysis sheds light on issues critical to modeling cognitive processes and representations, so too can the contrastive examination of data from differing experimental environments (as was discussed earlier). For some time the most popular models of lexical processing have characterized the access procedure as a *terminating* ordered search (e.g., Forster 1976; Hogahoam & Perfetti, 1975). It has been argued that candidate word forms are compared against internal representations in order of their frequency, in a search that terminates once a contextually appropriate entry is encountered. Much of the data for this position, however came from isolated word processing techniques (lexical decisions made on isolated words or word pairs). When this claim was examined with an on-line technique (CMLP) *during* the course of sentence processing (Oniter & Swinney, 1981), it was found that even when the most highly frequent interpretation of an ambiguity was required by the sentential context, *all* interpretations of the ambiguity were momentarily accessed. These results argue against any type of terminating search in access *during sentential processing*--but point up the potential difference between processes operating in isolated word processing situations and sentential processing.

Finally. examination of' the temporal characteristics of language processing leads to (sometimes surprising) evidence about the organization of the system, evidence that could never he discovered by simple intuitions. For example, it has been argued (Bobrow & Bell, 1973) that there is a special processing system for idiomatic interpretation. Evidence for this position came in the form of post-perceptual 'report' data in which it was found that only the literal *or* the idiomatic interpretation of a grammatical idiom (e.g., 'break the ice') was 'heard' by subjects, depending on the context. Again, however, analysis with more fine-grain processing measures (Swinney, 1981; Swinney & Cutler, 1979) has demonstrated that *both* idiomatic and literal interpretations are elaborated simultaneously for such materials, and there is simply no evidence to support a separate 'idiomatic mode' of processing. However, there *is* evidence from semantic printing studies that suggests that different "rise times" (a measure reflecting availability of information from lexical entries) exist for information that is: (1) a part of the literal (segmental) interpretation of a sentence; in contrast to that which is (2) derived from various inferential processes operating on this basic interpretation, such as might be found in metaphor comprehension. In general, information derived from such inferential analysis appears not to "arise" until a point considerably later than when it could first logically become available. Such evidence, although tentative, does suggest that we should consider these different types of informational analysis to constitute separate components of our language processing system.

GENERAL CONSTRAINTS ON USING PSYCHOLOGICAL DATA TO SUPPORT THEORETICAL POSITIONS IN THE COGNITIVE SCIENCES

The theory and research presented has been focused on demonstrating some of the underlying assumptions that psycholinguistic inquiry brings to cognitive science. One of the goals in this enterprise has been to provide evidence for a particular view of the nature of the psychological processes underlying language comprehension--namely, that the appropriate characterization is one of a modular, largely bottom-up system, that is composed of autonomous subprocesses each operating in an automatized and routinized fashion. Such a view is certainly not unique to psychological theorizing, although the real-time evidence presented here (and elsewhere) may provide somewhat stronger support for this characterization than has previously been possible.

There is a further consideration, however. It is largely (but not solely) in terms of its focus on language as a temporally distributed perceptual process, that the issues and assumptions detailed earlier differ from approaches to (tic question in a number of other fields. I have attempted here to demonstrate the value of tailoring both the theoretical constructs and the experimental techniques used to examine these constructs to the real-time facts of mental processing. Any model that fails to provide an account of the micro-structure of the operations involved in comprehending information in real time will fail to capture much of the essence of the mental structure underlying human language. However, it is precisely on this point that sonic further consideration of the role of psychological evidence in interdisciplinary studies in cognitive science is necessary. It is apparent in the work documented earlier that seemingly small changes in experimental technique can produce evidence supporting diametrically opposed theoretical positions: on-line phoneme monitoring results supported an interactive model of lexical processing, but on-line priming studies supported an autonomous modular view of that same process. To the theorist outside of psycholinguistics who is not familiar with the assumptions underlying the need for gathering real-time processing evidence (or about the sensitivity of various techniques to real-time processes) there is no basis for choice between the two sets of results. Thus, for example, it would he an obvious move for someone holding a "frames" model of language processing to assume that operations within a given "frame" are totally interactive (or, even, that the concept of time-dependent interaction is irrelevant to the theory) and to point to the psychological data from phoneme monitoring as support for such an interactive view. Were it simply that the data are wrong, the problem would he trivial. However, that is obviously not the case. The data simply reflect a level of processing that may be different from the level targeted for analysis with the technique. Thus, the "frames" theorist may be misleading himself by virtue of not recognizing that the data are not

descriptive of the level he believes is being addressed, or, worse, by failing to recognize that the issue of levels is relevant here. Unfortunately, unless those using such data to support inferences are informed as to the nature of the issues motivating real-time analysis, the use of such data will always he inappropriate and, except by pure chance, incorrect. One can find such situations all too often in the literature, often by researchers who have the best of scholarly motives in attempting to examine their own work in the light of evidence from another field. As a simple example from a field outside of language, one can easily find general models of memory in AI that refer to experimental work in psychology as providing support for their position, where that data reflects only a single stage of memorial processing, one that may not he relevant to the level of description at which the AI model is operating. The point is that unless researchers in fields outside of cognitive psychology specify the level of mental processing that constitutes their target of inquiry, and understand the assumptions behind the generation of psychological data they assume supports their position, there cannot be a fruitful interdisciplinary exchange of information involving such evidence.

One might take the pessimistic view here that until we have a performance model detailed in its entirety we cannot accurately make such decisions about levels of analysis in our work-be it interdisciplinary or otherwise. However, I believe that this is an unnecessary constraint to apply. The approaches within the cognitive sciences can fruitfully borrow from each other even without a complete performance model, as long as the assunptions underlying work in each constitute mutually held conditions.

It seems that one of the most useful goals to he shared by the fields comprising cognitive science will be that of attempting to determine the structural and functional (independent) modules underlying mental ability, and the nature of their operation and interaction. In any such enterprise, however, it will he necessary to recognize that mental processes are not undifferentiated with respect to levels of analysis or operation over time. Thus, sensitivity to real-time processing issues-- both theoretically and methodologically seems critical to the growth of cognitive science, and, it seems likely that "language" will continue to provide a major forum for this work.

REFERENCES

Bobrow, S., & Bell, S. On catching onto idiomatic experssions. *Memory & Cognition*, 1973, *1*, 343-346.

Cairns, H. S., & Hsu, L. R. Effect of prior contect upon lexical access during sentence comprehension. A replication and reinterpretation. *Journal of Psycholinguistic Research*, 1979.

Cairns, H. S., & Kamerman, J. Lexical information processing during sentence comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1975, *14*, 170-179.

Cutler, A., & Foss, D. J. *Comprehension of ambiguous sentences: The locus of context effects* Paper presented at the Midwestern Psychological Association, Chicage, May 1974.

Elkind, D., Anagnostopoulou, J., & Malone, S. Determinants of part-whole perception. *Child Development*, 1970, *41*, 391-397.

Forster, K. I. Accessing the mental lexicon. In R. Wales & E. C. T. Walker (Eds.), *New Approaches to language mechanisms*. Amsterdam: North Holland, 1976.

Forster, K. I. Levels of processing and the structure of the language processor. In W. E. Cooper & E. Walker (Eds.), *Sentence processing: Psycholinguistics studies presented to Merrill Garrett*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1979,

Foss, D. J. Some effects of ambiguity upon sentence comprehension: *Journal of Verbal Learning and Verbal Behavior*, 1970, *9*, 699-706.

Foss, D. J., & Jenkins, C. Some effects of context on the comrpehension of ambiguous sentences. *Journal of Verbal Learning and Verbal Behavior*, 1973, *12*, 577-589.

Garrett, M. F. Word and sentence perception. In R. Held, H. W. Liebowitz, & H. L. Teuber (Eds.), *Handbook of sensory physiology*, Vol. VIII: *Perception*. (Berlin: Springer-Verlag, 1978.)

Hogaboam, T. W., & Perfetti, C. A. Lexical ambiguity and sentence comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1975, *14*, 265-274.

Holmes, V. M., Arwas, R., & Garrett, M. F. Prior context and the perception of lexically ambiguous sentences. *Memory & Cognition*, 1977, *5*, 103-110,

Mackay, D. To end ambiguous sentences. *Perception Psychophysics*, 1966, *1*, 426-436.

Meyer, D. E., Schvaneveldt. R. W., & Ruddy, M. G. Loci of contextual effects on visual word recognition. In P. M. A. Rabbit & S. Dornic (Eds.), *Attention and performance V*. London/New York: Academic Press, 1975.

Morton, J. The interaction of information in word recognition. *Psychological Review*, 1969, 60. 329-346.

Neeley, J. Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited copacity attention. *Journal of Experimental Psychology: General*, 1977, *106*, 226-254.

Onifer, W., & Swinney, D. Accessing logical ambiguities during sentence comprehension: Effects of frequence-of-meaning and contextual bias. *Memory & Cognition*, 1981.

Prather, P. *The development of perceptual processing: Organization and representation*. Doctoral dissertation, Tufts University, 1980.

Prather. P., & Swinney. D. *Some effects of syntactic context upon lexical access*. Presented at a meeting of the American Psychological Association, San Francisco, Calif., August 1977.

Swinney, D. Lexical access during sentence ccomprehension: (Re) Consideration of context effects, *Journal of Verbal Learning and Verbal Behavior*, 1979, *18*, 645-659.

Swinney, D. The structure and time-comse of infurnnation interaction during speech comprehension: Lexical segmentation, access, and interpretation. In J. Mehler, S. Franck, E. C. T. Walker, & M. Garrett (Eds.)., *Perspectives on Mental Representation*. Hillsdale, N.J.: Lawrence Erlhaum Associates, 1982.

Swinney, D. Understanding non-literal language: The temporal course of literal and non-literal interpretations. Paper Presented a Psychomanic Society, 1981, Philadelphia, Pa.

Swinney, D., & Cutler, A. The access and processing of idiomatic expressions. *Journal of Verbal Learning and Verbal Behavior*, 1979, *18*, 523-534.

Swinney, D., & Hakes, D. Effects of prior context upon lexical access during sentence comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1976, *15*, 681-689.

Swinney, D., Onifer, W., Prather, P., & Hirshkowitz, M. Semantic facilitation across sensory modalities in the processing of individual words and sentences. *Memory & Cognition*, 1979, *7*, (3). 159- 165.

Tanenhaus, M., Leiman, J., & Seidenberg, M. Evidence for multiple stages in the processing of ambiguous words in syntactic contexts, *Journal of Verbal Learning and Verbal Behavior*, 1979, *18*, 427-440.