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Charting the Time-Course of Language Processing

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One key issue that we will surely continue to grapple with early in the next millennium is how language processing unfolds over *time.* This issue relates to several others, including (a) the type of information used during various temporal points, (b) the tasks used to assess time-sensitive processing, and (c) the functional architecture of the language processing system. In terms of (a)—information types—there are accounts that have claimed distinct processing routines geared toward different types of linguistic and nonlinguistic information. This hypothesis has proven quite fruitful. For example, lexical information appears to come into play quite early during the processing stream and initially ignores other information (e.g., Onifer & Swinney, 1981; Swinney, 1979), while discourse information may have a later-appearing time-course (e.g., Fodor, Ni, Crain, & Shankweiler, 1997; Swinney & Osterhout, 1990). There is also evidence that structural-syntactic information may have distinct temporal manifestations from other types of information (e.g., Fodor et al., 1997; Frazier & Clifton, 1996). Yet, this separability has been questioned recently by a series of investigations claiming that syntactic parsing is simply a matter of concatenated lexical processing (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994). Certainly one of the goals of psycholinguistic work early in the next millennium will continue to be whether distinct levels of representation are a convenient heuristic for examining language processing, or whether such a separability has in fact been a hindrance to the progression of the field.

Regarding (b)—the tasks used to assess time-sensitive processing—we continue to argue about the time-course of language processing without seriously considering how our tasks impinge on our observed results and their interpretation. The term ‘‘on-line’’ has been used to differentiate earlier,

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time-sensitive processing from later, ''off-line'' conscious processing. Yet, the range of such on-line tasks is broad: for example, word-by-word reading and eye-tracking, cross-modal lexical priming and decision, evoked potentials, and word monitoring have all been used to make distinct claims about the nature of language processing. Few of us have seriously examined how our ''on-line'' tasks measure up to one another. Thus it has been difficult to compare studies using distinct techniques. Another goal for early in the millennium, then, should be to take a serious look at each of our experimental tasks, and at least to examine how they compare to one another using similar linguistic materials.

Perhaps the greatest change we can expect in psycholinguistics regards (c)—investigating the functional and neurological architecture of the language processing system. For a greater part of the twentieth century we have relied on lesion studies to examine how language might be instantiated neurologically. With the millennium should come continuing advances in neuroimaging techniques, for example, fMRI and evoked potentials. So far, though, it appears that much of the lesion data examining language has been substantiated with the early use of these techniques (see, for example, Grodzinsky, in press).

We have recently completed three studies that have begun to address these issues. These studies take the different information types seriously and examine their interaction. In Borsky, Shapiro, and Tuller (1999) we investigated how semantic context influences the perception of a phonemic-lexical contrast (''goat/''coat'') that involves local acoustic information (voice onset time). We found different patterns depending on the experimental task used. With word monitoring we found that sentence context immediately influences perception; word monitoring times increased when context and acoustic information were incompatible. Using cross-modal interference we observed immediate effects of the acoustic manipulation but delayed effects of sentence context. Taking the fact that word-monitoring involves an explicit conscious decision about the ongoing sentence and the fact that CMI does not require such conscious reflection, these results were interpreted as evidence for initially context-independent phonological processing followed by rapid contextual integration. In a set of experiments examining the time-course of activating exemplars of basic category terms, Raczaszek, Shapiro, Tuller, and Kelso (1999) found that both atypical and typical exemplars are activated immediately, even in biasing contexts. Between 300 and 450 ms downstream from the basic category term, sentence context intervenes and ''selects'' the context-appropriate candidate. The time-course of lexical activation also appears to be nonlinear; there is an abrupt shift that indicates that the category structure has been reorganized under contextual influences. Finally, we (Shapiro, Hestvik, Garcia, & Oster, 1998) recently completed a series of experiments examining how inherent semantic properties of verbs influence the time-course of structural processing Using complex VP-ellipsis

constructions, we found that semantic properties are ignored initially, and that only later during the temporal unfolding of the sentence do lexical constraints influence processing.

Thus, these studies investigating phonetic to lexical to structural processing have found that probabilistic and semantic contextual information appears to be initially ignored; it is only after-the-fact that such information constrains final interpretation. Separate information types appear to be processed distinctly, and that different tasks (unsurprisingly) yield different results. What remains unresolved to some of us is how such a functional architecture is instantiated neurologically. Our research program—using lesion and neuroimaging data—is now focusing on just this issue: whether a form-based, temporally sensitive processing system is neurologically defensible.

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