Chapter **14**

The Time-Course of Lexical Access and the Role of Context: Converging Evidence from Normal and Aphasic Processing

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PREFACE

The purpose of this chapter is to consolidate existing literature and introduce new evidence from both focal lesion and neurologically unimpaired populations which speak to the behavioral processes and neural substrates involved in lexical access and lexical ambiguity resolution during sentence comprehension. The chapter is dedicated to Edgar Zurif, and in many ways, writing it has brought each of its authors full circle. It was in the very initial years of dealing with issues of context effects, lexical access, and mental modularity in Boston that Edgar exerted his influence on work by the first author concerning the issues inherent in claims of contextually independent mental processes and how such processes might play out in terms of brain organization. His influence in those early years was crucial, conceptually, central, and substantial (not to mention insistent). Soon thereafter, the second author joined Edgar at the Veterans Administration in Boston, and new consideration of the work on "bugs, bugs, bugs" (as the lexical ambiguity issues were referred to in those environs) brought on a resurgence of (re)considerations of the role of lexical processes in agrammatic aphasia. The third author joined this team a few years later. None of the excitement nor effectiveness of the work in either of those eras could have occurred without Edgar's central role. Now, after quite a number of years working in other realms of language processing, we find ourselves

returning to this fertile area of research, with some new localization-of-function evidence which allows a comprehensive and integrated view of the work. It leads, not surprisingly, to the story that Edgar has continually championed throughout his career working with each of the authors. His intuitions, like his research, have always been spot-on. Thus, it is with a sense of deja vu that we present this story and link it, as it belongs, with our most happy associations and collaborations with Edgar.

INTRODUCTION

Investigations of the nature of access to lexical information during sentence comprehension have been a centerpiece or research in the language processing literature since the inception of the field of psycholinguistics. Questions concerning whether such access is fundamentally a form-directed process (or alternatively, whether it is directed from predictions based on world knowledge and/or sentential context), whether it is a serial (or alternatively, parallel) process, and whether it is an exhaustive (or alternatively, delimited) process all form central issues that are still under debate today. The goal of this chapter is to resolve some of the key conflicts in the vast literature on these critical issues. We argue that the key to such resolution lies in the consideration of three fundamental issues.

The first is recognition that lexical access is not a single, uniform process. Like language processing in general, lexical access can be seen to have (some) different properties in (some) different situations. The work in this chapter will focus on one such (albeit major) situation: lexical access as it takes place *during auditory language comprehension,* at normal speaking rates. Such a focus potentially differs, for example, from a focus concerned with how such access might take place in isolated single-word presentation conditions, or two-word contexts, or in reading (to name but a few).

The second issue is methodological. It is the (surprisingly elusive) point that research methodologies (even on-line research methodologies) are not all alike. The literature in this field divides greatly based on the research techniques utilized to examine lexical access. Put simply, some methodologies reveal more about the details of language processing than others, and some interfere and interact with the ongoing process being measured less than others. Only detailed analysis of the manner in which methodologies interact with the process they are intended to reveal will allow an understanding of what part of the evidence derived from each method truly reflects the nature of lexical access as it occurs during auditory language comprehension.

Third, a more thorough understanding of the lexical access can be found by simultaneously considering evidence from both brain-damaged and non-neurologically involved populations. There is a great deal of work on lexical processing which exists largely independently in two separate research domains: evidence from examinations of processing in non-neurologically involved populations, and evidence derived from processing in populations with language disruptive focal lesions-the aphasias. However, with a few notable exceptions, there has been only minimal integration of these literatures. This chapter will compare and contrast relevant evidence from both types of populations, demonstrating a converging, coherent story of lexical processing. In the same vein, this chapter will also examine the role of each of the cerebral hemispheres in lexical processing in both normal and brain-damaged populations.

THE BASIC EVIDENCE

The work we will examine focuses on the access of words with more than one meaning-lexical ambiguities (specifically, homophones). Such words (which have been one of the standard workhorses of the lexical processing literature) allow for separable examination of access and processing of individually addressable interpretations attached to the same word-form (sounds). This allows for precise examination of issues such as "modularity" of access (e.g., Fodor, 1983), form-driven versus meaning-driven access, the role of context in access, and serial versus parallel accounts of access to information associated with words.

Access of information associated with lexical ambiguities during ongoing auditory sentence comprehension has been demonstrated to be an exhaustive process, *ceritus paribus.* An enormous array of evidence has supported the view that in the absence of a biasing context all interpretations of a lexical ambiguity are activated and accessed. Further, and more critically, the same exhaustive activation effect has even been shown to hold in the presence of a strong prior biasing context. Overall then, access of the several meanings of the lexical ambiguity is momentarily achieved independent of world knowledge or prior biasing context. (This last evidence has come from a small set of tasks which have been demonstrated to reflect the access process, but to have minimal interaction with the lexical access process itself; more on this, below.) Moreover, these findings have reliably led to a model which holds that lexical access per se is a form-driven, autonomous, exhaustive process (see, e. g., Love & Swinney, 1996; Onifer & Swinney, 1981; Picoult & Johnson, 1992; Prather & Swinney, 1977; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Simpson,

1981; Swinney, 1979; Swinney & Prather, 1989; Tanenhaus, Leiman, & Seidenberg, 1979, among others). Much of this same literature has demonstrated that a short time after access, only the contextually appropriate meaning of a lexical ambiguity encountered in a sentence remains active, an effect which may take place within 300 ms of initial activation (see, e.g., Swinney, 1979; Onifer & Swinney, 1981.) Thus, encountering the phonetic form of a word during ongoing auditory sentence comprehension appears to result in the immediate access to (and activation of) all meanings for that word. And, prior-occurring context has an effect only on the results of this access, acting to very rapidly determine the "appropriate" interpretation of the ambiguity from among the many activated.

This evidence stands in strong contrast to claims that lexical access is a contextually conditioned, predictive, highly interactive, process. Such claims (e.g., Liu, Bates, Powell, & Wulfeck, 1997; Tabossi, 1988) have resulted from several entangled lines of argument and data. We mention three here. First has been the confusion over claims concerning modularity of lexical access; some interactionist proponents have implied that evidence upholding modularity is, effectively a denial of context effects on lexical processing. That, of course, is hyperbole-no one questions the fact that context has an effect on lexical processing. Rather, the issue is *when* and *where* such contextual effects take place during ongoing processing. (The answer to that question appears to be, based on the best empirical evidence, only following access but not before it.) Thus, while context may not be used predictively in lexical access, it does have an effect on the processing of information, once accessed. Second, the claim has also been made that modularity makes no sense due to the fact that efferent fibers run from "higher" cortical areas to "lower" areas providing a built-in neural basis for top-down control. However, two issues make this fact irrelevant to questions of mental modularity re lexical access. First, we have little enough evidence about the neurological organization of language in the broadest form, much less the neurological organization of word access. And, we certainly have no evidence that there is hard wiring from centers of higher-order knowledge (or whatever organization is desired to describe such neurological representation) to lexical access (not do we have evidence that. even were such wiring present, that it might control/direct such access). More crucially, of course, this argument simply misses the essential distinction between claims of modularity of mind and modularity of brain. The claims and evidence about the autonomy of lexical access are concerned with functional facts-with modularity of mind-which, independently of any issue of afferent and efferent connections, is concerned with what is functionally used during access. Put more succinctly, even if it could be shown

that there were such efferent connections between representations of higher order knowledge and lexical access, and that such connections could in principle be used to control the latter, whether they actually were used to "control" or direct access is an issue for functional, behavioral research only-it cannot be established any other way. Therefore, it is only an issue resolvable via behavioral evidence, however difficult that is to obtain. Which brings us to the third issue-data purporting to demonstrate interactivity of prior context and lexical access. This data tends to come from two types of studies-those involving processing of isolated lexical items (or pairs of items) and a few studies involving the processing of words in sentences. The first of these will not be discussed in this chapter, as the processing of isolated (or paired, etc.) lexical items involves considerations of a wide range of issues that are unrelated to lexical processing in sentences. However, in both cases (and particularly those involving sentences), careful consideration of the methodologies involved in these studies mandates the rejection of these data as relevant to the basic question. Thus, it is necessary to have a methodological discussion before we proceed further.

Methodological Considerations

Fundamentally, examination of the question of precisely when and where context has its effects on lexical processing requires a methodology that is both temporally fine grained and sensitive to unconscious perceptual processes (yet, does not interact with them). This means, first, that only "on-line" methodologies are capable of distinguishing between competing theories of lexical access. The "on line-off line" distinction represents a continuum of techniques, where on-line refers to measures of processing that are employed during on-going processing. It should be noted that the concept on-line is often inappropriately conflated with some of the empirical methods used to measure on-line processing, such as "reaction time" or even "fast reaction time"; on-line refers to a well-defined match of (not only temporal, but other) critical parameters of the comprehension-process-of-interest to a particular technique. Speed of response alone is absolutely no guarantee that the task will capture any of the critical on-line processing information that is being investigated (see, e.g., discussion of Liu et al. 1997, below).

What is requisite in any examination of comprehension is finding the best match of the technique to the question under investigation. In that regard there are at least three separate (but often interacting) issues to be concerned with: (1) sensitivity of the task to the process of interest, (2) ability of task to reflect the process-of-interest *independently* of other

comprehension (or task) processes, and (3) timing of task as applied to (relative to) the time-course of the process-of-interest. We discuss each of these in turn.

Task sensitivity

First, there is the issue of whether any given task actually reflects (is sensitive to) the process under exploration. For example, using an on-line sentence grammaticality judgement task ("Is it a 'good' sentence in English?") may not be sensitive to experimentally induced perturbations in lexical access, although it may reflect other aspects of comprehension, such as the difficulty of integration of a lexical item into a sentence. Consider another example, the case of dual process interference tasks, such as phoneme monitoring (Foss, 1998), word monitoring (Foss, Starkey, & Bias, 1978), cross-modal lexical decision (Shapiro, Zurif, & Grimshaw, 1987), or Stroop technique (Stroop, 1935) tasks. These tasks all share the assumption of a "central processing bottleneck"; when subjects are both processing sentences and doing the secondary task (e.g., monitoring for a word), any increase in processing load in the former will be reflected in slowed - reaction times in the second (caused by interference). These tasks are quite valuable as on-line reflections of processing *when* an interference/ processing load effect is found. A problem occurs, however, when no increased load "effect" is found. It may be that there is simply no effect to be found, or it may be that the particular interference task utilized is simply *intensive* to the *level* of processing load actually present. It might be, for example, that the processing load increase caused by some variable is small and does not create sufficient interference to be reflected in a secondary "load" task. Or, it may be that the task load caused by (for example) phoneme monitoring is simply interfering with a response decision at a level of processing which is not involved in the level of processing being examined (e.g., inferencing at a discourse level). Unfortunately, it is very difficult to determine which of the various possibilities is actually true. In all, this first issue of task sensitivity can be an extremely difficult one to verify and establish (and, sadly, such effort is often omitted entirely), and yet it may be the easiest of the three concerns we have raised to meet adequately.

Task independence

Far more difficult to deal with is the second issue, which is concerned with how uniquely a task reflects *only* the subprocess of interest, and not *that subprocess along with several other processes* involved in comprehension. A large number of tasks are sensitive to several putative levels of processing, and, if these tasks are to be used effectively it is critical both to know

precisely which levels the task is sensitive to, and to factor out those levels that are not of interest. Unfortunately, this too can be extremely difficult. Take, for example, the task of "lexical-repetition-during-sentence-comprehension," which has been taken by some investigators to be a measure of lexical activation and access (e.g., Liu et al., 1997). The mechanics of this task are as follows: First, subjects hear a stimulus sentence presented auditorily. At some point during the sentence a key word in the sentence is spoken in a voice (male/female) different from that of the rest of the sentence. Hearing this "difference voice" is the cue for a subject to repeat this word out loud (this "key" word is standardly the last word in the sentence or phrase which is heard; reaction time to repeat the word is measured, beginning with the onset of the key word). Resulting reaction times are often taken by researchers as a measure of lexical access alone. However, this task, while it involves aspects of lexical access, also standardly reflects the time taken to integrate the word into the prior sentential material. That is, the time to "consciously hear and repeat" the word spoken in the "other" voice not only includes the time involved in preparing the word to be produced (and perhaps, reaccessing aspects of the word for such production), but also the time involved in understanding the word in light of the sentential context in which it is being comprehended. Unfortunately, the two factors of access and integration are totally intertwined in their effect on response reaction time. This task is essentially identical to the class of tasks in psycholinguistics which can be termed "sentence continuation" (or sentence interruption) tasks, tasks which are standardly used to study the effect of integration of material into sentential contexts. These tasks are commonly used to demonstrate ease or difficulty of integrating lexical elements with certain types of characteristics into the prior sentential material (e.g., Ahrens & Swinney, 1995; Tyler & Marslen-Wilson, 1977, 1982; Wright & Garrett, 1984), and, in fact, have been shown to be quite sensitive to such "ease of integration" effects.

In general, there are at least two major, but related, types of confounds involved in sorting out the answer to any concern over whether a particular task reflects *only* the process of interest: *specificity confounds* and *task-induced confounds*. The above discussion of the "lexical repetition" task demonstrates an example of a specificity confound- the operating characteristics of the task cannot be isolated to the single process of interest (here, lexical access); the task necessarily reflects other processes in its operation. The other type of counfound, *task-induced confounds* distribute themselves into several subclasses. One such class (the only one we will discuss here), can be termed metalinguistic confounds. These are confounds introduced when a task requires conscious reflection on a typical

unconscious ongoing process (such as normal sentence comprehension). One example is the "gating" task (in which a subject is required to "guess" which words are still possible candidates from an auditory partial-word fragment, thus putatively providing a "uniqueness point" for word recognition (Grosjean, 1980). While this task most certainly does provide a consciously determinable uniqueness point, such a point may not relate in any direct way to lexical identification/access involved in standard fluent language comprehension, where conscious introspection concerning words is at a minimum. "Word-by-word reading" is another such task. The single-word-by-single-word aspect of the sentence presentation leads many subjects to treat each word as if it were the final one in the sentence (particularly in judgement/ monitoring versions), hence encouraging "early closure" of sentences (for discussion, see, e. g., Ferreira, & Henderson, 1990). Thus, many uses of this technique force (encourage) conscious resolution of the sentence before the end of the sentence may occur (at each possible ending point). Examples of these types abound; the solution is to find, where possible, tasks that do not encourage such (metalinguistic or other) intrusions into the normal comprehension process.

Task timing

The third issue is that of the *timing* of the occurrence of the task in relation to the time-course of the process of interest. Most sentential processes are temporally evanescent. Reflecting such rapidly fading, brief, subtle, and momentary processing events is difficult for any task. Clearly, however, to be maximally useful, such a task must be one that can be equally applied at *any point during* sentence processing (i.e., not just at certain points-such as only after words, or at the beginning or ends of clauses, etc.). Rather than focusing on tasks that do not meet this criteria, we will focus on some tasks that best accomplish the needed timing and flexibility, while also not producing the problems associated with the first two issues raised above.

The set of such tasks is a small one, involving both electrophysiological and reaction time techniques. Electrophysiological techniques such as event-related brain potentials (ERP) or MEG have the virtue of being continuous-recording tasks (they can be gathered throughout the entire time-course of the sentence/discourse being examined). Such techniques hold the promise of ultimately becoming one of *the* methods of choice for real-time eamination of language processing at some point in the future. Currently, however, with few exceptions, ERP examinations of language involve visual word-by-word presentation (reading) of language stimuli-typically with 500 ms or more occurring between successive words. This

slow presentation changes the nature of the comprehension process (see task induced confounds, above) and does not reflect the form of language processing we will consider here (auditory comprehension; the nature of how reading related to auditory comprehension is still far from determined). Among reaction-time based behavioral techniques, one of the most temporally flexible and temporally relevant behavioral methods currently is use is cross-modal lexical priming. In what follows, we will briefly focus on how this task works, and on both appropriate and inappropriate uses of the task in measuring language processes.

Cross-modal priming techniques

While many on-line behavioral methodologies each have revealed important properties of language processing, cross-modal lexical priming (CMLP; Swinney, Onifer, Prather, & Hirshkowitz, 1979) has proven to be a particularly illuminative and sensitive measure of moment-by-moment sentence processing. CMLP comes in many varieties, but all involve the following conditions and properties: First, the sentential material under study is presented *auditorily* to subjects, who are told that their major job is to understand the sentence(s) or discourse they hear. (Subjects are standardly tested for comprehension throughout the experiment-to keep attention to the task of comprehension.) Second, subjects are told they have another task to perform: at some point while they are listening to the sentence(s) a visual item will appear on a screen in front of them and they will have to make a decision about that visual item. This visual item may be a letter string (to which subjects may be required to make a lexical decision, or a classifying decision, or a "naming" response) or it may be a picture (again to which some type of classifying response is made, such as "animal/nonanimal"). Work has shown that most two-choice classification responses work quite well in obtaining basic effects with this task.

Several aspects of this technique require specific mention: First, presentation of the auditory sentence is always continued throughout and beyond presentation of the visual item (and on to the end of the sentence). That is, the sentence is never ended with the visual probe; this prevents the probe from being integrated into the ongoing sentential material (provided, of course, that the sentential material is presented normally-see, e.g., Nicol, Swinney, Love, & Hald, 1997). Second, this "secondary" task never involves metalinguistic judgments about the sentential material (such as, "Was this word in the sentence?"). Third, at least up to the point of the visual target presentation, processing of the sentence is uninterrupted and "normal." In this regard, the task differs considerably from many other on-line techniques that require subjects to

evaluate each word in a sentence as it appears, or to hold a target in mind while the sentence is being processed. Thus, this task is one of the least intrusive behavioral techniques we have for the on-line examination of the normal comprehension process. There is, of course, a planned relation between the two tasks the subject performs (auditory sentence comprehension and visual target classification) in CMLP. On experimental trials, the visual target is associatively semantically related to a critical word (or phrase) in the, sentence. Following the principle of automatic semantic priming, occurrence of an auditory word (the prime) in the sentence just prior to processing of another item (the visual target word) that is associatively related to that auditory word results in speeded processing/classification of the target, a result that is generally known as priming (see, e.g., Meyer, Schvaneveldt, & Ruddy, 1974; Neely, 1991). The CMLP task uses the fact that such priming occurs to provide an indication of WHEN critical words in the sentence are active during processing. Thus, if a visual target is "primed" when presented at a certain point in the sentence, this is taken as evidence that, at that point, the meaning of the relevant (associatively related) word in the sentence is active. The fact that such priming has been demonstrated for interpretations of a lexical ambiguity (even following strong biasing context) has been the prime evidence of autonomous lexical access during sentence comprehension.[1] With the critically fundamental considerations of methodology now on the table, we return to the basic facts of lexical access during ongoing sentence comprehension.

[1] There is one additional methodological issue that deserves airing, even though not directly relevant to the issue of lexical ambiguity, and that relates to the difference between the use of CMLP in *interrupted versus noninterrupted sentential presentation procedures.* Following publication of a large array of CMLP studies demonstrating reactivation of "fronted" direct object NPs following the matrix verb in object-relative constructions (see e.g., Swinney, Ford, Frauenfelder, & Bresnan, 1987, as reported in Nicol & Swinney, 1989: Hickok, Canseco-Gonzalez, Zurif, & Grimshaw, 1992; Love & Swinney, 1996; Nagel, Shapiro, & Nawy, 1994; Nicol & Pickering,1993; Swinney, Zurif, Prather, & Love, 1996, among others), McKoon and Ratcliff (1994) raised a particular objection to these findings. A model of priming effects supported by McKoon and Ratcliff-the compound cue model of priming (see, e.g., Ratcliff & McKoon, 1988)-has no principled mechanism to allow for priming during sentence processing when an overt-prime is not present. Hence the findings of reactivation as generated by structural processes was quite disturbing to this general approach. McKoon and Ratcliff took as a point of attack the materials in the first paper demonstrating such reactivation (research by Ford, Frauenfelder Bresnan, & Swinney, which motivated much of the later work-see, Swinney et al., 1987). They pointed out that there was a possible confound between the experimental and control probes used by Swinney et al., such that reaction time to the experimental probes may have been faster than that for the control probes not because of priming at the "empty" postverb position, but because the experimental probes

"fit" more easily into the ongoing sentence than did the control probes at that point. They then attempted to demonstrate experimentally that this potential confound could cause the incongruity reaction time (RT) effect they predicted. In this they used a subset of the sentences and target items originally employed by Swinney et al. (1987), altering the sentences so that the filler NP appeared *after* the probe point, as in the following example (compare to object-relative example, above): "The crowd at the party accused the boy." Here, what had been the head of the relative clause ("the boy") now appears after the verb, and the sentence no longer contains a filler-gap relation.

Now the critical point relevant to methodological concerns: McKoon and Ratcliff (1994), in attempting to replicate the "potential confound" in the Swinney et al. (1987) work, CHANGED THE TASK from the cross-modal lexical priming (CMLP) task used by Swinney et al. to a word-by-word visual presentation format study. In the latter, subjects see (rather than hear, as in CMLP) sentences presented visually, word by word, so that each new word in the sentence overwrites the preceding word. Further, in this task, target words also appear visually, offset to the right of the sentence presentation area, marked with asterisks, at one of two positions: immediately before and immediately after the verb. The targets, were either a semantic associate of the direct object (e.g., "girl") or a matched nonassociate (e.g., "body"). McKoon and Ratcliff found speeded response times to "girl" (relative to the control) after the verb "accused," but the reverse pattern before it. Their interpretation of this finding was that after the verb, the set of "related" target items (here "girl") simply fit better into the ongoing sentence than the controls. They then concluded (again, from results obtained with an entirely different task) that that the findings from the fluent, continuous-sentence presentation format of auditory CMLP were due to these differences in "congruence of the targets with the sentences."

The question is, of course, can such generalizations across sentence-presentation formats be validly made? First, however, we wish to interject at least a couple of points about the operation of CMLP. For one thing there has long been evidence, based on extensive experience with the CMLP task, that the visually presented probes are *not* typically integrated into the ongoing auditory sentence (and hence that the "fit" of visual targets with the sentence is not a factor with CMLP, when used standardly). This assumption has been backed by evidence, the major piece of which will be described immediately below. A second point is that the basic finding of Swinney et al. (1987) on gap-filling has been replicated a number of times with the CMLP Technique in studies that do *not* contain the potential confound of "probe fit" pointed to by McKoon and Ratcliff (1994). Most recently, for example, Love and Swinney (1996), in a study which used relative-clause constructions, explicitly controlled for equivalence of "fit" or "integratability" into the auditory sentence of both related and unrelated targets; their findings fully replicated (and extended) the earlier findings obtained by Swinney et al. (1987; reported in Nicol & Swinney, 1989). Thus, it is important to make clear at the outset that the effect demonstrating "reactivation" of fillers at gap sites with the CMLP technique is secure and replicable, *independent* of any *potential* confound in the original Swinney et al., 1987 materials, and the speculations by McKoon & Ratcliff, 1994).

To explore the question of whether inferences about sentence processing and methodology can be validly transferred across two very different types of sentence-presentation formats, Nicol et al. (1997) performed an experiment aimed precisely at comparing effects revealed by CMLP to those discoverable via the unimodal visual sentence interruption technique employed by McKoon and Ratcliff (1994). The particular focus here is on a technique in which subjects are presented with a fluent, uninterrupted, auditory sentence, and also make a judgment about a visually presented target word which appears *concurrently* with

some portion of the auditory sentence (but before the end of that sentence), as compared to a technique in which the sentence is presented (visually) in such a fashion that the visually presented target interrupts the ongoing flow of the sentence being comprehended. The focal question was, will the targets integrate into the ongoing sentence in either case?, thus potentially distorting findings obtained with a priming task under either mode of sentence presentation (via differential responses to "good fit" targets compared with "bad fit" targets).

For this study, identical materials were created for use in two separate methodologies: (1), the CMLP continuous (uninterrupted) auditory sentence presentation approach and (2) the unimodal visual probe-sentence interruption paradigm employed by McKoon and Ratcliff (1994). Sentences were of the following structure: noun phrase, prepositional phrase, verb, noun phrase, prepositional phrase; as in example (1), below (probe/target point is indicated with an asterisk). Each (pair of) sentence(s) was paired with two target words, one of which was (and the other was not) "congruent" with the sentence fragment (although neither target was meant to be predictable from the prior context; congruence was tested in continuation-judgement prestudies). Members of each target pair were matched in length and frequency, and, most importantly, a priori lexical decision times (taken from a lexical decision test performed on the words presented in isolation) as well as for length and frequency. Thus, the word *apple* is more congruent with the sentence fragment than the word *agony* on the grounds that an apple may be pushed, but agony cannot.

(1) *The cat at our house pushed * the old soccer ball from the neighbor's roof.*
Congruent target: APPLE
Incongruent target: AGONY

In addition, the target words were paired with a second sentence which provided a matched-sentence control case. As can be seen, the incongruent target for sentence (1) is the congruent target in sentence (2).

(2) *The mother with the pony instilled * great happiness in her young daughter.*
Congruent target: AGONY
Incongruent target: APPLE

These materials were then presented to (different groups of) subjects under each of the two different sentence-presentation techniques. The data were unequivocal: In the unimodal sentence-interruption paradigm, there was *significant priming* for congruent targets compared to incongruent targets, fully replicating McKoon and Ratcliff (1994). However, in the CMLP study there was NO *priming* for congruent versus incongruent targets.

The CMLP results contrast sharply with those of the McKoon and Ratcliff (1994) task. The utter lack of a congruence effect in CMLP argues that the cross-modal continuous-sentence presentation, at least when used with normal fluent speech, effectively prevents integration and intrusion of visually presented target words.

The morals of this last set of methodological issues is clear. First, one cannot make assumptions about the mechanics of any one task based on data or properties of performance from another task. And, relatedly, McKoon & Ratcliff (1994) are simply wrong about their assumptions that priming in CMLP (when used normally, of course) is affected by congruence of the target words with the sentence; hence their model of priming is also likely wrong (or at least highly insufficient)-structural processing can cause priming without an overt NP present. Second, fluent, uninterruptable presentation of sentential material is crucial to the study of comprehension, as it resists intrusion of extraneous material (including visual targets) into the ongoing comprehension process. Finally, CMLP is extremely flexible, with reliable tasks, and is among the most sensitive measures of on-line sentence processing in the comprehension task inventory.

LEXICAL ACCESS AND CONTEXT EFFECTS: EVIDENCE FROM NEUROLOGICALLY INVOLVED AND NON-NEUROLOGICALLY INVOLVED POPULATIONS

Lexical Processing in Nonimpaired Populations

As stated earlier, an abundance of evidence from real-time processing studies of lexical ambiguities has demonstrated that access to the surface (phonetic) form of lexical ambiguities results in the immediate activation of all meanings for that word. These finding have been used to support the view that the initial access of meanings for lexical ambiguities in sentences involves modular, exhaustive, context-independent, encapsulated processing (e.g., Swinney, 1991). This phonetic, form-driven access provides a tool that allows us to gain leverage in questioning the underlying neural substrates of this level of language processing.

However, before turning to that evidence, we will briefly review a small portion of a comprehensive study which used lexical ambiguities as antecedent fillers in object-relative constructions, a study which will allow us to examine more details of the time-course of activation of the several meanings of an ambiguous word in biasing contexts than has previously been available in the literature (Love and Swinney, 1996). In this study, participants (non-neurologically involved college students) heard sentences such as:

The professor insisted that the exam be completed in ink, so Jimmy used the new pen" that his mother-in-law ^{*2} recently purchased ^{*3} because the multiple colors allowed for more creativity.

Strong biasing contexts in these sentences were created according to criteria used by Tabossi (1988). In this study priming for each of two meanings of the antecedent filler "pen" (i.e., "pencil" and "jail") was examined at the offset of the ambiguous word via a CMLP technique. The results demonstrated significant priming for words related to both the primary (most frequent-"pencil") and the secondary (less frequent "jail") meanings immediately following initial occurrence of the ambiguity in the sentence ($*^1$). This study thus replicated a long established finding of context-independent, exhaustive access for lexical ambiguities, thus reiterating evidence supporting a model of lexical access as a modular, autonomous, and encapsulated process. At the second test (point ($*^2$), only visual target words related to the contextually relevant interpretation of the ambiguity (pencil) were found to be primed, as was the case at test point ($*^3$). Thus, context has a rapid effect in choosing the appropriate interpretation of the meaning of the ambiguous word, and that is maintained

(and perhaps reactived) later in sentence processing. This pattern of exhaustive, form-driven access has also been demonstrated in pre-school-age children (Swinney and Prather, 1989; Love, Swinney, Bagdasaryan, & Prather, 1999), in studies involving cross-modal picture priming (the children tested were too young to make lexical decisions). Children as young as 3 years, 11 months demonstrate context-independent access for lexically ambiguous words.

Lexical Processing in Brain-Injured Populations

Work with focal lesion populations has provided an interesting and critical addition to the literature on lexical processing. This arena of research provides a vehicle via which certain aspects of intricately entwined cognitive subsystems can be disentangled. In one study that is central to the issues of this chapter, an attempt to examine the role of lexical processing in the disorder known as Broca's (agrammatic) aphasia, and in an attempt to discern the role of neural substrate(s) underlying Broca's aphasia, work studying the effects of semantic context on lexical access in nonfluent agrammatic (Broca's) and fluent aphasic (Wernicke's) patients was undertaken by Swinney, Zurif, and Nicol (1989). They presented agrammatic aphasics, fluent aphasics and nonimpaired control subjects with sentences biased toward the primary interpretation of a (already inherently biased) lexical ambiguity (e.g., SCALE: where the interpretation of "WEIGHT" is given 75% of the time in the absence of context). In replication of past findings, the nonimpaired control population demonstrated exhaustive access for both meanings of the ambiguous word (via CMLP priming) regardless of sentential bias. The fluent aphasic population also displayed the same pattern of effects (contextually independent access, as inferred from priming for visual target words related to each meaning of the ambiguity). In contrast to these two populations however, the agrammatic aphasics demonstrated a very different pattern of results: only the primary, most frequent interpretation of the ambiguous word was found to be primed immediately after the word was heard in a sentence. This result led to the conclusion that only the most frequent interpretation of ambiguous words is immediately available to Broca's aphasics, with other lexical meanings only available following a more temporally protracted (slower-than-normal "rise time") period.

Prather, Zurif, Love, and Brownell (1997) further examined the "slowed activation" hypothesis in Broca's and Wernicke's aphasia by studying the time course of lexical activation in two patients. Using a list-priming paradigm, temporal delays between successive words were manipulated-ranging from 300 to 2100 ms. In contrast to elderly subjects, who prime at relatively short interstimulus intervals (ISIs) beginning at 500 ms, the

Broca's aphasic subject showed reliable *automatic* priming *only* at a long ISI of 1500 ms. That is, this subject retained the ability to access lexical information automatically if allowed sufficient time to do so, a finding that may help explain disrupted comprehension of normally rapid conversational speech.

In further support of the notion of slowed access to (some aspects of) word meanings following damage to Broca's area, Swaab, Brown, and Hagoort (1997) studied whether spoken sentence comprehension deficits in Broca's aphasics result from their inability to access the subordinate meaning of ambiguous words or from a delay in their selection of the contextually appropriate meaning. They employed an ERP methodology. Broca's aphasics and unimpaired control subjects were asked to actively listen to the sentences presented auditorily. The status of "activation" of a sentence-final ambiguous word was inferred from the amplitude of the N400 to the targets at two interstimulus intervals (ISIs)- short and long. The ERP evidence demonstrated that Broca's aphasics, in contrast to elderly controls, were not successful at selecting the appropriate meaning of the ambiguity in the short ISI condition. But at the long ISI, the patients were able to successfully complete the contextual selection process.

Thus, overall, it appears that the (left-hemisphere) neural substrate underlying Broca's aphasia (Broca's area) is involved in the ability to have rapid/immediate access of multiple interpretations of a word and the resolution of those interpretations to a single meaning; damage to that cortical area appears to damage both the ability to initially have all interpretations of a word under consideration (only the most frequent appears to be in play initially) and to integrate context into consideration of the appropriate interpretation of an ambiguous word.

DIFFERENTIAL CEREBRAL HEMISPHERIC CONTRIBUTIONS TO LEXICAL ACCESS (AND CONTEXT EFFECTS)

Over the past few years there has been work on the role of the individual (independent) contributions of the left (LH) and right (RH) cerebral hemispheres in non-neurologically involved individuals to lexical processing, work which fits interestingly with the work on aphasia, as presented above. For instance, in studies of visual (isolated) word processing, Burgess and Simpson (1988) demonstrated, via a visual hemiretinal priming paradigm,[2] that the LH provides activation of multiple interpretations (primary and

[2] In this, ambiguous words are presented foveally, and visual targets associated to one or another meaning of the ambiguity are presented in only one or the other visual field (thus limiting each hemisphere's access to the information).

secondary meanings) of ambiguous words immediately on *viewing* the word. However, by 750 ms later, only the primary (more frequent) interpretation of the ambiguity is actively maintained (can be primed). In contrast, the RH appears to initially only have access to the more frequent interpretation of an ambiguous word, and "exhaustive" availability of both meanings of an ambiguous word (as measured via priming) are only found at longer temporal delays (750 ms) in the RH. Thus, from this visual, isolated word study, it would appear that the LH is involved in initially accessing all interpretations of lexical entry, and this same hemisphere also has the capacity to select and maintain activation for the most contextually relevant meaning of such words. In contrast, the RH appears to have the capacity to slowly develop and maintain activation for ancillary semantic information (e.g., secondary meanings) for words (see also Faust & Chiarello, 1998). A number of related papers tend to support this view of the role of the individual hemispheres in lexical processing. For example, Tompkins, Baumgaertner, Lehman, and Fossett (1997) conducted a study with RH damaged (RHD) individuals involving auditorily presented sentences with sentence-final lexical ambiguities. In this, an interference task involving presentation of visual targets I s after the end of the sentence was used. It was found that the RHD individuals (as opposed to nonimpaired control subjects) demonstrated difficulty in suppressing the contextually inappropriate meaning of the ambiguities. The authors argue that this lends support to the role of the right hemisphere in maintaining alternate (secondary) interpretations. Similarly, in a study involving non-brain-damaged subjects, Faust and Chiarello (1998) investigated hemisphere asymmetries in resolving lexical ambiguity within a sentence context. Sentences containing sentence-final ambiguous words (biased toward a single meaning) were presented, followed by a hemifield lateralized target word which was related to either the contextually relevant or contextually incongruent meaning of the ambiguous word. Right-visual-field-presented contextually congruent targets were facilitated, while RVF incongruent targets were not. In contrast, in the left visual field both congruent and noncongruent targets were facilitated, regardless of sentence context. This suggests that selecting the contextually appropriate word meaning requires the left hemisphere, and supports a right hemisphere role in maintaining alternate word senses. In a final related study, Titone (1998) also used an end-of-sentence-ambiguity hemifield-target paradigm and found evidence consistent with differential sensitivity to semantic relationships in the cerebral hemispheres. All of the above studies, however, employed end-of-sentence ambiguity targets, something that has been called into question due to end-of-sentence ambiguity targets, something that has been called into question due to end-of-sentence wrap-up effects in other studies of sentence processing (see, e.g., Balogh et al., 1998).

Hickok, Swinney, Bouck, and Hald (1998) conducted a study with 66 native English right-handers exploring the hemisphere asymmetries found in lexical ambiguity resolution by utilizing a CMLP experiment with divided field presentations. This study employed ambiguous words which were embedded *within* (not at the end of) a contextually biased auditorily presented sentence. Visual lexical decision targets related to the primary and secondary meanings of the ambiguity were presented to either the LH or RH only. Preliminary analysis of data from this study demonstrates clearly that priming for both interpretations of a lexical ambiguity is initially available in the LH, but only that for the contextually relevant interpretation is immediately available in the RH. With a short temporal delay, the LH shows priming ONLY for the contextually relevant interpretation, while the RH demonstrates priming for BOTH interpretations. This overall body of work thus supports a story that integrates well with data reported for both neurologically impaired lexical processing and normal sentence processing.

AN INTEGRATED VIEW OF LEXICAL ACCESS AND CONTEXT EFFECTS: CONVERGING EVIDENCE FROM NORMAL AND APHASIC POPULATIONS

The overall story that emerges is one in which the left and right hemispheres work *together* to produce the findings that have been gathered from the focal lesion literature and the general language-processing literature. The left hemisphere's role appears to be one that underlies initial form-driven exhaustive lexical access and rapid contextual postaccess choice during ongoing sentence comprehension. In this hemisphere, immediately on encountering an ambiguity, there is exhaustive access of all meanings of the ambiguity. Broca's aphasic patients, who have damage to a particular portion of the left hemisphere, do not demonstrate such immediate exhaustive access. Thus, it follows that anterior regions of the frontal lobe (Broca's area) appear to be responsible for the exhaustive, form-driven, fast-acting aspect of lexical access demonstrated in studies of normal processing involving lexical ambiguities. When this area is damaged, individuals (Broca's aphasic's) must rely on lexical activation from the RH, which, as shown by the CMLP hemifield studies, initially results in activation of only a single interpretation of an ambiguity. Other meanings of the ambiguity are made available in this hemisphere only with a considerable time delay-thus accounting for the apparent "slow rise time" of secondary meanings found for ambiguities in Broca's aphasics. This same LH area also appears critical for the ultimate selection of a single interpretation of the ambiguity to be used in later processing during

normal fluent sentence comprehension. (This is evidenced in the hemifield studies by the finding of priming for only a single contextually relevant interpretation of an ambiguity following a short delay.) The right hemisphere displays the opposite pattern of access/activation effects (only the contextually relevant meaning is active immediately, whereas at a delayed point in processing, all meanings of the ambiguity are active). However, this effect is not reflected in processing displayed in standard on-line studies of normal sentence processing. Thus, it appears that the right hemisphere, while active, has no critical contribution to first-pass analysis of language in STANDARD language processing conditions in non-brain-damaged individuals (although it appears to be critical to Broca's aphasics processing). Note in all of this that the fluent (Wernicke's) aphasics' processing is similar to that of non-neurologically involved subjects. Thus, it is specifically the anterior portions of the left hemisphere (Broca's area) that subserves the exhaustive, fast-acting process of lexical access found in normal processing. And, the fact that damage to this area results in lexical processing that demonstrates slowed access to secondary interpretations suggests that important aspects of Broca's (agrammatic) aphasics' processing relies on more "temporally forgiving" routines involved at a discourse level, and fits well with the evidence of reliance on right-hemisphere (lexical and other) processing in these patients. Just as Edgar would have it (see, e.g., Zurif and Swinney, 1994).

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