Grouping of list items reflected in the timing of recall: implications for models of serial verbal memory

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Abstract

Three experiments examined the effect of temporal grouping on the timing of recall in verbal serial memory. Compared to an ungrouped condition, recall in a grouped condition produced a peak in latency between the groups (Experiment 1). However, the ratio of within- to between-group intervals at presentation was not reflected in recall (Experiment 2), contrary to the predictions of some oscillator models (Brown, Preece, & Hulme, 2000; Burgess & Hitch, 1999). In Experiment 3, grouped and ungrouped lists of different lengths were compared to assess a recent version of the ACT-R model applied to serial recall (Anderson, Bothell, Lebiere, & Matessa, 1998). Recall latencies showed a cost at group onset related to group size and a cost for all items of the first group associated with carriage of a second group. Results are discussed with reference to oscillator models, the ACT-R model, and augmented versions of it. © 2002 Elsevier Science (USA). All rights reserved.

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Reproduction, over the short term, of the order of verbal sequences has been a preoccupation of both classic (Ebbinghaus, 1964) and contemporary research (see, e.g., Baddeley, 1986; Brown et al., 2000). Generally, this work has been subsumed under the rubric of 'working memory,' a component of cognitive architecture embodied universally in general theories of human performance. The current paper explores the structure of working memory by measuring the timing of response production in a serial recall task. Response timing has been used only rarely in studies of serial recall—the measurement of errors has been the dominant method—but recently the measurement of timing has become more relevant to theory testing with the emergence of models that embody elements of temporal representation in the process of retrieval. Specifically, several recent theories suggest that the timing of the presented sequence should be echoed in the timing of the recall sequence. This paper reports experiments that manipulate the temporal grouping of auditorily presented lists and assess how this is reflected in the timing of responses.

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In studies of temporal grouping, series of items, such as words, are presented for retention and their timing is manipulated to form distinct sub-series (e.g., ABC–DEF–GHI versus ABCDEFGHI). This form of grouping has been found to improve the accuracy of serial recall (e.g., Frankish, 1985, 1989), to create effects of primacy and recency within the sub-series (Hitch, Burgess, Towse, & Culpin, 1996; Ng & Maybery, 2002; Ryan, 1969a, 1969b), and to reduce the probability of items migrating to adjacent positions if migration involves crossing from one sub-series to another (Henson, 1998; Ng and Maybery). Several models of serial memory can account for the above data (Brown et al., 2000; Burgess & Hitch, 1996, 1999; Henson, 1998; Henson & Burgess, 1997). However, these data are almost exclusively error scores.

At a general level, current models of short-term memory account for the retention of serial order in radically different ways. Order is presumed to be retained: (i) by encoding associations between items, as with TODAM and extensions to it (Lewandowsky & Murdock, 1989; Murdock, 1995), (ii) by encoding successive items with differential strength, as with the primacy model (Page & Norris, 1998a), (iii) by associating items with a context signal, as with oscillator models (Brown et al., 2000; Burgess & Hitch, 1996, 1999; Henson & Burgess, 1997), or (iv) by encoding items within declarative knowledge units, as with the Adaptive Character of Thought—Revised (ACT-R) production system model (Anderson et al., 1998; Anderson & Matessa, 1997). Recent reviews have identified several phenomena that are problematic for the first two classes of model (Brown et al., 2000; Burgess & Hitch, 1999; Henson, 1998, 1999), among them temporal grouping. Our focus, therefore, is on the context models—specifically the oscillator models of Burgess and Hitch and Brown et al.—and declarative knowledge models—specifically the ACT-R model of Anderson and his colleagues.

Contemporary context models assume that temporal oscillators provide the context that serves as the basis for retrieval. Temporal oscillators are neural cell assemblies that fire in regular cycles, but with different oscillators cycling at different frequencies. Oscillators therefore provide a rich signal that changes continually over time. Two recent models embodying oscillators are capable of making predictions about the effect of grouping on the timing of responses. Following a brief description of each of these models, we consider the alternative perspective involving declarative knowledge provided by the ACT-R model.

The phonological loop model

Burgess and Hitch (1996, 1999) and Hitch et al. (1996) include temporal oscillators as one of several features in a computational model which elaborates the phonological loop (PL) construct (Baddeley, 1986). In this model the current signal from a set of oscillators is associated with each item as the to-be-remembered list is presented. Then, at recall, the oscillators are reset to the points they had occupied in their cycles at the commencement of list presentation. As the oscillators are replayed, their changing signal then provides cues for the serial recall of the list items. To illustrate, assume that successive items i and $i + 1$ had been presented at times t_i and t_{i+1} after the onset of list presentation. When the oscillators are reset at recall and allowed to evolve, after time t_i has elapsed, the signal they provide will closely resemble the signal that had been associated with item i during list presentation. At this point in recall, item i should be cued more strongly than the other list items. As the oscillators continue to evolve to time t_{i+1}, they assume a state that is optimal for cueing the recall of item $i + 1$. Serial recall therefore proceeds under the direction of the signal provided by the oscillators.

According to the PL model, the oscillators provide a more sophisticated signal when lists are presented in temporal groups. If there is a constant interval from onset of one group to onset of the next, a group of oscillators becomes entrained to this frequency. The signal of these oscillators repeats itself in phase with the groups. This group of oscillators effectively encodes within-group position. Consequently, items within a group have highly differentiated contextual codes, but items occupying the same position in different groups have very similar codes. However, only some of the available oscillators become entrained to the inter-group frequency. The remaining oscillators continue to operate with varying frequencies, and are used to encode the listwise positions of items, as described in the preceding paragraph. At recall, all the oscillators are reset to the points they had occupied in their cycles at the start of the list, and their composite signal evolves to provide the cues for serial recall. Because the oscillators evolve at recall in the same way as they had done during list