Modeling Dissociations in Short- and Long-Term Recency Effects

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Introduction

The free recall paradigm has led many theorists to speculate about the structure of human memory. The task involves repeating a sequence of words in any order immediately after its presentation. Typically, the first, *primacy*, and the last few, *recency*, words are better recalled than those presented in the middle of the sequence. The traditional view is that primacy effects result from the increased opportunity to rehearse those words, whereas recency effects are due to retrieval from a short-term buffer. However, this view was challenged by the finding of recency effects in a long-term memory task (Bjork & Whitten, 1974) named the *continuous distractor task*. In this task, a buffer-emptying distractor task is added before and after every word. Although this method is designed to eliminate the presence of items in the buffer, a *long-term recency* effect is found in this task, which has been interpreted to provide evidence against the existence of a short-term store (Crowder, 1982).

The Model

The current model (see Davelaar, 2003) takes a Hebbian view to short-term maintenance, which states that the content of short-term store is the activated portion of long-term memory representations, in a brain system distinct from the episodic system.

Activation-Based Short-Term Memory

The model consists of a semantic long-term store of localistic units (corresponding to sparse distributed representations) with self-excitatory connections. A global inhibition (resulting from a pool of interneurons) prevents an unbound spread of activation and underlies the capacity limitation of the system. The activation of all units (1 to N, N > listlength) are updated in parallel and depends on the neural current in the previous time-step, the recurrent (self-excitation and global inhibition) and the external noisy input.

Contextual Episodic Memory

There is a general consensus that structures in the medial-temporal lobe play a critical role in the encoding and retrieval of episodic memories (e.g. Nadel & Moscovitch, 1997). In the model, the medial-temporal lobe is simplified as a layer of context units. At each moment, one context is active. At the beginning of a trial, the first unit is activated (to unity), which coincides with the start signal (e.g. 'GET READY') to which it is associated. The context then changes according to a random walk process with a drift. This random walk is implemented as follows. The active context unit *n* remains active with probability $1 - P_{inc} - P_{dec}$ or with probability P_{inc} and P_{dec}, unit $n + 1$ or $n - 1$ will be activated. This contextual change continues throughout the distractor interval in the continuous distractor task and during the retrieval phase. Because the context drifts away from the starting unit, the contextual system implements a positional coding mechanism that is sensitive to the passage of time, as used in recent models of serial recall that feature a contextual system (Burgess & Hitch, 1999).

Encoding and Retrieval

At encoding, the connections between supra-threshold active prefrontal representations and active context units undergo Hebbian weight changes. At retrieval, items that reside in active memory are immediately reported (cf. Raaijmakers & Shiffrin, 1980), which is followed by a more elaborate episodic retrieval process. During the retrieval phase, the context units are still following a random walk with drift. All representations that have been associated with the active context unit compete for output. The selected item will be output if it was not already output and its episodic strength is larger than a recovery threshold. By default, the retrieval phase starts with the context unit that is active when the prompt for recall is given (the end-cue). After a fixed number of selection-recovery cycles, the context is reset to the start context (begin-cue) and retrieval continues for an additional fixed number of cycles. Several models make use of the begin-cue as a driving force for recall, which accounts for the increased inter-response time before reporting the first item (Metcalfe & Murdock, 1981).

Modeling Recency

The model accounts for basic findings like serial position effects and as the serial position gradient in immediate free recall shows a recency function for the active memory component, factors that only affect retrieval from episodic memory, like listlength (Murdock, 1962), do not affect the recency portion. In contrast, a primacy/negative recency function is found for the episodic trace strengths, allowing the model to readily account for negative recency effects in final free recall (Craik, 1970) and primacy effects under rehearsal-preventing conditions (Richardson & Baddeley, 1975). As in the continuous distractor task the contribution of active memory is absent and the episodic trace strength is uniform across serial positions, the model suggests that not only short- and long-term recency effects have different sources, but that this also true for primacy effects. The long-term primacy and recency effects are due to the increased contextual overlap between the end-cues and the list items (see also Howard & Kahana, 2002).

Several dissociations between short- and long-term recency effects disqualify the claim that all recency effects can be explained with a single retrieval mechanism. Dalezman (1976) found that the recency effect was abolished when participants started recall with the first items, whereas a recency effect was present when retrieval started with the end-of-list items. This effect is absent in the continuous distractor task (Whitten, 1978). The model accounts for this dissociation by switching the order in which the (begin- and end-) cues are used. In the case of immediate free recall, the end-first instruction leads to the emptying of the buffer. For the begin-first instruction, it is assumed that output interference displaces the content of primary memory, thereby eliminating short-term recency. In the continuous distractor task on the other hand, changing the order in which the cues are used does not affect the serial position function, as no changes in episodic trace strength or primary memory contribution occur.

Carlesimo and colleagues (Carlesimo, et. al., 1996) reported that compared to matched control participants, amnesic patients have lower performance levels for the pre-recency positions in immediate free recall and for all positions in the continuous distractor task. The model accounts for the dissociation in recency by assuming that as these amnesic patients have damage to the medial-temporal lobe, the episodic strengths are lower or more difficult to use, resulting in only recency positions in immediate free recall to be unaffected.

General Discussion

As the model accounts for dissociations between short- and long-term recency, it can provide valuable insight in the processes needed to account for the full dataset focused on in the single- versus dual-store debate. In addition, the model implements a Hebbian view of activation-based short-term and weight-based long-term store, showing this framework's explanatory power in cognitive and neuro-psychology. The current model makes a clear distinction between episodic and semantic memory, where the former is mediated by subcortical and the latter more by cortical areas. Like the single-store model by Howard and Kahana (2002), the current model accounts for long-term recency (and long-term primacy) effects by having a changing context. Future research could explore the specifics of the changing context, including its neural underpinnings. As a first approximation a drifting random walk process forms a good candidate mechanism.

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