Managing Working Memory: Mechanisms of Active Suppression

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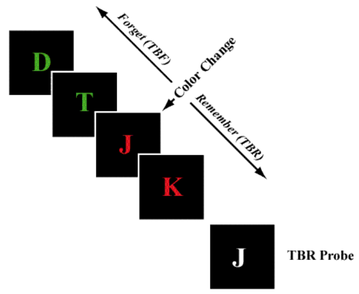
Introduction

- In order to understand how working memory (WM) is used during complex cognitive tasks it is essential to understand how WM capacity is managed.
- Several researchers (e.g., Hasher & Zacks, 1988; Gernsbacher, 1993) have suggested that suppression of non-goal-relevant information may be an important mechanism by which WM capacity is preserved.

Paradigm and Prior Findings

- A paradigm that may have the potential to clarify the role of suppression in WM was introduced by Bjork, Abramowitz and Krantz (1970), who modified Sternberg's (1966) memory-scanning task to include trials on which there were cues to forget pre-cue items (see Figure 1).
- As in traditional memory scanning experiments, participants showed a load effect of the number of items To-Be-Remembered (TBR; See Figure 2).
- The surprising result was that while responses To-Be-Forgotten (TBF) items were slower than responses to both TBR and new probes (NP), they showed no effect of TBF load, indicating that they were not scanned, but nonetheless had an effect on performannce.

a)



b)

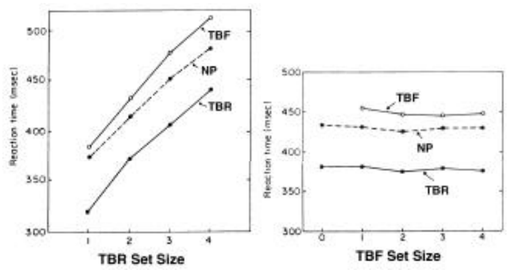


Figure 1. a) Directed Forgetting Working Memory Paradigm (Bjork, Abramowitz and Krantz, 1970), b) Typical results for Directed Forgetting Working Memory Paradigm (adapted from Bjork, 1989).

A Possible Explanation

- One explanation for these data, suggested by Bjork (1989), is that responses to TBF items were slowed because the representations of these items had been actively suppressed as a result of the cue to forget, which made them more difficult to encode when presented as probe items. This added encoding time then produced the parallel shift in TBF RTs relative to TBR and NP RTs evident in Figure 2.

Current Experiment

- In an effort to understand how suppression affects goal-related WM performance, we included trials on which a given item in the TBF set was then presented again in the subsequent TBR set (To-Be-Forgotten-then-Remembered; TBFR). The remaining items TBF and TBR items were unique to their sets (see Figure 3).
- We hypothesized that (a) to the extent that active suppression can be flexibly used to manage WM, TBF items should be slower than NP items, but TBFR items should be at least as fast as TBR, showing no evidence of prior suppression; and (b) to the extent that activation and suppression are separate resources, TBFR probes should be faster than TBR probes owing to repetition priming.

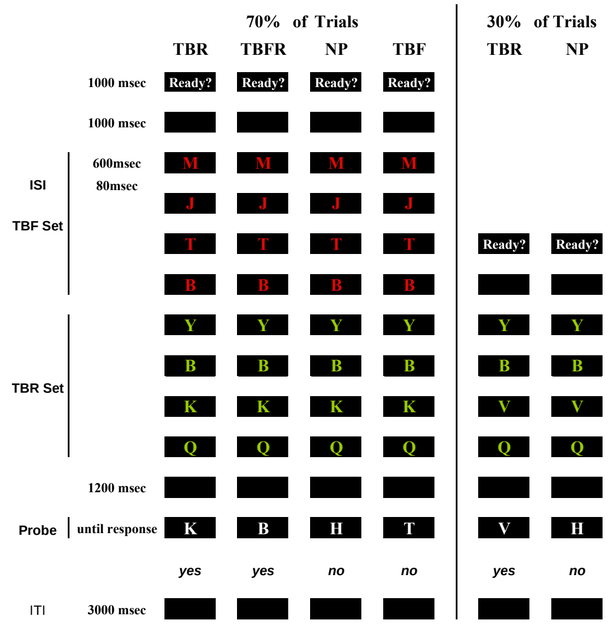


Figure 2. Experimental Design with TBFR trials. In the actual experiment, trials were equally likely to start with red or green letters.

Materials & Design

- Random letter streams were generated from all consonant letters except W.
- 32 catch trials (30%) had no color change (0 letters TBF) and had either 2 or 4 letters TBR
- 72 remaining trials had one color change and were equally divided amongst TBFR, TBR, TBF and NP probe types with either 2 or 4 letters TBF and TBR.
- In all color change trials one letter in the TBF set was repeated in the TBR set--in TBFR trials this repeated letter was probed

Procedure and Participants

- Instruction screens explained the task and presented examples
- 20 Participants practiced the task on 24 practice trials representing the different probe types and received feedback
- 2.5cm high letters were presented in red or green using a serif font on a black screen. Half of the trials began with red letters and half began with green.
- The timing of the sequence events on a given trial was as shown in Figure 2.
- Probe letters were presented in white on a black screen and remained until response.
- Subjects indicated whether the letter had appeared in the TBR set by pressing either the 1 or 3 key on the numeric keypad of a Macintosh Computer.

Results

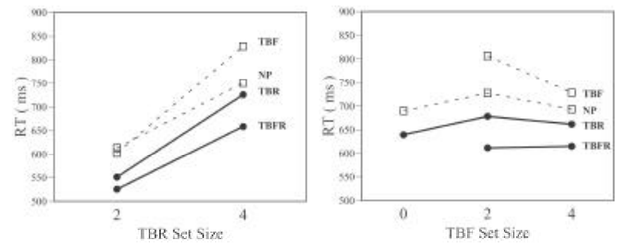


Figure 3. Results from Directed Forgetting Working Memory task.

- A within-subjects Analysis of Variance (ANOVA) showed a reliable effect of probe type and TBR set size on RT; F (3,57) = 7.17, MSE = 15962, p < .001 and F (1,19) = 16.46, MSE = 68524, p = .001, respectively. The interaction between probe type and TBR set size was not significant; F (3,57) < 1, ns.
- A single degree of freedom planned comparison of TBFR probes vs. TBR probes, collapsed across TBF load, showed that TBFR probes were processed reliably faster than TBR probes; F (1,19) = 146.98, MSE = 288899, p < .001.
- A within-subjects Analysis of Variance (ANOVA) showed a reliable effect of probe type but not TBF set size on RT; F (3,57) = 4.92, MSE = 32941, p = .004 and F (1,19) < 1, *ns*., respectively. The interaction between probe type and TBF set size approached significance; F (3,57) = 2.54, MSE = 11357, p = .066.
- Error rates were low (< 5%) and showed no systematic pattern.

Discussion

- In this experiment we replicated the basic phenomenon of the Directed Forgetting Working Memory paradigm: (a) RT was a function of TBR set size; (b) TBF responses were slower than NP responses; and (c) RT was not a positive function of TBF set size.
- In addition, we found that items twice presented in a trial--once in the TBF set and once in the TBR set (TBFR)--were correctly judged faster than items that were only presented only once in the TBR set.
- On such TBFR trials, participants initially encoded the letter in question believing that they have to remember it, were then cued to forget that and the other letters in the TBF set, but were again presented that letter in the TBR set
- Faster correct responding to such TBFR probes suggests that activation from "remember" encoding is separate from the action of suppression because when suppression is lifted there is enhanced performance from repetition priming.
- Suppression appears not to directly affect activation level, but instead has the separate ability to interfere with the item representation when it later attempts to enter WM.
- This interpretation is consistent with results from Neumann et al. (1993) who argued for separate activation and inhibition resources in WM and with previous findings that TBF items are readily relearned (Reed, 1970; Geiselman & Bagheri, 1985).

References

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