



# Cross-task repetition amnesia: Impaired recall of RSVP targets held in memory for a secondary task

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Received 16 May 2006; received in revised form 31 July 2006; accepted 12 August 2006

Available online 20 November 2006

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## Abstract

People often fail to select and encode the second of two targets presented within less than 500 ms in rapid serial visual presentation (RSVP), an effect known as the attentional blink. We investigated how report of the two targets is affected when one of them is maintained in working memory for a secondary, memory-search task. The results showed that report of either target was impaired when it was a member of the memory set relative to when it was not. This effect was independent of both the temporal interval separating the RSVP target from the presentation of the memory set and the interval separating the targets. We propose that the deficit in recall occurs because the association between a target and the memory-search task interferes with the formation of a new association between that target and the following RSVP task, with the result that observers may be biased to ascribe the target only to the memory set.

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*PsycINFO classification:* 2346; 2343

*Keywords:* Selective attention; Visual attention; Interference; Short-term memory; Verbal memory

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## 1. Introduction

Working memory and selective attention are core cognitive functions that enable us to interact with our environment in a goal-directed fashion. [Baddeley \(1997\)](#) defined working memory as “a system for temporarily holding and manipulating information as part of a wide range of essential cognitive tasks such as learning, reasoning and comprehending” (p. 49). Selective attention, on the other hand, controls the input of perceived information into the working memory system (e.g., [Baddeley, 1986](#); [Broadbent, 1958](#); [Reeves & Sperling, 1986](#)). Thus, in order to update goals and perceptions with new and relevant information from the world, processes of selective attention and working memory must interact.

The interaction between information held in memory and attentional selection can be observed in many common tasks, such as searching for a particular object in a field of other objects. In the context of search tasks, [Desimone and Duncan \(1995\)](#) proposed that attentional selection is driven by short-term descriptions (i.e., templates) of objects held in working memory. One hypothesis that follows from this view is that attentional selection of visual stimuli should be biased towards those stimuli that correspond to representations held active in working memory. Consistent with this hypothesis, [Downing \(2000\)](#) found that reaction time to a probe presented at the location of a face that had previously been memorized was faster than reaction time to probes presented at the locations of “new” faces, suggesting that faces held in memory more readily attracted attention than new, non-memorized, faces. Further support for memory-contingent attentional capture was reported by [Pashler and Shiu \(1999\)](#), who found that a previously imagined object automatically attracted attention when it was presented in a sequence of other objects. Specifically, when a search target (a digit) was presented shortly after the imagined object, target identification was hindered – presumably because of the time required to disengage attention attracted to the previously imagined object. Taken together, these findings indicate that objects held in visual working memory automatically attract attention when they are encountered in the visual environment.

In the present study, we investigated whether maintaining letters in working memory enhances selection and encoding of these letters when they are used as targets in a dual-target RSVP task ([Broadbent & Broadbent, 1987](#)). In this task, observers are to identify two visual targets (e.g., letters) embedded in a sequence of distractors (e.g., digits). Previous studies using this paradigm have shown that recall of the second target (T2) is often impaired when it is presented within 200–500 ms of the first target (T1). This phenomenon, called the *attentional blink* (AB; [Raymond, Shapiro, & Arnell, 1992](#)), has been shown to reflect a temporal limitation in our ability to select successive visual stimuli ([Nieuwenstein, Chun, Van der Lubbe, & Hooge, 2005](#); [Nieuwenstein & Potter, 2006](#)). In particular, [Nieuwenstein et al.](#), showed that the deficit in T2 report is substantially reduced when this target is directly preceded by a distractor that shares one of two target defining features (e.g., color). This result suggests that the AB reflects a failure to allocate attention to T2 in time before it is replaced by its mask, a failure that can be overcome by precuing the target with a distractor that shares a feature with the target.

Given that the AB effect depends critically on the allocation of attention to T2, we hypothesized that report of T2 should be facilitated if the target were to capture attention because it is held in memory. To test this hypothesis, we had observers perform an AB task during the retention interval of a memory-search task that required them to maintain a set of letters in memory for a later recognition task. The AB task required identification of two

letter targets presented in an RSVP sequence of digit distractors, so the identity of the targets was not known in advance. On half the trials, T2 (Experiments 1A and 1B) or T1 (Experiment 2) was included in this memory set. In order to control for the effect of maintaining a memory set, we also included conditions in which the AB task was performed in isolation. The effect of a match between one of the letters in the memory set and the RSVP target was determined by comparing identification performance for matching and non-matching targets, and the effect of maintaining a memory load was determined by comparing identification performance for the condition in which the memory set did not include either of the targets with performance in a condition in which the AB task was performed in isolation.

## 2. Method Experiments 1A and 1B

### 2.1. Participants

A total of 30 undergraduate students from Utrecht University participated in the experiments. Fourteen students participated in Experiment 1A (all stimuli in uppercase), and 16 in Experiment 1B (memory-set items in lowercase and targets in uppercase). All participants gave informed consent and received payment of €10 for participating.

### 2.2. Apparatus and stimuli

The stimuli were presented on a 17-in. monitor with a 75-Hz refresh rate. The generation of stimuli and collection of responses were controlled using E-Prime 1.0 software running on a Pentium III, 900-MHz processor. The stimuli were digits (excluding 1 and 0) and uppercase and lowercase letters (excluding all vowels, M, and W), presented in 12-point Courier font.

The experiments were conducted in a dimly lit laboratory room. Participants were seated at approximately 50 cm from the monitor. At this viewing distance, the stimuli subtended 0.8 by 0.6° of visual angle, on average.

### 2.3. Procedure and design

Each of the two experiments consisted of two blocks of trials. In one block, the AB task was performed in isolation, and in the other block it was performed in combination with the memory-search task. Each block consisted of 288 experimental trials preceded by 16 practice trials; the order of presentation of the blocks was counterbalanced across participants. Participants were told to give priority to the AB task. The experiment was completed in one session lasting about 90 min; participants were given the chance to take a break after 144 trials.

For the condition in which the AB task was performed in isolation, a trial started with the presentation of a fixation cross for 1500 ms, followed by an RSVP sequence containing 12 randomly selected digits and two randomly selected letters. Each item in the RSVP sequence was presented for 93 ms. The first target always appeared as the second item in the sequence and T2 followed after 0, 2, 4, or 7 digits (hereafter referred to as lags 1, 3, 5 and 8, respectively). Each lag was used equally often. Following the RSVP sequence, participants were asked to type the letters that they had seen in the RSVP stream using the keyboard. Although the order of report was not scored, participants were encouraged to

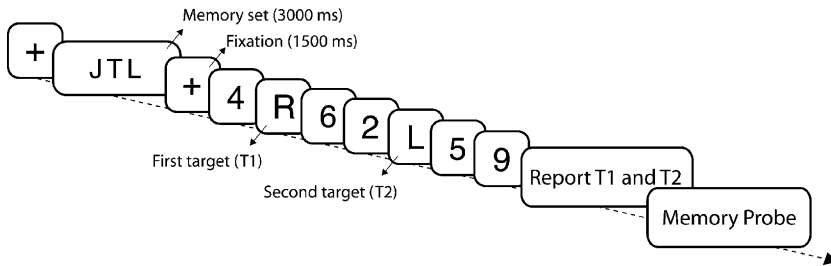


Fig. 1. Schematic representation of the sequence of events within a trial in which a memory load was present. On this trial, T2 was presented at lag 3, and included in the memory set.

type the letters in the order in which they had been seen. If a letter was not seen, the space bar was to be pressed instead.

The sequence of events for a trial in which the AB task was combined with the memory-search task is illustrated in Fig. 1. A trial began with the presentation of a fixation cross for 1500 ms, followed by the presentation of the memory set (which always contained three letters) and the AB task. In one half of the trials, T2 was a member of the memory set, whereas in the other half of the trials it was not. Following the participants' responses to the AB task, a memory probe (i.e., a letter that may have been a member of the memory set) appeared below the fixation cross in the same letter-case as that used for presentation of the memory set. In one half of the trials, the memory probe was present in the memory set, and in one half it was absent. Participants pressed the "1" key on the numeric keypad for target-absent responses and the "2" key for target-present responses.

For the trials in which a memory set was presented, each combination of T2 memory-set membership ("T2 in set" versus "T2 not in set"), lag (1, 3, 5, or 8) and correct probe response (absent versus present) was repeated 18 times, resulting in 36 trials per lag/memory-set membership combination.

#### 2.4. Data analysis

A first set of analyses showed that there were no differences in performance with an uppercase versus a lowercase memory set, indicating that the visual similarity between the T2 and the corresponding letter in the memory set did not affect performance for memory probe, T1 or T2 responses. Therefore, the results from Experiments 1A and 1B were combined for analysis. For the trials with a memory set, only those trials in which the response to the memory probe was correct were included in the data analyses. Performance for T1 and T2 identification was analyzed with repeated measures analyses of variance (ANOVA), using lag and memory-load condition as factors. For the analyses of T2 identification accuracy, pre-planned comparisons were made between the no load and T2 not in set condition to evaluate the effect of memory load on T2 report and between the T2 not in set condition and the T2 in set condition to evaluate the effect of maintaining T2 in memory.

### 3. Results Experiments 1A and 1B

The memory probe was correctly classified on 95% of the trials in which a memory set was presented. On these trials, T1 was identified correctly in 91% of the cases. Fig. 2a shows

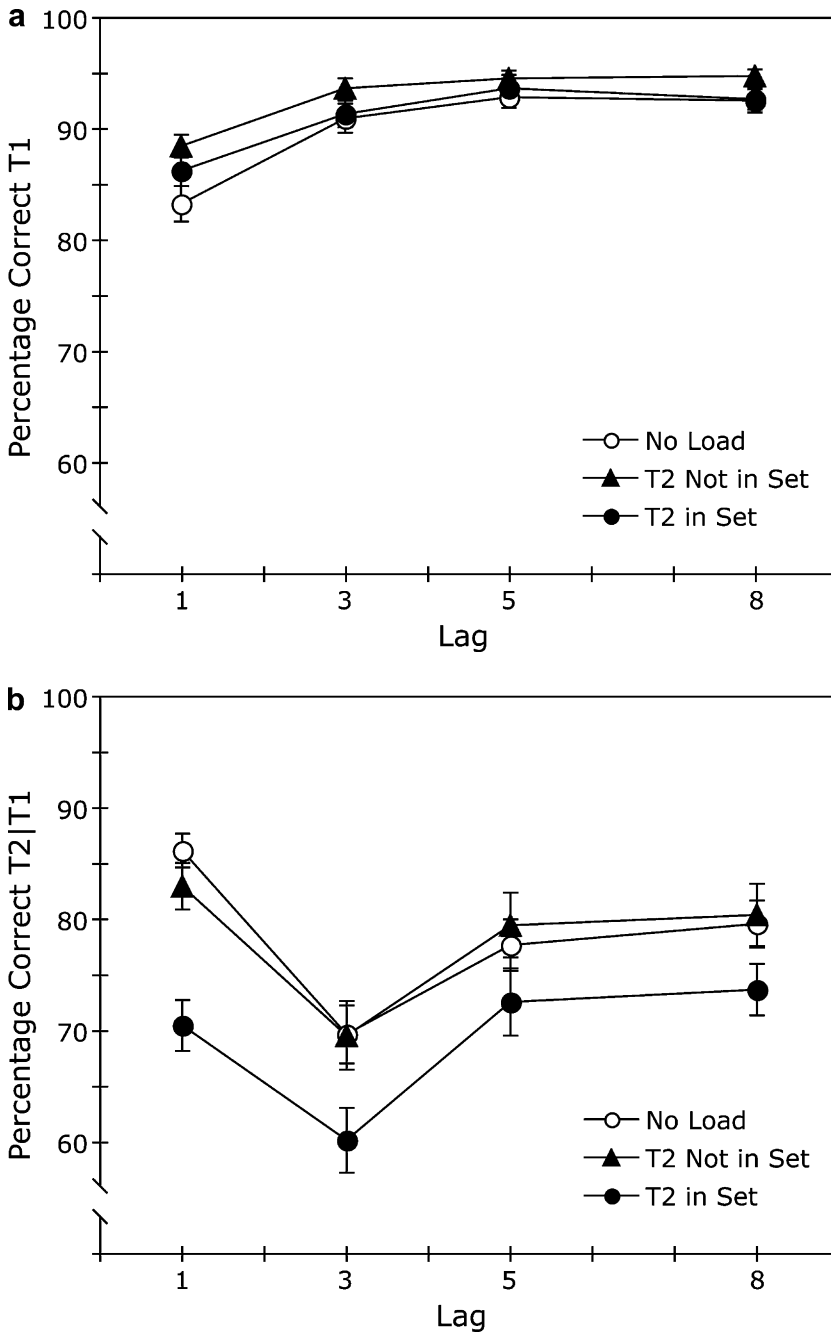


Fig. 2. Results Experiment 1. (a) T1 report accuracy plotted across lags and memory-load conditions. (b) Report accuracy for T2 for trials on which T1 was correctly identified (T2|T1), plotted as a function of lag and memory-load condition. Error bars show the standard errors of the means.

T1 performance across lag and memory-load condition. The ANOVA of the effects of lag (1, 3, 5, or 8) and memory-load condition (no load, T2 not in set or T2 in set) showed that both factors had a significant effect on T1 report,  $F(3, 87) = 40.3$ ,  $p < .001$ ,  $MSE = .003$ , and  $F(2, 58) = 8.7$ ,  $p = .001$ ,  $MSE = .007$ , respectively, while the interaction of these factors was not significant,  $F < 1$ . The effect of lag was such that T1 report increased from lag 1 to lag 3, while performance remained relatively stable across lags 3–8 ( $M = 85\%$ ,  $M = 91\%$ ,  $M = 93\%$  and  $M = 93\%$  for lags 1, 3, 5, and 8, respectively). As for the effect of memory-load condition, T1 report accuracy was 92%, 89%, and 90% correct, respectively, for the no load, T2 not in set, and T2 in set conditions. To examine whether the differences in T1 performance between the three conditions were significant, we conducted post hoc comparisons using the Student Newman–Keuls test ( $\alpha = .05$ ). These tests revealed that the difference between the no load and T2 not in set condition was significant, while none of the other pair-wise differences reached significance.

Identification performance for T2 on trials in which T1 was correctly identified (i.e., T2|T1) is shown across lags and memory-load conditions in Fig. 2b. As can be seen in this figure, there were two main results. First, T2 identification accuracy showed a “U”-shaped function across lags in all conditions, signifying the occurrence of an AB. Second, there was little difference between T2 report in the no load and T2 not in set conditions, whereas performance in the T2 in set condition appeared to be impaired relative to the two other conditions.

The effect of memory load on T2 report was evaluated with a repeated measures ANOVA using lag (1, 3, 5, and 8) and memory-load condition (no load versus T2 not in set) as factors. The results showed a significant main effect of lag,  $F(3, 87) = 21.80$ , while the effect of memory-load condition was not significant ( $F < 1$ ). The Lag  $\times$  Memory-load interaction also failed to reach significance,  $F(3, 87) = 1.4$ ,  $MSE = .005$ ,  $p = .25$ . A second ANOVA on T2 report accuracy examined the effect of the presence versus absence of T2 in the memory set. This analysis showed significant main effects of both lag and memory-load condition,  $F(3, 87) = 15.7$ ,  $MSE = .013$ ,  $p < .001$  and  $F(1, 29) = 76.85$ ,  $MSE = .006$ ,  $p < .001$ , respectively. The interaction between lag and memory-load condition was non-significant,  $F(3, 87) = 1.2$ ,  $MSE = .008$ ,  $p = .30$ . To further evaluate the main effect of memory-load condition, the difference between the two conditions at each lag was analyzed using Student Newman–Keuls tests. These tests showed that the difference between the T2 report in the T2 not in set and T2 in set conditions was significant at each lag (familywise  $\alpha = .05$ ).

Analyses of errors in T2 identification in the two conditions with a memory load showed that intrusions of letters from the memory set occurred no more frequently than would be expected by chance (i.e., 16.6% intrusions in the T2 not in set condition, with chance being 3 out of 18, versus 12.1% in the T2 in set condition with chance being 2 out of 18).

#### 4. Discussion Experiments 1A and 1B

The results from Experiments 1A and 1B reveal a counterintuitive finding: Report accuracy for the second of two RSVP targets was impaired rather than improved when the corresponding letter was included in a memory set that was retained throughout the presentation of the RSVP trial. This impairment for targets retained in memory for the memory search task suggests that there was item-specific cross-talk between the two task, an effect similar to the finding that reaction times for solving an arithmetic task with a particular digit are slower when that digit is held in memory for another task (Dutta, Schweickert, Choi, & Proctor, 1995). The lack of any differences between the results of

Experiments 1A and 1B further show that the cross-talk effect was not affected by whether T2 was presented in the same letter-case as the letters in the memory set. In addition, the magnitude of the deficit was stable across temporal separations between the two targets, and, therefore, also did not depend on the temporal separation between the presentation of the memory set and T2. An additional noteworthy result from Experiments 1A and 1B was that T2 report was not affected by the requirement to maintain a memory set when T2 was not included in this set. On the other hand, there was a small, but reliable, reduction in T1 performance when the AB task was performed in conjunction with the memory-search task. Further discussion of these results is provided after Experiment 2 is reported.

## 5. Method Experiment 2

The main finding from Experiments 1A and 1B was that T2 report accuracy was impaired when T2 was included in the memory set that was retained throughout the RSVP trial. The goal of Experiment 2 was to determine whether this effect generalizes to T1. In other words, would T1 identification also be impaired when T1 is included in the memory set? Experiment 2 was identical to Experiment 1A (targets and memory set both presented in uppercase) with the exception that now T1 (and not T2) could be included in the memory set. Twenty-four students from Utrecht University volunteered to participate in the experiment, for which they were paid €10.

## 6. Results Experiment 2

The memory probe was correctly classified on 91% of the trials. On 85% of these trials, T1 was correctly identified. As can be seen in Fig. 3a, T1 report accuracy increased across lags in all conditions. In addition, T1 performance appeared to be worst when T1 was included in the memory set, and there also appeared to be a difference between the no load and T1 not in set conditions.

A repeated measures ANOVA of T1 identification accuracy as a function of lag (1, 3, 5, or 8) and memory-load condition (no load, T1 not in set, or T1 in set) revealed significant effects of lag and memory-load condition on T1 report,  $F(3,69)=16.28$ ,  $p<.001$ ,  $MSE=.006$ , and  $F(2,46)=38.72$ ,  $p<.001$ ,  $MSE=.013$ , respectively. The Lag  $\times$  Memory-load condition interaction failed to reach significance,  $F(6,138)=1.9$ ,  $p=.08$ ,  $MSE=.004$ . A comparison of T1 report in the three conditions showed that T1 report was significantly worse in the T1 not in set condition than in the no-load condition,  $M=82\%$  versus  $M=87\%$ , respectively,  $F(1,23)=11.97$ ,  $MSE=.029$ ,  $p=.002$ , while performance in the T1 in set condition ( $M=73\%$ ) was worse than performance in the T1 not in set condition,  $F(1,23)=47.80$ ,  $MSE=.014$ ,  $p<.001$ . The percentage of trials in which errors in T1 report were intrusions of other letters from the memory set did not differ significantly between the conditions in which T1 was or was not included in the memory set, with 15.7% intrusions for the T1 not in set condition versus 13.7% intrusions for the T1 in set condition,  $F<1$ .

In a second set of ANOVAs, T2 report was analyzed as a function of lag and memory-load condition (no load, T1 not in set, or T1 in set), including only those trials on which T1 was correctly identified (T2|T1, see Fig. 3b).<sup>1</sup> There was a significant main effect of lag,

<sup>1</sup> Including trials in which T1 was not identified did not change the pattern of results.

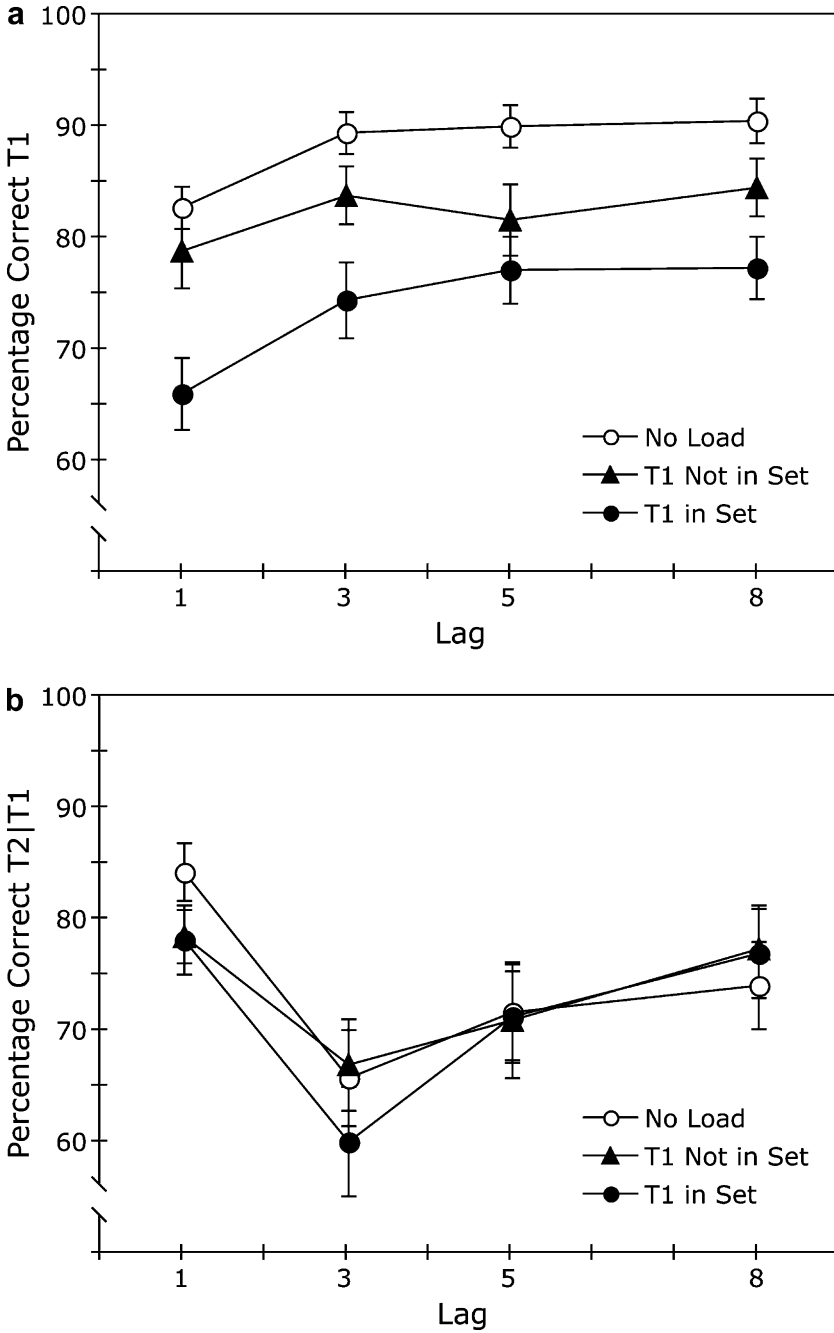


Fig. 3. Results Experiment 2. (a) T1 report accuracy plotted across lags and memory-load conditions. (b) Report accuracy for T2 for trials on which T1 was correctly identified (T2|T1), plotted as a function of lag and memory-load condition. Error bars show the standard errors of the means.

$F(3, 69) = 11.38$ ,  $MSE = .03$ ,  $p < .001$ , whereas the effect of memory-load condition was non-significant,  $F < 1$ . In addition, there was a significant Lag  $\times$  Memory-load condition interaction,  $F(6, 138) = 2.27$ ,  $MSE = .008$ ,  $p = .04$ . Importantly, however, this interaction was not significant for the comparison of the T1 not in set and T1 in set conditions,  $F < 1$ , indicating that the AB effect for T2 was not modulated by whether or not T1 was included in the memory set. Instead, this interaction was driven by significance of the interaction for the difference between the T1 not in set and the no load conditions,  $F(1, 23) = 5.93$ ,  $MSE = .013$ ,  $p = .023$ . This interaction appeared to be driven by the difference between the two conditions at lag 1 ( $M = 78\%$  versus  $M = 84\%$  correct T2 report for the T1 not in set and no load conditions, respectively), such that the interaction became non-significant after excluding lag 1 from the analysis.

## 7. Discussion Experiment 2

The results from Experiment 2 replicate the finding of Experiment 1 that report of RSVP targets is impaired for targets that are included in the memory set. In particular, Experiment 2 buttresses the generality of the effect observed for T2 report in Experiments 1A and 1B by showing that the same effect occurs for T1 report. In addition, the results from Experiment 2 show that even though T1 report was impaired on trials in which T1 was included in the memory set, this did not affect report of a following T2, given that T1 was correctly reported. Finally, the results from Experiment 2 also replicate the results from Experiments 1A and 1B in showing that when neither of the targets was present in the memory set, the requirement to encode and retain the memory set interfered with report of T1, but not with report of T2 (although there was some hint of a detrimental effect of memory load on T2 report when T2 appeared in direct succession to T1 at lag 1).

The finding that the presence of a memory set interfered with T1 report is likely to reflect a residual cost of encoding of the memory set. Notably, as argued by Logan (1978) in his review of studies using memory retention as a secondary task, “in general, memory loads of five items or less produce no interference”, but “loads of less than five items have been shown to produce interference when the array for the visual task is presented less than 1 s after the memory load” (p. 36). Consistent with this conclusion, the results from the two experiments reported in the present study showed no effect of a memory load of three letters on T2 report, while a load effect was consistently observed for report of T1. Given that T1 always appeared as the second item in the RSVP sequence, the load effect thus appeared to be confined to targets appearing shortly after the offset of the memory set.

The conclusion that memory load in general does not produce a dual-task decrement in RSVP target identification (unless the target shortly follows the memory set), stands in contrast to previous work by Akyürek and Hommel (2005) in which evidence for a memory-load effect on RSVP target identification was found. However, the results reported by Akyürek and Hommel should be interpreted with caution for two reasons. First, the magnitude of the effect of varying memory load observed in those experiments was small. For example, mean T2 report accuracy under conditions of maintaining a memory set of 2, 4, or 6 items (letters, digits or keyboard symbols) averaged 86.4%, 85.5%, and 83.9% correct, respectively. Thus, there was only a 2.5% difference between a memory load of two and a memory load of six items, an effect that most likely reached significance because the data were pooled across 90 subjects. In addition, it is possible that this effect was confounded with the use of different encoding strategies for the different set sizes. This is because the

memory sets in the study by Akyürek and Hommel were drawn from sets of eight items and therefore participants could have attempted to solve the memory task in the condition with a load of six items by remembering which two items were not included in the memory set. Therefore, the results reported by Akyürek and Hommel cannot be interpreted as conclusive evidence for a memory-load effect on target report in RSVP.

## 8. General discussion

In three experiments, we investigated how recall of letter targets presented in RSVP is affected when the target matches a letter retained in working memory for a secondary task. In contrast to the predicted benefit for report of memorized targets, the results from all three experiments consistently showed that report accuracy was reduced for targets that were held in memory during the RSVP task. The magnitude of the impairment observed for memorized targets was stable across inter-target intervals, and it also did not depend on the temporal separation between the presentation of the memory set and the target. In addition, the impairment occurred regardless of whether the target was presented in the same letter-case as the memory set. Thus, there was no evidence for memory-guided attentional capture for RSVP targets retained in working memory, and, surprisingly, these targets were actually more difficult to remember than targets that had not been included in the memory set. A meta-analysis across all three experiments showed that this cross-talk effect also appeared to influence performance on the memory-search task. In particular, the results from this analysis showed that observers were reluctant to ascribe to the memory set probe letters that had been present in both the memory set and the RSVP sequence,  $M=90\%$  versus  $M=94\%$  correct for probes that were present versus absent in RSVP, respectively ( $p < .001$  by  $t$ -test). That is, when the probe was one of the targets in the RSVP task, observers were less likely to ascribe it to the memory set.

The finding that the AB was not attenuated for targets that matched one of the items in the memory set seems inconsistent with the results from previous studies that did find an attentional bias for stimuli that corresponded to representations held in working memory (Downing, 2000; Soto, Heinke, Humphreys, & Blanco, 2005). There are two possible reasons for this discrepancy. The first is that the RSVP target identification task we used to probe whether there is attention capture for memorized items required observers to identify and memorize RSVP targets that were either present or absent in the memory set. On the other hand, the studies that have found support for attention capture by memorized stimuli used tasks in which the memorized item appeared as a distractor, and thus did not require memorization. As discussed below, the requirement to encode into memory an item that is already held in memory for another task may be critical for the present finding of impaired rather than improved performance for memorized RSVP targets.

A second reason for the discrepancy between the present results and previous work that did find support for an attentional bias for memorized information may lie in the nature of the stimuli used. In the present study, subjects had to remember letters while the working-memory representation in these other studies consisted of faces, colored shapes, or self-generated visual representations created by imagery. These types of stimuli differ in that letters are likely to be recoded into a non-visual, phonological format and subsequently retained by means of subvocal rehearsal, while maintaining the latter types of stimuli in working memory is more likely to require sustained activation of the corresponding visual representations (e.g., Smith & Jonides, 1999). From these considerations it follows that

memory-guided capture of visual attention may occur only for stimuli that match pictorial representations retained in visual working memory, and not for visual stimuli that match working memory representations that are maintained in verbal working memory.

The impairment observed for letters that matched one of the letters in the memory set was found to be independent of a variety of manipulations, including the availability of attentional resources as indexed by the AB, the match between the letter-case of the RSVP target and the items in the memory set, and the duration of the interval separating the offset of the memory set and the onset of the RSVP target (i.e., 1.5–2.0 s). On the basis of these characteristics and the specifics of the procedures used in the present study, it can be argued that the effect is different from previously described cases in which recall accuracy has been found to be impaired for repeated stimuli; namely, repetition blindness (Kanwisher, 1987) and the Ranschburg effect (e.g., Crowder, 1968; Henson, 1998; see Fagot & Pashler, 1995; for a comparison of these two effects). Notably, the impairment we observed for RSVP targets is different from transient repetition blindness effects (i.e., the failure to encode and recall stimuli that are repeated in RSVP across intervals of less than 200–400 ms) because it was found to be robust across repetition intervals of more than 2 s. Similarly, the present effect can also be differentiated from the so-called Ranschburg effect: a failure to report repeated items in serial recall (e.g., Crowder, 1968). In particular, the Ranschburg effect has been shown to reflect a bias towards not repeating previously retrieved and recalled items (Henson, 1998), while the repetition deficit we observed occurred in a procedure that required observers to first report the RSVP targets, and then to perform the probe-recognition task for the memory-search task.

The differences between the characteristics of the repetition deficit we observed and those of the repetition blindness and Ranschburg effects may be ascribed to a critical aspect of the present procedure: the fact that repetitions occurred across two separate tasks (i.e., the memory-search task and the RSVP task). In contrast, repetitions occur in the same task and within a single list of items in the procedures that give rise to repetition blindness and the Ranschburg effect. Therefore the differences between the latter phenomena and the present finding may be due to the fact that our task required observers to know both which letters were presented and to which task which letters belonged, while in these other procedures task context was not a factor.

In order to devise an account of how the association between an RSVP target and the memory set might interfere with reporting that target when it is presented in RSVP, it is informative to first consider the sequence of processing events that underlie the ability to report the identity of an RSVP target. Based on previous accounts of target report in RSVP and the attentional blink in particular (Chun, 1997; Chun & Potter, 1995; Davenport & Potter, 2005; Kanwisher, 1987; Potter, Staub, & O'Connor, 2002), the following – simplified – scenario can be constructed (see Fig. 4 for the main components).

A first step in processing RSVP items involves the categorization of the items on the basis of conceptual representations activated early on in processing. When one of these items matches the target description, the allocation of attentional resources is initiated (e.g., Chua, Goh, & Hon, 2001; Nieuwenstein et al., 2005). These resources allow the otherwise fleeting and volatile representation of the target to be sustained so that additional processing can occur. Additional processing involves full identification (i.e., convergence on a single matching representation; Davenport & Potter, 2005), the activation of the appropriate response (e.g., Hommel, 1998), and the binding of the representation to information about the episodic context in which it was encountered. The result of this binding or *tokenization*

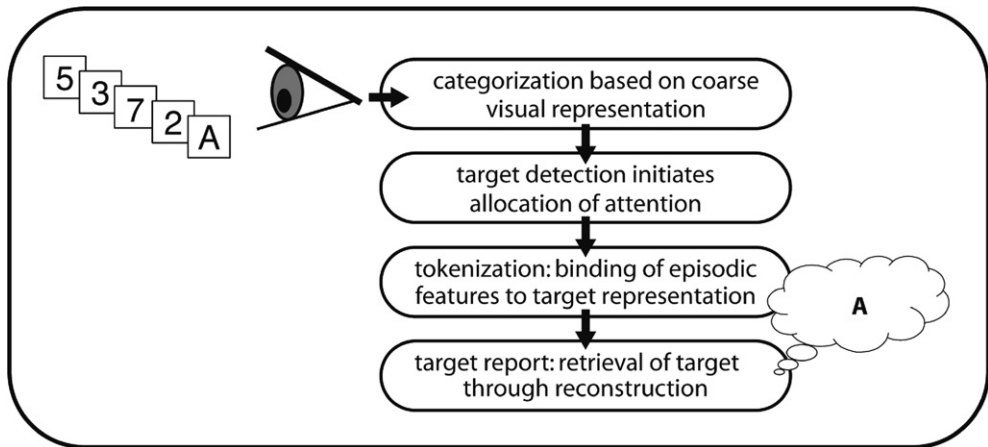


Fig. 4. Sequence of processing events underlying target report in RSVP.

process is a short-term memory representation, often referred to as a token (Chun, 1997; Kanwisher, 1987) or object file (Kahneman, Treisman, & Gibbs, 1992), that links target identity to the context in which it was perceived. This contextual information can later be used at the time of report to reconstruct the serial order of successive targets (Wyble & Bowman, 2005), and to determine to which task a particular item represented in short-term memory belonged.

Given that the repetition deficit was not modulated by the availability of attentional resources (i.e., its magnitude did not depend on whether the target was presented during the AB), the processing scheme described above leaves two possible, *post-attentive* loci where processing of the RSVP target might have suffered interference from the previously established association between that target and the context of the memory set. Indeed, there are reasons to argue that both the stage of tokenization and the stage of retrieval may have been affected. During the tokenization stage, the establishment of binding links between the target and the context of the RSVP task may have been interfered with by a pre-existing link between this target and the context of the memory set. This interference might occur because the previous association is automatically retrieved when the representation of the RSVP target is activated – a mechanism similar to that described in episodic retrieval accounts of negative priming (e.g., Neill & Mathis, 1998; Neill, Valdes, Terry, & Gorfein, 1992; see also Logan, 1988). As a consequence of the automatic, rapid, activation of the previously established association, the process of binding the target to the context of the RSVP task may be delayed. Given that the target is only briefly presented and masked in RSVP, this delay would prevent the formation of a strong association between the target and the RSVP task, thereby resulting in a less distinctive memory trace for targets that were included in the memory set.

A second mechanism that might have contributed to the impairment in recall of targets previously encountered in the memory set is competition between the memory traces for the two tasks at the time of report. This possibility is suggested by the fact that performance for the memory-search task also appeared to be affected by whether or not the probe had been presented as a target in RSVP. Notably, observers more often falsely rejected probes that had been present in the memory set when these probes had also

appeared in the RSVP sequence than when they were not present in the RSVP sequence. This finding suggests that observers were biased towards ascribing each stimulus to only one of the two tasks. Assuming that this bias depended on the strength of the associations between the target and the two tasks (i.e., the tokens, or memory traces for the memory-search and RSVP targets, respectively), it follows that observers would be more inclined to ascribe repeated targets to the memory set than to the RSVP task. In particular, there was ample time for encoding the memory set without any interference from previously established tokens. In contrast, less time was available for encoding of the RSVP targets, both because of the brief and masked exposure and because there may have been interference from the association with the memory set.

Although the deficit for report of RSVP targets that were held in memory was observed across three experiments in the present study, it is important to note that a recent study by Akyürek and Hommel (2006, Experiment 2B) did not find a repetition deficit under similar conditions.<sup>2</sup> However, there are several procedural differences between our experiments and Akyürek and Hommel's Experiment 2B that may account for this discrepancy. These differences are that the memory-set items in the study by Akyürek and Hommel were drawn from a smaller set of stimuli than ours (i.e., 10 digits versus 18 consonants), that Akyürek and Hommel used digits whereas we used consonants, that the memory set was always four items in Akyürek and Hommel's study whereas it was three items in our study, and that the memory set was presented for 1 s in Akyürek and Hommel's study whereas it was presented for 3 s in our experiments. The shorter presentation duration of the memory set, together with the larger number of items in the memory sets used in Akyürek and Hommel's study, may have resulted in weaker associations between the memory-set items and the memory-search task than that in our experiments, which according to our account, would decrease the magnitude of the repetition deficit. In addition, the differences between targets that were present in the memory set and targets that were not in the set may have been reduced in Akyürek and Hommel's study because the use of a small set of stimuli (i.e., the 10 digits) may have diminished the difference in association strength for items retained in memory and items not retained in memory on a particular trial. Notably, it is possible that the association between a target and the memory set to some extent carries over from one trial to the next and that as a consequence a target not present in the memory set on trial  $N$  might still suffer the interference caused by that targets' association with the memory set on trial  $N - 1$ . Finally, the use of digits may have constrained the repetition deficit for individual digits in Akyürek and Hommel's experiment because it allowed for recoding individual digits into composite numbers (e.g., 1240 might be encoded as twelve-forty) and other strategies (e.g., one could do the memory task for the set "6987" by remembering that all digits were larger than 5), while such recoding seems less likely with consonants. In short, we believe that Akyürek and Hommel's Experiment 2B might not have been sensitive to the repetition deficit, much as our experiments were not sensitive to the load effects they did observe. It should also be noted that we have now replicated the repetition deficit across several experiments (see Martens, Johnson, & Nieuwenstein, 2004; Johnson, Nieuwenstein, & Martens, submitted for publication), using both words and letters as stimuli, and we are therefore confident that this is a robust and replicable effect.

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<sup>2</sup> We would like to thank an anonymous reviewer for informing us of this study, and we would like to note that we were unaware of this work at the time of submitting the paper.

In conclusion, the present work shows that observers have difficulty in remembering stimuli that are repeated across different tasks. We argued that this repetition deficit reflects the difficulty of forming distinctive, context-specific, memory traces for stimuli repeated across different tasks, and differentiating between these at the time of retrieval. This effect, which we would like to term “*cross-task repetition amnesia*”, points towards an intriguing shortcoming of the short-term memory mechanisms that allow us to deal with an environment in which different instances of similar and identical objects are frequently encountered in different situations.

## Acknowledgements

The experiments reported in this study were conducted as part of Mark Nieuwenstein’s dissertation while at Utrecht University. This work was also supported by NIMH grant MH47432. We would like to thank Mary C. Potter, Sander Nieuwenhuis and an anonymous reviewer for helpful comments.

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