Working Memory and Language

Susan E. Gathercole & Alan D. Baddeley. Hove, U.K.: Erlbaum.

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Verbal Working Memory: A View With A Room

The present volume investigates the applicability of the working memory model, articulated previously by Baddeley (1986), to the understanding of various language processing phenomena including vocabulary acquisition, speech production, reading and its development, and linguistic comprehension. The verbal wing of the working memory model reflects a view that cannot be dismissed casually, based as it is on a large number of studies involving word length, phonological similarity, irrelevant speech, articulatory speed, articulatory suppression, interactions between these factors, and changes in their functioning during childhood. There are experimental conditions for which the effects of these manipulations act rather predictably and can be explained by the model rather well. Thus, the view adopted by the authors need not wander nomadically through a world of empirical phenomena searching for its proper place; it clearly now has a domain of applicability. To twist metaphors, it is a theoretical view with a room to call its own -- a view with a room. The layout of the room and its contents are explored well in this book, and the room's boundaries are fairly well defined.

On the other hand, it seems important for investigators also to look at what may be outside of the room. Baddeley's working memory model does not work well for all short-term memory tasks. One educated guess (with which the authors might well agree) is that it applies best when the contributions of long-term memory factors are minimized. In short-term memory tasks, this occurs most clearly when the subject must recall the same

information trial after trial, with a heavy emphasis on attaining the correct unique serial order of recall on each trial.

The verbal working memory model, which was reviewed in Chapter 1, includes a phonological memory store that holds information passively for a few seconds, an articulatory process that is capable of entering and re-entering items into this phonological store, and central executive processes that are used to monitor the entire system and carry out more complex mental operations. Most of the specific discussion of memory mechanisms was on the store and articulatory process, which together make up the "phonological loop." (For the sake of completion, the nonverbal storage component, the visuospatial sketchpad, also was described.) Verbal memory limitations result when information decays from the phonological store before it can be reactivated through the articulatory process. This simple mechanism can account for numerous effects. For example, the detrimental effect of the phonological similarity between items in a list to be recalled is said to result from confusions between similar items in the process of retrieval from the phonological store, and the detrimental effect of longer words in the list to be recalled is said to occur because longer words produce a longer delay in the process of reactivating items in phonological storage through covert articulatory rehearsal.

What was not discussed in the book is that, in many experimental situations, the theory does not apply well and the typical hallmarks of the phonological loop mechanism may fail to appear. For example, because most of the effect of phonological similarity on recall consists of interference with serial order information rather than item information (Wickelgren, 1965), the phonological similarity effect is much reduced or absent in free recall. Again, most of the effect of word length on recall is eliminated when items are drawn from a large pool, rather than from the same restricted pool on trial after trial (LaPointe & Engle, 1990). It seems likely that language skills, as well, depend on the

phonological loop mechanism only to the extent that they too require the serial recall of phonological information to supplement insufficient long-term memory codes. Below, I will examine both the metaphorical room occupied by the verbal working memory model, (i.e., its successes) and what may lurk outside of the room (its limitations).

The View Described in the Book: Inside the Room

The book does a good job of showing how far the model can take us. Much of the available evidence is interesting and meaningful. Consider, for example, some of the neuropsychological evidence. Patients with a deficit in articulatory planning show a severe reduction in the phonological similarity and word length effects, much like normal subjects who are required to articulate irrelevant materials during the short-term memory task, thus blocking their mnemonic use of articulatory processes (Waters, Rochon, & Caplan, 1992).

The main thrust of the book is to assess the degree to which verbal working memory processes play a role in various domains. Chapter 2 explains how working memory may be involved in development. It is clear, for example, that the developmental increase in verbal memory span co-occurs with an increase in the maximal rate at which the articulatory process can be used. Chapter 3 discusses one practical consequence of working memory, namely that it is essential for vocabulary acquisition. Children with better verbal working memory acquire vocabulary more quickly, even with many other factors taken into account; and an adult with a severely limited memory span cannot learn new vocabulary at all.

Chapter 4 examines the role of working memory in speech production, and here the role of the phonological loop processes is not so clear. The same will be said later, in Chapter 7, about visual word recognition. In the chapter-final overview it is stated (p. 199) that "the only reading situations in which phonological loop involvement has been

consistently identified have required subjects to make rather complex comparisons about the segmental and prosodic structures associated with letter strings." A similar conclusion emerges from Chapter 8, in which the role of working memory in language comprehension is examined. It appears that this depends on the phonological loop only in special cases, for phrases and sentences that are complex enough to require that part of the sentence be retained in literal, phonological form for a while. In all of these cases, it could be argued, the availability of schemes from long-term memory takes precedence over phonological working memory. Of course, the potential role of the central executive in such situations is greater.

Chapters 5 through 7 treat written language. Chapters 5 and 6 deal with reading development and a substantial link to the phonological loop portion of working memory is found, though the link appears stronger in the early phases in which children are learning to convert print into a phonological form. Once reading skills are established, the role of phonological working memory appears to subside, as Chapter 7 (on visual word recognition) and Chapter 8 (on language comprehension) demonstrate. All of these discussions are quite helpful for anyone who is trying to keep abreast of a rapidly growing literature on verbal working memory and its linguistic applications, and it is especially useful in determining the likely role of working memory in the applied situations. The research is presented with much of its inherent complexity intact and then is summarized and simplified nicely at the end of each section. Chapter 9, the concluding chapter, sums up theoretical and practical points. The theoretical summary characterizes the phonological loop portion of working memory as a semi-independent module that, with the guidance of the central executive, functions as a support system for language and other mental tasks. However, it appears that the phonological loop is needed only when the task requires that series of phonemes be retained in memory. This is a well-defined

room of research, but it is of course not the entire neighborhood. The practical applications section emphasizes the possibility, based firmly on the preceding material, that one might be able to assist language learning and other domains through training in phonological memory.

<u>Limitations of the Book's View: Outside the Room</u>

Let us turn now to what may lie outside the standard working memory view. The level of description of each of the components of the verbal working memory model can be questioned. First, consider the phonological memory store. The discussion (p. 8, Figure 1.3) suggests that "speech inputs" enter the store automatically whereas "nonspeech inputs" enter only with the assistance of the articulatory processes. This conclusion is based largely on the finding that articulatory suppression can prevent phonological similarity and word length effects for printed words, though not for spoken words, along with the finding that irrelevant speech interferes with memory. However, this status of "nonspeech inputs" cannot be true of nonverbal sounds, inasmuch as irrelevant pure tones do interfere with working memory (Jones & Macken, 1993) and the irrelevant speech effect recently has been found to depend only minimally on the degree of phonological similarity between the relevant printed and irrelevant spoken items (Jones & Macken, in press). These findings suggest that the "phonological store" actually may not be specialized for speech, but may instead be just one special application of a more general temporary information storage medium that can contain various types of stimulus feature including, at the least, both acoustic and articulatory/phonological features (such as was proposed, for example, by Cowan, 1988).

Various other theoretical problems for the phonological store remain to be explored. An especially important one is how serial order information is encoded. If the articulatory process works by rehearsing items in a repeating loop, as is proposed within

the working memory model, then the relative vividness of items in the store cannot reflect the serial order of the original stimulus input.

The role of the articulatory process in working memory also is uncertain, and here the authors do show some cautious movement from their original views. Consider, for example, that the correlation between the maximal speech rate and memory span across childhood has been explained on the basis of a developmental increase in the rate of rehearsal, which in turn would increase the number of items that could be kept active within the phonological store. This logic always has seemed questionable to me because of earlier reports that young children do not verbally rehearse at all (e.g., Flavell, Beach, & Chinsky, 1966). The present book (p. 31) alluded to findings by Henry (1991) suggesting that young children do not rehearse and indicating that, in 5-year-olds (but not in 7-year-olds), the word length and phonological similarity effects are eliminated when a pointing response is used instead of the ordinary spoken response. This suggests that the effects in 5-year-olds result entirely from verbal output effects. The authors were on the right track when they connected this result with the finding that word length effects even in adults appear to occur largely because of output rather than rehearsal; specifically, because items are lost from short-term memory while other items are being repeated during the response period (Cowan et al., 1992). However, Henry's result nevertheless was termed "very puzzling." This suggests that the priority in the book was on preserving the standard theory as long as possible. That is a reasonable stance for the proponents of a major theory to take, but readers would do well to be aware of it.

The research mentioned above suggests that articulation limits memory in a different way than is assumed by the standard model (i.e., during output rather than, or at least in addition to, during covert rehearsal). A more radical modification would be to consider the role of covert processes other than articulation, and some recent research is pointing

in that direction. According to the working memory model, sets of short words are recalled better than sets of long words for the same reason that older children recall words better than younger children: because both young age and long words impede the rate at which the subject can rehearse the list items. However, this type of unified account does not explain the results of Cowan et al. (in press), who examined the timing of words and pauses within spoken recall in a memory span task. Word length affected the duration of words in the response, but not the duration of interword pauses, whereas age affected the duration of interword pauses but not the duration of words in the response. Whereas word length may function as suggested above, by modulating the rate of recall and thus the period during which memory is lost, age appears to function at least in part by modulating the rate of some rapid, covert process.

The interword pauses in recall are much too short, and too free of word length effects, for the covert process to be verbal rehearsal. Cowan et al. (in press) proposed instead that the rate at which items are searched in memory may change with age. One related finding is that language-disordered children not only have a subnormal memory span, but also engage in memory search at a much slower-than-normal rate (Sininger, Klatzky, & Kirchner, 1989). Articulatory rate is certainly not the only rate that covaries with memory span (e.g., see Hitch, Halliday, & Littler, 1989; Kail, 1992). Thus, at present, there is insufficient evidence to conclude that speech rate is the most important causal factor in memory span, as the standard working memory account suggests.

One also could question the exact role assigned to the central executive in verbal working memory tasks. For example, it is not supposed to be involved much in covert rehearsal, but that may be true only under some circumstances. Guttentag (1984) showed that rehearsal is much less automatic (more susceptible to dual task demands) in children who have just learned to rehearse than it is in adults. What may develop with age is more

efficiency in the use of the central executive, either because of biological maturation or because of extensive practice in various tasks. This more efficient use could result, in turn, in an increase in the rate of various mnemonically relevant processes, including but not necessarily limited to rehearsal and memory search.

Research on working memory eventually should strive to account for a wider variety of tasks. At present, there are some classic ones that cannot be accounted for. The authors acknowledge factors outside of the working memory model implicitly, for example in their referral (p. 48) to the finding that lexical knowledge of the list items alters the relation between speech rate and memory span (Hulme, Maughan, & Brown, 1991). However, there was not much emphasis placed on following up on the implications of such observations. Could they help us to account for the finding that, in a free recall task with items changing from trial to trial, subjects remember a roughly equivalent number of meaningful units no matter whether the units are single words or idioms such as "a stitch in time saves nine" (Glanzer & Razel, 1974), counter to the model's emphasis on item length effects? Could they help us to understand procedures in which inter-item interference appears to have a much larger detrimental effect on retrieval than does the passage of time alone (Waugh & Norman, 1965), counter to the model's emphasis on temporal decay?

Finally, all of these are theoretical concerns, whereas the book has a strong bent toward practical applications. Are the theoretical controversies relevant only to theoreticians, or should they concern practitioners as well? To answer this, let us consider the authors' main practical recommendation, that phonological memory training might improve language and other skills dependent on verbal working memory. If this is true, the preferred method of phonological memory training should depend on what the causal factors of phonological memory are. For example, should one try to train

rehearsal, as the standard theory suggests, or should one try to train memory search, as some of the recent research suggests? Theory and practice may indeed interact.

More basic for practical purposes is the theoretical predisposition of much of the field toward confirmation rather than disconfirmation of a theory, which in turn colors the way in which research is conducted. For example, the research on the role of working memory in language- and reading-disordered children, reviewed extensively in the book, has proceeded mostly through studies in which a disordered population is obtained and working memory abilities are studied. This is understandable, but it carries with it a confirmation bias. We need to know not only what working memory deficits co-occur with language and reading disorders, but also how rare it is for a person to develop normal language and reading abilities despite an abnormal working memory. Thus, a more informative research strategy may be to assess working memory in a large number of children and then to observe the relation of that measure to other disorders. The research of Gathercole, Willis, Emslie, and Baddeley (1992), showing that nonword repetition at 4 years of age predicts vocabulary at 5 years, and not the reverse, can be viewed as a successful step in this direction.

In sum, the present volume serves as a useful compendium of the standard verbal working memory view of Baddeley (1986), and a thoughtful inquiry into the extent of its applicability to various language tasks. The working memory view is one metaphorically with a nice room that has been well kept up, renovated, and even expanded over the years. I would only remind readers to step outside of the room occasionally, to deal with the less wieldy outer world.

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