Research Report

The Importance of Temporal Distinctiveness for Forgetting Over the Short Term

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ABSTRACT—*Rapidly forgetting information once attention is diverted seems to be a ubiquitous phenomenon. The cause of this rapid decline has been debated for decades; some researchers claim that memory traces decay as a function of time out of the focus of attention, whereas others claim that prior memory traces cause confusability by interfering with the current trace. Here we demonstrate that performance after a long delay can be better than performance after a short delay if the temporal confusability between the current item and previous items is reduced. These results provide strong evidence for the importance of temporal confusability, rather than decay, as the cause of forgetting over the short term.*

A common occurrence for many of us is the feeling that, if attention is diverted away from some information, then that information will be rapidly lost from memory. For instance, imagine being introduced to someone named “Bob” at a party. After the introduction, the conversation proceeds at a lively pace until the end, when you realize that you cannot remember the name of the person you were just speaking with. Why is this? What happened to the person’s name during the conversation? Is there any way to alleviate this rapid loss of information? Investigators have conducted many studies to try to understand why information seems to be lost rapidly from memory. Indeed, one of the most fundamental and widely known patterns of data in psychology is the classic *forgetting function*. This function, taught in every introductory psychology class, reflects the loss of information from memory over a delay period of varying length. The mechanism or mechanisms responsible for this loss are still hotly debated. Two main theories have been proposed to explain this rapid loss of information. Some theorists hold that passive decay due to absolute amounts of time underlies information loss, whereas others endorse a temporal-discrimination view and posit that items are rendered unretrievable by interference from other presented items. Here we examine these two causes of forgetting by examining the retention of single items after delays of varying length (Peterson & Peterson, 1959).

The notion that the absolute amount of time intervening between presentation and recall of a memory is important has long been a component of intuitive and scientific theories of forgetting. Indeed, much of the scientific work examining absolute amounts of time on forgetting over the short term started with experiments by J. Brown (1958) and Peterson and Peterson (1959). In these experiments, participants were presented with a single item (e.g., three consonants) and then were required to perform a rehearsal-prevention task (e.g., counting backwards by 3s) for varying amounts of time (e.g., 3–18 s). Much as when one tries to remember someone’s name after a short conversation-filled delay, performance was high after a delay of only 3 s, but dropped off rapidly as delay increased. Early researchers interpreted this precipitous drop in performance as evidence for the decay of memory traces. Specifically, it was suggested that the memory trace of the item had a greater opportunity to decay as the absolute amount of time between presentation and recall of the item increased, leading to poor performance. In these views, it is argued that absolute amounts of time are critical for forgetting over the short term and leave open the possible mechanism that is correlated with absolute amounts of time (Cowan, Saults, & Nugent, 1997; although see Cowan, Saults, & Nugent, 2001, for an alternative explanation based on distinctiveness). According to this view, if rehearsal is prevented, then forgetting is due only to the absolute amount of time that has passed since the item was presented. Thus, this view leads to a fairly intuitive and straightforward account of forgetting. That is, you forgot the name of the person you were speaking with simply because that information decayed to a point that it could no longer be recovered.

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Other researchers, however, have roundly rejected decay as the cause of forgetting, and instead endorse the notion that previously presented items interfere with the ability to recall the current item because of problems in discrimination at retrieval (Baddeley, 1976; G.D.A. Brown, Neath, & Chater, 2007; Capaldi & Neath, 1995; Crowder, 1976; White, 2002). Specifically, these researchers have suggested that forgetting occurs because the current item gets confused with items presented previously, and it is this proactive interference, and not decay, that is the main cause of forgetting. The findings that there is virtually no forgetting on the first trial of an experiment, and hence no proactive interference (Keppel & Underwood, 1962), and that there is generally very little forgetting if participants are given only one trial (Baddeley & Scott, 1971) are consistent with this interpretation; however, it should be noted that Baddeley and Scott interpreted the drop in performance in their study as evidence for decay (see G.D.A. Brown et al., 2007, for an explanation of these results based on temporal distinctiveness). Thus, according to these views, proactive interference (and hence forgetting) occurs because the information is no longer temporally distinct after a long delay, but rather blends in with other similar information presented previously, causing increased confusability between items. Thus, you forgot the name of the person you were speaking with because the name became confused with other names presented previously at the party.

This view has been supported by studies showing that if the time between trials (intertrial interval, ITI) is relatively long (i.e., 60 s), there is usually very little proactive interference and very little forgetting (Bennett, 1975; Kincaid & Wickens, 1970; Loess & Waugh, 1967). Making an item temporally distinct by increasing the amount of time between trials leads to either an overall boost in performance (but still some forgetting) or a flat forgetting function in which performance does not drop with delay. A further demonstration of the importance of temporal distinctiveness comes from a study (Turvey, Brick, & Osborn, 1970) in which participants were tested in a version of the Brown-Peterson task during which each item was recalled after a constant retention interval (RI; i.e., 5, 10, 15, 20, or 25 s) in the first four trials. On the fifth trial, some participants received the same RI as on the previous four trials, some received a shorter RI, and others received a longer RI; participants in the three conditions received the exact same RI on the fifth trial (15 s), but the groups differed in the length of the RI on the previous four trials (i.e., 10, 15, or 20 s). In line with a temporal-distinctiveness account, Turvey et al. (1970) found that performance was virtually the same for participants who received the same RI as the previous four trials (15–15 group), worse for participants who received a longer RI relative to the previous four trials (10–15 group), and better for participants who received a shorter RI relative to the previous four trials (20–15 group). This finding suggests that it is not the absolute amount of time that is important (each group received the same RI), but the relative amount of time between trials (see also Greene, 1996). Collectively, these studies suggest that temporal confusability (lack of distinctiveness), rather than pure decay of items, is important for forgetting from working memory (G.D.A. Brown et al., 2007).

The primary goal of the current study was to determine whether decay or temporal confusability is the primary cause of forgetting over the short term. According to decay views, performance after long delays should always be worse than or equal to performance after short delays, whereas, according to temporal confusability views, it should be possible to construct a situation in which performance is better after a long delay than after a short delay by making the long delay temporally distinct relative to the previous trials. We used a variant of the classic Brown-Peterson task (see Fig. 1) to examine whether decay or temporal confusability is the primary cause of forgetting over the short term. Participants were presented with a single consonant trigram and were instructed to remember it for a later test. In between the presentation of the item and recall, participants counted backwards from a three-digit number for varying amounts of time (i.e., RI). Three between-subjects conditions were tested manipulating the ITI at one specific RI. Specifically, in the control condition, the ITI (i.e., 1.5 s) was the same for all RIs. In the 16–60 RI-ITI condition, a long ITI (60 s) preceded only the 16-s RI; all other RIs were the same as the control condition. Likewise, in the 8–60 RI-ITI condition, only the 8-s RI was preceded by the long ITI (60 s). Thus, in all three conditions, the absolute amount of time between presentation and recall of items was exactly the same. The only difference between the conditions was the amount of time between trials, and this was isolated only to a particular delay for each of the experimental conditions. According to decay theories, there should be no difference between the three conditions because the conditions were equated for absolute amounts of time, leading to the same amount of decay. In contrast, temporal confusability theories should predict better overall performance in the two experimental conditions because proactive interference has been reduced. Additionally, because the experimental manipulation of temporal distinctiveness (i.e., the 60-s ITI) is localized to only one delay, temporal confusability theories should predict improved performance on those trials than on trials that are less

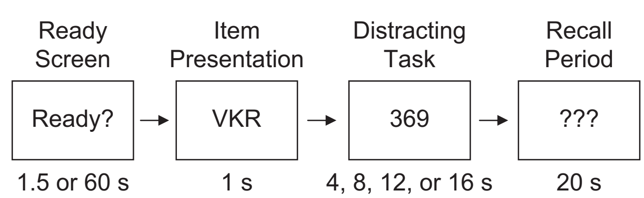

Fig. 1. Schematic layout of a trial sequence for the Brown-Peterson task used in the current study. First, a ''ready'' screen was presented for 1.5 or 60 s. Then, participants saw one consonant trigram. On some trials, participants then moved directly to the recall phase. On other trials, participants were presented with a distracting task before recall; a three-digit number was presented, and participants were required to count backward out loud from that number for a designated amount of time (4, 8, 12, or 16 s). In the recall phase, participants were allowed 20 s to type in the consonant trigram.

temporally distinct. That is, there should be a temporal release of proactive interference localized only to delays preceded by the 60-s ITI. Hence, for the 16–60 RI-ITI condition, these theories should predict that performance after this long delay should actually be better than performance after a shorter delay. To our knowledge, such a finding has never been empirically demonstrated.

METHOD

Participants and Design

Participants were 87 undergraduate students recruited from the subject pool at the University of Georgia. Participants were randomly assigned to one of the three conditions (control condition, $n = 30$; 8-s condition, $n = 29$; 16-s condition, $n = 28$). Participants were between the ages of 18 and 35 and received course credit for their participation. Each participant was tested individually in a laboratory session lasting approximately an hour and a half. Participants performed two practice trials and 75 real trials (15 trials for each of the five delays). The design was a 3 (condition: control, 8–60 RI-ITI, or 16–60 RI-ITI) $\times$ 5 (RI: 0, 4, 8, 12, or 16 s) mixed factorial design, with RI as the within-subjects variable.

Procedure

As shown in Figure 1, the "Ready" screen was presented for either 1.5 or 60 s. An item (a consonant trigram) was then presented alone for 1 s. After item presentation, participants engaged in a distractor task before recall: Participants saw a three-digit number and were required to count backwards aloud for a designated amount of time (4, 8, 12, or 16 s). The five different delays were randomly intermixed throughout the task, and participants did not know the duration of the delay beforehand. In the no-delay condition, participants were presented with the item, and the recall period followed immediately. At recall, participants saw three question marks appear in the middle of the screen, and they were required to type in their response within 20 s. Before the practice and real trials, participants received a brief typing exercise (typing the words *one* through *ten*) to assess their typing efficiency. Immediately after the recall period, a new Ready screen appeared and the same sequence was repeated. In the control condition, a 1.5-s Ready screen preceded all trials. In the 16–60 RI-ITI condition, a 60-s Ready screen preceded *only* the 16-s RI; all other RIs were preceded by the 1.5-s Ready screen. Likewise, in the 8–60 RI-ITI condition, only the 8-s RI was preceded by a Ready screen for 60 s; all other RIs were preceded by the Ready screen for 1.5 s.

RESULTS AND DISCUSSION

The resulting forgetting functions for the three conditions are shown in Fig. 2a. There was substantial forgetting in the control condition, replicating many previous findings. Additionally, performance in the 8–60 RI-ITI and 16–60 RI-ITI conditions was

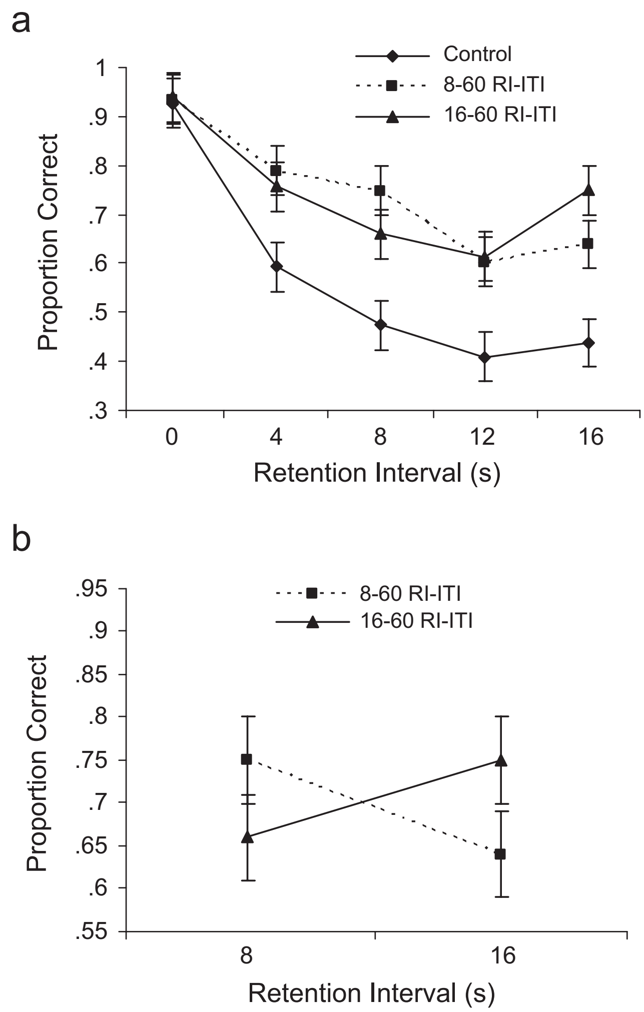

Fig. 2. Forgetting functions (proportion correct as a function of retention interval, RI). The graph in (a) shows results for the control condition and the two experimental conditions. In the control condition, the intertrial interval (ITI) was 1.5 s for all RIs. In the two experimental conditions, a longer, 60-s ITI was used before trials with the 16-s RI (16–60 RI-ITI) or before trials with the 8-s RI (8–60 RI-ITI), and the 1.5-s ITI was used in all other cases. The graph in (b) highlights the crossover interaction observed for the 8-s and 16-s RIs in the experimental conditions. Error bars represent 95% confidence intervals (based on the methods of Loftus & Masson, 1994).

better than performance in the control condition (both p_{rep}s $> .99$), but not different from each other overall ($t \leq 1$). However, critically, we found that performance in the 16–60 RI-ITI condition after the 16-s RI ($M = .75$, $SE = .04$) was reliably better than performance after an RI of 8 s ($M = .66$, $SE = .04$) or 12 s ($M = .61$, $SE = .05$; both p_{rep}s $> .99$) and not different from performance after an RI of 4 s ($M = .76$, $SE = .04$; $t < 1$). Thus, performance after the longest RI was reliably better than performance after shorter RIs because only that delay was temporally distinct.

Furthermore, our results suggested that the two experimental conditions only differed at those RIs where the time between trials was manipulated. Specifically, the 8–60 RI-ITI and 16–60 RI-ITI conditions only differed at the 8- and 16-s RIs (both p_{rep}s $> .88$;

all other *t*s < 1). To examine this more thoroughly, we examined only the two experimental conditions at the two RIs where the experimental manipulation was present. The resulting interaction is shown in Figure 2b. As can be seen, there was a strong crossover interaction ($p_{rep} > .99$, $\eta_p^2 = .31$), suggesting that performance was better for the 8–60 RI-ITI condition than for the 16–60 RI-ITI condition after the 8-s RI and, conversely, that performance was better for the 16–60 RI-ITI condition than for the 8–60 RI-ITI condition after the 16-s RI. Critically, the main finding is that the 8–60 RI-ITI condition demonstrated classic forgetting, with better performance after a short RI rather than after a long RI. The 16–60 RI-ITI condition, however, showed the opposite pattern, with performance being reliably better after a long RI rather than after a short RI.

GENERAL DISCUSSION

The current results provide strong support for the notion that temporal confusability rather than decay is what is important for forgetting over the short term. Thus, our results reconfirm the importance of temporal confusability and proactive interference as the main causes of forgetting over the short term and cast further doubt on the notion of decay. Moreover, our results highlight the fact that the classic form of forgetting need not always be a negatively accelerating function, but rather it is possible to change the form of the function by increasing distinctiveness for items associated with a long delay. Thus, the debate for "the" form of the forgetting function (Rubin & Wenzel, 1996; Wixted & Ebbesen, 1991) may be an oversimplification. Rather, we must be mindful of the relativistic nature of remembering and forgetting (Roediger, 2008).

The results from the current study suggest that it is possible to reverse the classic forgetting function by making information temporally distinct regardless of the length of the delay. Temporal distinctiveness, as used in the current study, is but one example of distinctiveness that can be used to alleviate forgetting (G.D.A. Brown et al., 2007). Other means of making information distinct, and hence leading to less forgetting and better remembering, are currently being heavily studied (Hunt & Worthen, 2006). Overall, these results suggest that rapid loss of information, which seems to plague us all, is not a consequence of some unalterable mechanism. Rather, it is possible to alleviate and even reverse the classic pattern of forgetting by making information distinct, so that it stands out relative to its background.

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REFERENCES

Baddeley, A.D. (1976). *The psychology of memory*. New York: Basic Books.

Baddeley, A.D., & Scott, D. (1971). Short term forgetting in the absence of proactive interference. *Quarterly Journal of Experimental Psychology*, *23*, 275–283.

Bennett, R.W. (1975). Proactive interference in short-term memory: Fundamental forgetting processes. *Journal of Verbal Learning and Verbal Behavior*, *13*, 123–144.

Brown, G.D.A., Neath, I., & Chater, N. (2007). A temporal ratio model of memory. *Psychological Review*, *114*, 539–576.

Brown, J. (1958). Some tests of the decay theory of immediate memory. *Quarterly Journal of Experimental Psychology*, *10*, 12–21.

Capaldi, E.J., & Neath, I. (1995). Remembering and forgetting as context discrimination. *Learning & Memory*, *2*, 107–132.

Cowan, N., Saults, J.S., & Nugent, L.D. (1997). The role of absolute and relative amounts of time in forgetting within immediate memory: The case of tone pitch comparisons. *Psychonomic Bulletin & Review*, *4*, 393–397.

Cowan, N., Saults, J.S., & Nugent, L.D. (2001). The ravages of absolute and relative amounts of time on memory. In H.L. Roediger, III, J.S. Nairne, I. Neath, & A.M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 315–330). Washington, DC: American Psychological Association.

Crowder, R.G. (1976). *Principles of learning and memory*. Hillsdale, NJ: Erlbaum.

Greene, R.L. (1996). The influence of experimental design: The example of the Brown-Peterson paradigm. *Canadian Journal of Experimental Psychology*, *50*, 240–242.

Hunt, R.R., & Worthen, J.B. (Eds.). (2006). *Distinctiveness and memory*. New York: Oxford University Press.

Keppel, G., & Underwood, B.J. (1962). Proactive inhibition in short-term retention of single items. *Journal of Verbal Learning and Verbal Behavior*, *1*, 153–161.

Kincaid, J.P., & Wickens, D.D. (1970). Temporal gradient of release from proactive inhibition. *Journal of Experimental Psychology*, *86*, 313–316.

Loess, H., & Waugh, N.C. (1967). Short-term memory and inter-trial interval. *Journal of Verbal Learning and Verbal Behavior*, *6*, 455–460.

Loftus, G.R., & Masson, M.E.J. (1994). Using confidence intervals in within-subjects designs. *Psychonomic Bulletin & Review*, *1*, 476–490.

Peterson, L.R., & Peterson, M.J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, *58*, 193–198.

Roediger, H.L., III. (2008). Relativity of remembering: Why the laws of memory vanished. *Annual Review of Psychology*, *59*, 225–254.

Rubin, D.C., & Wenzel, A.E. (1996). One hundred years of forgetting: A quantitative description of retention. *Psychological Review*, *103*, 734–760.

Turvey, M.T., Brick, P., & Osborn, J. (1970). Proactive interference in short-term memory as a function of prior-item retention interval. *Quarterly Journal of Experimental Psychology*, *22*, 142–147.

White, K.G. (2002). Psychophysics of remembering: The discrimination hypothesis. *Current Directions in Psychological Science*, *11*, 141–145.

Wixted, J.T., & Ebbesen, E. (1991). On the form of forgetting. *Psychological Science*, *2*, 409–415.

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