Semantic Clustering in Free Recall: Evidence for a Semantic Buffer?

Eddy J. Davelaar (e.davelaar@psychology.bbk.ac.uk)
Marius Usher (m.usher@psychology.bbk.ac.uk)
School of Psychology, Birkbeck College, Malet Street, WC1E 7HX, London, UK

Introduction

Recent years have seen the revival of the view that semantic information can be maintained for a short period of time (e.g. Haarmann & Usher, 2001; Martin, Shelton & Yaffee, 1994). However, less emphasis has been placed on accounting for findings that have been taken as evidence against such a view, like the effect of clustering semantically related words in an immediate free recall task (Craik & Levy, 1970). Here, the increase in overall with clustering is assumed to be entirely due to increase in the retrieval from secondary (long-term) memory.

Craik and Levy (1970) presented participants with lists containing 20 unrelated words or 14 unrelated and 6 related words. In the latter type of lists, those 6 words were presented in a cluster either in the middle (M-list) or the end (E-list) of the list. They estimated the contribution of primary memory by applying the idea of Waugh and Norman (1965) that performance at recency reflects the combined results of retrieval from primary and secondary memory. In order to estimate the contribution of primary memory (P_{PM}) the probability that items are retrieved from secondary memory (P_{SM}) have to be estimated and combined with the raw recall probability (P_R) in the equation: $P_{PM} = (P_R - P_{SM})/(1 - P_{SM})$. To estimate P_{PM} in the control lists, Craik and Levy (1970) used the average of the middle 'cluster' as the estimate of P_{SM} for the final 'cluster'. However, they used the average recall performance of the middle cluster of *M-lists* as an estimate of P_{SM} for the final cluster in *E-lists.* Although the absolute performance level at recency was higher in E-lists than in control lists (see figure 1, top), it was found that the estimate of the primary memory contribution did not increase for E-lists (1.8 items) compared to control lists (2.82 items). Levy and Baddeley (1971) followed up on this result and used a delayed free recall task to get an estimate of the contribution from secondary memory. Their conclusion parallels that of Craik and Levy (1970).

Critique

Although, Craik and Levy's results have been cited as evidence against the notion of semantic coding in primary memory, several issues make the interpretation doubtful. First, the actual Waugh and Norman (1965) procedure requires estimating the number of intervening items between presentation and recall (including those during retrieval). In a serial probe experiment (Waugh & Norman, 1965) this is the same as the listlength minus the serial position, but in free recall one needs to consider the effect of output interference during the retrieval phase. Second, Craik and Levy (1970) instructed their participants to start their recall with the final words. This may have led to differences in the attention given to the middle list items compared to the final list items.

Third, Waugh and Norman's procedure assumes that the probability that items are retrieved from secondary memory is equal for middle and final list items. However, this need not be so (see Watkins, 1974) as the probability of retrieval from secondary memory may vary across serial positions. In fact, basing the estimation procedure on this assumption leads to an underestimation of the contribution of primary memory. Such an underestimation would also be present when the recall performance of recency items in a delayed free recall task is used as a measure for the contribution of secondary memory for the recency items in an immediate free recall task (Levy & Baddeley, 1971).

Fourth, Craik and Levy made the strong assumption that the items of the middle cluster are all reported from secondary memory and that this provides a good estimate for the contribution of secondary memory in the end cluster for E-lists. However, it may well be possible that clustering items in a list prolongs the duration that the items within the cluster reside in primary memory, especially when the cluster is embedded within a list of unrelated words. This would not only lead to an increase in the contribution from primary, but also from secondary memory as more time is available for items to be transferred from primary to secondary memory.

Co-Activation in a Semantic Buffer

The hypothesis that clustering related items increases the duration that the items reside in primary memory finds support in an experiment by Glanzer (1969). Glanzer (1969) presented lists with eight pairs of associated words. The lists were constructed such that 0, 1, 3 or 7 unrelated intervening items separated the members of a pair. Free recall performance for these lists decreased with increase in the number of intervening items. Glanzer (1969) proposed that when the first member of a pair is in short-term store when the second member is presented, the semantic associations between the words cause a facilitative effect on the short-term retention. Essentially, when two related words are in short-term store they support each other. Haarmann and Usher (2001) followed this up and found that the effect of proximity between the associates in free recall is present at recency and was still present under articulatory suppression. This finding not only supports the view that the phonological loop does not underlie short-term recency (Baddeley & Hitch, 1974), it also suggests that a semantic buffer may underlie short-term recency and renders an explanation based on redintegration (e.g. Schweickert, 1993) difficult, as it is assumed that suppression eliminates phonological traces.

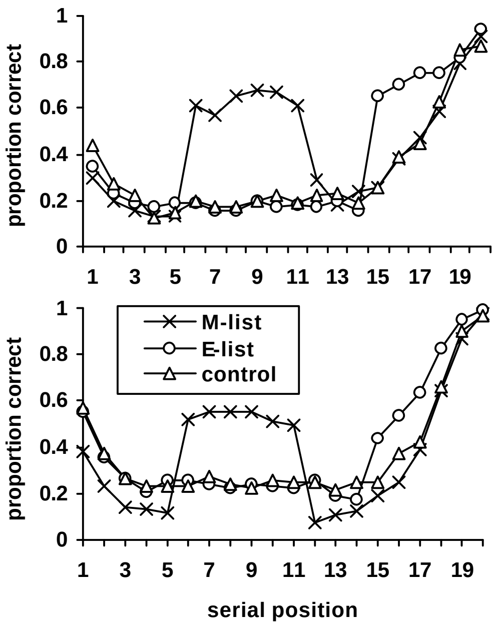

Figure 1. Semantic clustering in free recall. Top: data (Craik & Levy, 1970). Bottom: model predictions.

As mentioned above, it is believed that related items tend to support each other in short-term store, by being co-active. A new neurocomputational model of free recall (Davelaar, 2003) was applied to the effect of semantic clustering. In the model, the contents of the short-term store are the activated part of lexical-semantic long-term memory representations. The model comprises of an activation-based short-term memory buffer and a weight-based contextual episodic memory system. Small excitatory connections exist between associates, making up a semantic network.

Figure 1 (bottom) shows the model predictions for the serial position function for the control list and the M- and E-lists. Using the same procedure by Craik and Levy (1970) to estimate the primary memory contribution, the model 'predicts' that primary memory contributes (on average) 2.54 items in the E-list compared to 2.77 items in the control list. The model can be used to obtain an actual estimate of the contribution of primary memory, which is simply the capacity as computed by the average number of items that are active at time of test. The actual contribution of primary memory to performance in the current simulation is 3.28, 3.31 and 4.00 items in the control, M- and E-list, respectively. Several points about these results can be mentioned. First, clustering semantically related items increases the contribution of primary memory. Second, the assumptions that 1) middle and end-of-list items have equal contributions from secondary memory and that 2) raw recall performance on middle-list items (always) form a good estimate of P_{SM} are questionable. Third, the estimation procedure systematically underestimates the capacity.

These simulation results not only challenge the conclusions drawn by Craik and Levy (1970) and Levy and Baddeley (1971), it also supports the conclusions of various investigators who hold that there exists a verbal short-term store that maintains semantic information. In addition, it forms a strong case for how computational modeling can be used to test assumptions.

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