Evidence Against the Global Speed of Processing Theory of Working Memory

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Introduction

Several theorists have suggested that a single, global speed of processing explains individual and developmental differences in working memory (e.g., Fry & Hale, 1996; Kail & Park, 1994; Kail & Salthouse, 1994; Salthouse, 1996). I propose that a more complex view must be taken. There are several different processing speeds that are unrelated to one another, both of which are nevertheless related to working memory ability. Moreover, one of these processing speeds is affected by memory load. These two separate types of speeds cannot be reduced to a single, global speed of processing.

Discussion of Evidence

New evidence comes from the duration of responses in memory span tasks administered to children ranging from 4 to 12 years old, and young adults. Using a sound waveform editor, a fine-grained analysis has been obtained. Specifically, the duration of words and silent pauses between words in the spoken responses within span tasks have been measured (Cowan, 1992; Cowan, Keller et al., 1994; Cowan, Wood et al., in press). These measurements have been made only for stimulus lists that were repeated by the subject without error.

The durations of words in the memory span task response are affected very little by list length, the subject's age, or the subject's memory span ability. Only the durations of stimulus words affect them. However, the durations of inter-word pauses in the response are affected by different factors. They are unaffected by stimulus word length but are longer within responses to longer lists, suggesting that subjects must search through the list repeatedly to retrieve each word to recall next. For lists of a fixed length, the pauses are longer for younger and less capable subjects. These results suggest that a memory retrieval process (which is not covert rehearsal, given the absence of word duration effects in pauses) occurs between words in the response, is set-size-dependent, and occurs more quickly for more capable subjects.

For converging evidence, we also have collected memory search probe reaction times in adults (Cowan, Wood et al., in press) using a modification of the method of Sternberg (1966) that can be used with adults in groups. They are given a fixed period to search through an array to find items that come from the memory set and circle those items.

We also have examined how quickly subjects can repeat short sets of words as an estimate of rehearsal rates (see Baddeley, 1986) and have developed another task in which rehearsal remains covert and subjects make a mark on paper to reflect each rehearsal cycle (Cowan, Wood et al., in press).

Both retrieval rates (indicated by inter-word pauses in span task responses and by memory search reaction times) and rehearsal rates (indicated by rapid speaking and covert rehearsal rates) are correlated with span, generally at about $r = .4$. Nevertheless, retrieval and rehearsal rates are completely uncorrelated with one another, accounting for non-overlapping portions of the variance in memory span. For example, Cowan, Wood et al. (in press) found that, in a sample of children ranging from first grade through fifth grade, inter-word pauses and rapid speaking rates together accounted for 60% of the variance in span and 87% of the age-related variance in span.

Conclusion

These results suggest that there is not just a single, global speed of processing. Retrieval rates are highly load-sensitive and may reflect the capacity of the focus of attention, whereas rehearsal rates may reflect the speed of automatic processing in a phonological loop mechanism. The two types of processing rates are not related to one another and therefore must be accounted for through separate mechanisms.

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