Fractionated working memory: Even in pebbles, it's still a soup stone

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Abstract: We agree with Caplan & Waters that there are problems with the single-resource theory of sentence comprehension. However, we challenge their dual-resource alternative on theoretical and empirical grounds and point to a more coherent solution that abandons the notion of working memory resources.

Caplan & Waters (C&W) argue for the inadequacy of the single-resource theory of verbal working memory in sentence comprehension. We are sympathetic to this position and see two approaches to developing an improved account. One is the approach that C&W adopt: dividing the single working memory resource into two independent resources, each dedicated to a particular processing module. The other is to reject the construct of a limited processing resource; Navon (1984) clearly articulated this position and likened the notion of processing resources to a theoretical “soup stone,” contributing no explanatory power to theories of cognition. We have elsewhere advocated this position for theories of language comprehension and have argued that the abandonment of the notion of verbal working memory provides a superior account of the individual differences in sentence-comprehension abilities that C&W review (MacDonald & Christiansen 1998). We see C&W’s dual-resource account as nothing more than cracking the superfluous soup stone into pebbles. Instead, we suggest that individual differences emerge from interactions between variations in linguistic experience (e.g., some people read more than others) and processing architecture (e.g., some people have more accurate phonological representations than others). Thus, individual differences in working memory tasks correlate with language comprehension not because there is a separate resource constraining these tasks but rather because the same architectural and experiential constraints that shape the accuracy of language comprehension also affect skill in performing verbal working memory tasks.

C&W have noted that understanding a sentence and following instructions are not the same thing, a point that no one would wish to dispute. They have reified this observation into a claim about separate working memories, however, and this move is an unfortunate one for a theory of cognitive processes. The motivation for the fractionated working memory is that performance in the two arenas is not particularly well correlated. By this logic, any two correlated tasks should be constrained by separate working memories; the proliferation of working memories would be enormous. Indeed, it is not at all clear why C&W propose only two working memories for language; segmenting the speech stream,
activating lexical semantics, parsing, and pronominal reference interpretation are very different processes, and probably abilities in these areas are not perfectly correlated, yet C&W assume that these processes are all part of one “interpretive” working memory. Thus, the decision to have one vs. two vs. twenty working memories is unjustified.

A serious concern with all resource theories is that they are nearly impossible to falsify, because there is no theory of how reductions in resource availability will affect the myriad processes that purportedly draw on the same resource. By dividing this resource into two pools each constraining many processes, C&W have not made this concern go away; they have compounded it. C&W suggest that current data do not yield the complex interactions predicted by the single-resource theory, but in fact they review almost every conceivable pattern of data (including those with the putatively crucial interactions) and conclude that no result is inconsistent with their account. It is always possible to invent a scenario in which comprehenders allocate resources to tasks in a way that accounts for the data, especially if the sizes of the two “independent” resource pools are positively correlated, as C&W imply.

Whereas C&W go to great lengths to explain away conflicting data from studies with young normal adults, they non appear to be on firmer ground with data from patient populations. We suspect that this situation is merely an artifact of the paucity of online studies of language comprehension and working memory in these populations. Contrary to C&W’s claims, our work with patients with Alzheimer’s disease (AD) has shown that these patients’ on-line sentence processing is impaired compared to that of controls (Almor et al. 1998). Patients appear equivalent to normal individuals in cross-modal naming only when the stimuli are constructed in such a way that subjects can ignore all but a few words in the sentence (typically the last few) and still perform the task accurately. Moreover, Almor et al. (1998) found that AD and normal subjects’ accuracy producing and interpreting pronouns correlated well with performance on putatively “post-interpretive” working memory measures. Thus C&W’s claim that patients with impaired “central executive functioning” have normal syntactic processing is not supported by studies that carefully manipulate the on-line processing demands of the stimuli. Instead, the ability to develop a discourse representation, a key part of “interpretive processing” in C&W’s account, is related to performance on “post-interpretive” working memory tasks.

Much of the confusion in C&W’s account stems from a narrow view of sentence processing and a failure to appreciate that notions of working memory are inseparable from views of processing architecture. C&W make several mistakes in their discussion of sentence-processing theories, including (1) an inconsistent blending of constraint-based and reanalysis approaches to ambiguity resolution and (2) questioning the lack of reading effects in ambiguous sentence regions for ambiguities in which no theory predicts any effects in this region. At the architectural level, C&W’s account (as well as the single-resource theory) incorporates the assumption that sentence comprehension consists of building syntactic representations word by word as the basis for semantic interpretation. Working memory resources are needed for storage of partial processing results. The constraint-based account that we advocate holds that sentence comprehension involves the parallel application of multiple probabilistic constraints from sentential and discourse context. In connectionist instantiations of this view, there is no distinction between storage of linguistic knowledge, comprehension processes, and working memory resources. An individual’s “capacity” to process language is realized as the efficiency of passing activation through a network and is constrained by the interaction of network architecture and experience. Including the notion of working memory resources adds nothing to this account.

Distinguishing interpretive and post-interpretive processes

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Abstract: A separation between interpretive and post-interpretive processes is central to Caplan & Waters’s theory of language comprehension. This commentary raises some issues that are intended to help sharpen the distinction.

Caplan & Waters (C&W) present an excellent overview of their research. Their work demonstrates that differences in working memory capacity do not affect sentence-interpretation processes themselves but may influence operations performed on the output of those processes. I find the general approach the authors take convincing, but a number of questions can be raised concerning the distinction between interpretive and post-interpretive events during sentence comprehension. Let me begin by acknowledging that C&W do go some way toward providing clarification on this point in their section 4, entitled “Discussion: Fractionating verbal working memory.” There they suggest that interpretive processes include accessing words, computing prosody, assigning thematic roles to syntactic constituents, establishing coreference (although presumably not coreference relations that rely extensively on real-world plausibility), and determining a sentence’s focus-presupposition structure.

What strikes me as requiring more justification are the authors’ assumptions about what constitutes post-interpretive processes. Likely everyone would agree that it is not really language that tells us that if Harvey used to sell junk bonds and now he sells pencils, we no longer care what he does. We realize our conversations would not be private; and The aggressive trial lawyer questioned in minute detail by the judge hesitated. The first presumably involves lexical reanalysis and the second syntactic reanalysis. The problem here is that certainly not all cases of either require post-interpretive processing. For example, the sentence The team defeated in the Super Bowl vowed revenge next season might require repair once vowed is encountered, but re-analysis does not seem to require more than the basic interpretive processes of the sentence-comprehension system. Indeed, recently Fodor and Inoue (in press) proposed a theory of syntactic revision that is deliberately designed to keep reanalysis internal to the sentence-interpretation mechanism. In their theory, when a word cannot be incorporated into the current syntactic phrase marker (vowed in the Super Bowl example above), it is “attached anyway,” and then the parser faces the syntactic consequences of that attachment by moving right to left through the tree, making necessary adjustments. Therefore, it seems that C&W should say much more about what sorts of repair processes might be post-interpretive and what sorts are not.

Another question concerns C&W’s assumption that sentences with more than one proposition invoke post-interpretive processing. First, I do not understand how the sentences they give as examples contrast in number of propositions; second, I do not see why number of propositions by itself should matter. The authors devote several paragraphs in the article to their argument that the processing of multi-propositional sentences interacts with resource limitations because such sentences require post-interpretive processing, but they do not really spell out how this is supposed to work. Let us take an example from the beginning of the paper that is meant to illustrate the contrast:

1. The boy hugged the girl and the baby.
2. The boy hugged the girl and kissed the baby.

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