Selective memory retrieval can revive forgotten memories

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Humans remember less and less of what was encoded as more and more time passes. Selective retrieval can interrupt such time-dependent forgetting, enhancing recall not only of the retrieved but also of the nonretrieved information. The recall enhancement has been attributed to context retrieval and the idea that selective retrieval reactivates the retrieved item's temporal context during study, which can facilitate recall of other items that had a similar context at study. However, it is unclear whether context retrieval induces a transient discontinuity in the stream of temporal context only, or a more permanent updating of context that would entail a lasting interruption of time-dependent forgetting. In three experiments, we analyzed time-dependent forgetting of encoded information right after study and after time-lagged selective retrieval. Selective retrieval boosted recall of the nonretrieved information up to the levels observed directly after study. Intriguingly, it also created a restart of time-dependent forgetting that made forgetting after retrieval indistinguishable from forgetting after study and thus induced a reset of the recall process. The results suggest that selective retrieval can revive forgotten memories and cause lasting recall enhancement, effects likely mediated by context retrieval and a permanent updating of temporal context.

episodic memory | retrieval | context | forgetting

People recall much more detail of an event shortly after they observed the event than a few hours or even days later. In fact, recall typically declines rapidly soon after encoding followed by a long, much slower decline in recall performance (1–4). It is important to understand if and how such time-dependent forgetting can be attenuated or even be interrupted. Recent research has demonstrated that memory retrieval can interrupt time-dependent forgetting.

When people study a list of items or study some prose passage and, after a longer time interval, selectively retrieve some of the studied information, recall of the other nonretrieved information is often enhanced (5–8). This recall enhancement interrupts time-dependent forgetting of this information, creating a recall level that can even be similar to the recall level shortly after study (Fig. 1). However, it is unclear whether the interruption represents a short-lived or a lasting effect on recall performance. The interruption may be transient in character, with the recall level of the nonretrieved information returning to the original course of forgetting soon after the selective retrieval. But the interruption may also be more permanent in character and, for instance, be accompanied by a restart of time-dependent forgetting. Such restart would make the forgetting after retrieval identical to the original time-dependent forgetting after study. Selective retrieval would thus revive the forgotten memories, induce a reset of recall of these memory contents, and create lasting effects of recall enhancement. It is the primary goal here to examine the time-dependent forgetting of nonretrieved information after selective retrieval and compare it with the time-dependent forgetting after study.

The observed recall enhancement of the nonretrieved information right after selective retrieval has been attributed to context retrieval (7, 8). Temporal context, which reflects external conditions but also an ever-changing internal context state, changes gradually over time (9, 10), and each studied item is associated with the temporal context in which it is shown (11–14). A temporal lag between study and retrieval thus induces context change and makes context during retrieval different from context during study, which can cause forgetting (15). However, retrieval of an item can reactivate the context that was present when that item was studied, and this retrieved context can then serve as a retrieval cue for other items with a similar context at study (16–18). Thus, if retrieved and nonretrieved items share contextual features encoded during study, retrieval can reactivate part of the study context of nonretrieved items and thus facilitate recall of these items.

Context retrieval updates context by adding the retrieved study context to the current state of temporal context (13, 14, 19). Such updating effectively shifts the study context closer to the later time-of-test context (20). If lasting, such shift of study context could cause a restart of the forgetting process and make time-dependent forgetting after selective retrieval similar to time-dependent forgetting after study. However, it is unclear whether such context updating is lasting. Another possibility is that the updating reflects a transient effect and study context becomes available for a short time after retrieval only. In such case, the effect would reflect a transient discontinuity in the stream of temporal context only (21) and recall would quickly return to the information's original course of forgetting after study.

Significance

Recall of encoded information gets impaired as time passes. We show that selective retrieval can interrupt such time-dependent forgetting. Selective retrieval of some studied information can revive the nonretrieved information and bring recall levels back to the levels shortly after study. Strikingly, we found that time-dependent forgetting after selective retrieval mimics time-dependent forgetting after study, which implies that the revival of the forgotten memories is lasting and caused by a reset of the recall process. In the real world, retrieval of encoded episodes is often selective and is often time-lagged, like in educational settings or in eyewitness testimony situations. Our findings suggest that selective retrieval can improve people's memory in such situations.

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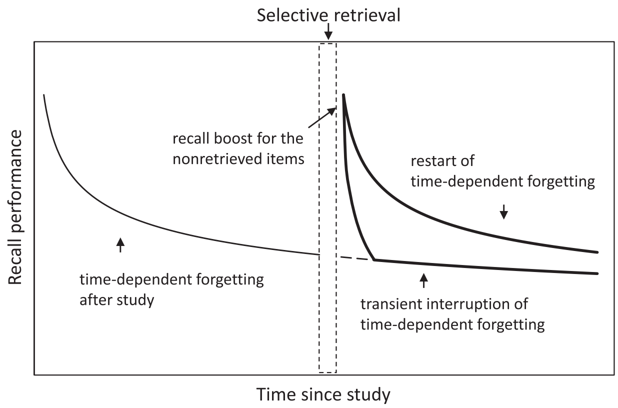

Fig. 1. Hypothetical time-dependent forgetting of studied items is shown before and after intermediate selective retrieval. The left curve represents time-dependent forgetting directly after study before selective retrieval. Selective retrieval interrupts the nonretrieved items' forgetting and boosts their recall right after the selective retrieval. The two right curves represent hypothetical time-dependent forgetting of the nonretrieved items as time since selective retrieval passes. One curve assumes that the recall boost reflects a transient effect and recall quickly returns to the original course of forgetting. The other curve assumes that selective retrieval creates a restart of time-dependent forgetting that makes the forgetting after retrieval identical to time-dependent forgetting after study.

Here, results from three experiments are reported aimed at shedding light onto how selective retrieval influences time-dependent forgetting. In each experiment, we compared time-dependent forgetting of studied items when recall was tested after study in the absence of selective retrieval with time-dependent forgetting of retrieved and nonretrieved items when recall was tested after selective retrieval. During selective retrieval, participants retrieved some studied items, thus creating retrieved and nonretrieved items. Both when recall was tested after study and when it was tested after selective retrieval, recall was assessed at different delay intervals, which allowed a comparison of the time-dependent forgetting before and after selective retrieval. Retrieval has recently been found to attenuate time-dependent forgetting of the retrieved information and improve its recall performance (22–24). Our experiments provide a link to this research by permitting a comparison of the time-dependent forgetting of retrieved and nonretrieved information.

Results

Experiments 1 and 2. In each experiment, participants studied a list of items and were later tested on the list (Fig. 2). Participants were divided into two groups to understand how selective retrieval influences time-dependent forgetting. Recall of one group was tested directly after study in the absence of any preceding selective retrieval. To address time-dependent forgetting, the group was divided into several subgroups and each subgroup was tested at different times since study. Recall of the other group was tested after selective retrieval, which took place 0.5 h (experiment 1), 1.5 h (experiment 2), or 3 h (experiment 2) after study. Different subgroups of the group were tested at different times since selective retrieval. To demonstrate the expected initial recall boost for the retrieved and nonretrieved items after selective retrieval, some participants of the first group were tested at exactly the same time since study as those participants of the second group who were tested right after the selective retrieval.

In both experiments, typical time-dependent forgetting emerged when testing occurred directly after study in the absence of selective retrieval (Fig. 3). Recall of the studied items was much lower after the longest than the shortest retention interval [experiment 1: $t(54) = 3.90$, $P < 0.001$; experiment 2: $t(54) = 4.61$, $P < 0.001$]. However, selective retrieval interrupted this forgetting. Right after the selective retrieval, recall of both the retrieved and the nonretrieved items was enhanced relative to recall of the studied items. This finding held in experiment 1 when selective retrieval occurred 0.5 h after study [retrieved items: $t(54) = 6.87$, $P < 0.001$; nonretrieved items: $t(54) = 3.77$, $P < 0.001$], and in experiment 2 when selective retrieval occurred 1.5 h after study [retrieved items: $t(54) = 6.09$, $P < 0.001$; nonretrieved items: $t(54) = 4.19$, $P < 0.001$] or 3 h after study [retrieved items: $t(54) = 5.45$, $P < 0.001$; nonretrieved items: $t(54) = 2.76$, $P = 0.008$]. In all three cases, retrieved and nonretrieved items did not differ significantly in recall level [experiment 1: $t(27) = 1.32$, $P = 0.199$; experiment 2: $t(27) = 1.42$, $P = 0.167$, and $t(27) = 1.34$, $P = 0.192$], indicating that selective retrieval boosted recall of retrieved and nonretrieved items to a similar degree. As time since selective retrieval increased, mainly the nonretrieved items showed time-dependent forgetting. For these items, recall was lower after the longest compared with the shortest retention interval [experiment 1: $t(54) = 2.17$, $P = 0.035$; experiment 2: $t(54) = 2.16$, $P = 0.035$, and $t(54) = 2.31$, $P = 0.025$], whereas recall of the retrieved items was not much affected by retention interval [experiment 1: $t(54) = 1.06$, $P = 0.292$; experiment 2: $t(54) = 0.30$, $P = 0.768$, and $t(54) = 0.43$, $P = 0.670$].

To quantify time-dependent forgetting, we fitted in each experiment a power function of time, $r(t) = at^{-b}$, to the recall rates of the three item types (3, 4) (*SI Appendix*). In this function, $r(t)$ represents the percentage of recalled items at time t, parameter b represents the forgetting rate as time passes, and parameter a represents recall level after one unit of time (i.e., 1 min after study for the studied items and 1 min after selective retrieval for the retrieved and nonretrieved items). The function described the time-dependent forgetting of the three item types well (*SI Appendix*, Table S1). We examined whether the function's two parameters varied between item types. In both experiments, nonretrieved and studied items did not differ in the function's parameter a [all χ^2s(1) < 0.92] nor did they differ in the function's parameter b [all χ^2s(1) < 3.40] (*SI Appendix*, Table S2). The finding indicates that time-dependent forgetting directly after study in the absence of selective retrieval and time-dependent forgetting of nonretrieved items after selective retrieval were comparable. Retrieved and nonretrieved items also did not vary in the function's parameter a [all χ^2s(1) < 2.41]. But the two item types differed in forgetting rate b, which was smaller for the retrieved than the nonretrieved items and indicates reduced time-dependent forgetting for the retrieved items [all χ^2s(1) > 11.17] (*SI Appendix*, Table S2). The forgetting rate of the retrieved items was also reduced relative to the forgetting rate of the studied items [all χ^2s(1) > 25.48] and did not differ significantly from $b = 0$ [all χ^2s(1) < 1.52].

Experiment 3. The findings of experiments 1 and 2 provide evidence that selective retrieval can interrupt time-dependent forgetting of nonretrieved items. It can boost recall of these items and, from the enhanced recall level, induce a restart of the forgetting process. To strengthen this evidence, experiment 3 examined time-dependent forgetting of studied, retrieved, and nonretrieved items using an educationally relevant prose passage as study material. A similar experimental setup was employed as in experiments 1 and 2 but, both during selective retrieval and at test, a fill-in-the-blank test format was employed. Gapped versions of single sentences of the studied passage were provided as retrieval cues and participants were asked to fill in the correct item from the text. Selective retrieval took place 2 h after study.

Again, time-dependent forgetting emerged when testing occurred directly after study in the absence of preceding selective retrieval (Fig. 4) and recall of the studied items was lower after

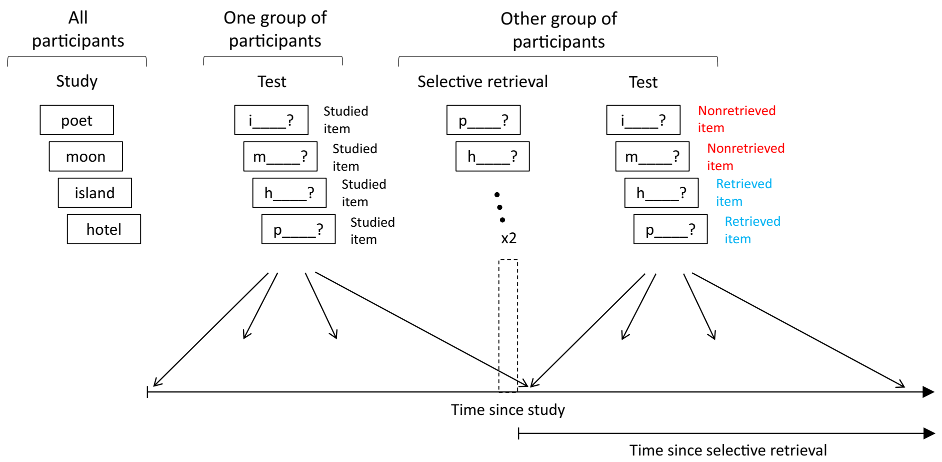

Fig. 2. Experimental design for experiments 1 and 2. Two groups of participants studied a list of words. Recall of one group was tested directly after study without preceding selective retrieval. Different subgroups were tested at different times since study. Recall of the other group was tested after selective retrieval, which took place 0.5, 1.5, or 3 h after study and created retrieved and nonretrieved items. Different subgroups of the group were tested at different times since selective retrieval.

the longest compared with the shortest retention interval [$t(54) = 6.75$, $P < 0.001$]. This forgetting was again interrupted by selective retrieval. Right after the selective retrieval, recall of both the retrieved and the nonretrieved items was enhanced relative to recall of the studied items [retrieved items: $t(54) = 3.65$, $P = 0.001$; nonretrieved items: $t(54) = 4.03$, $P < 0.001$]. Retrieved and nonretrieved items did not differ in the size of the recall boost [$t(27) = 0.74$, $P = 0.465$]. As time since selective retrieval

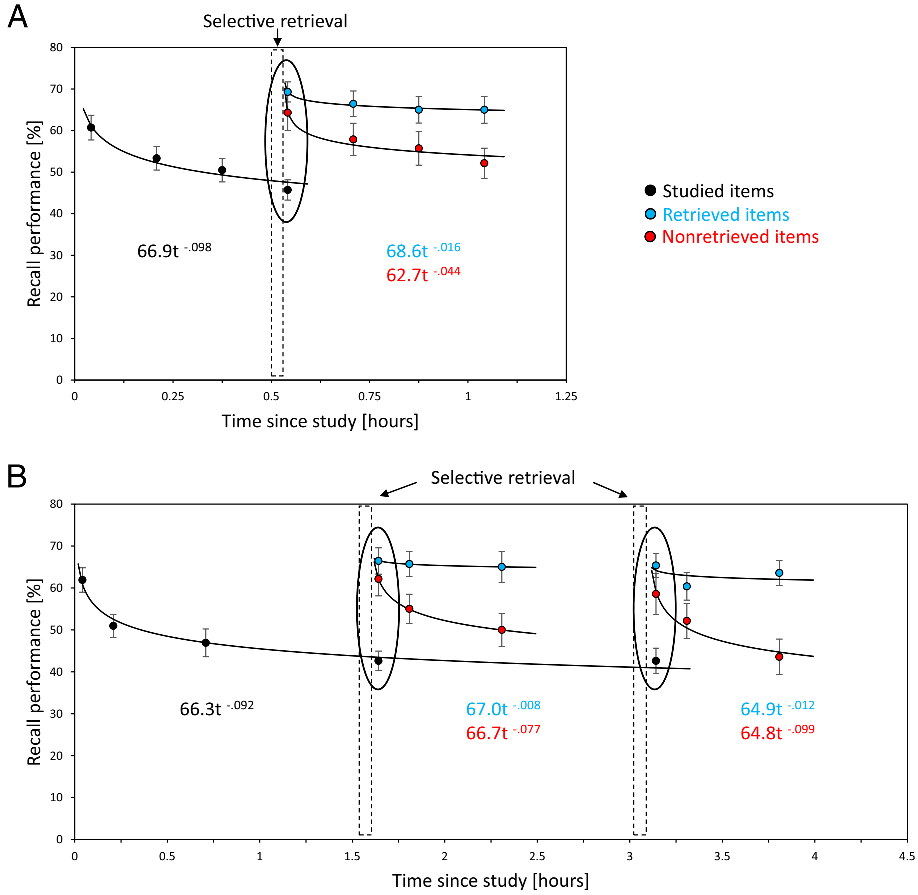

Fig. 3. Results of experiment 1 (*A*) and experiment 2 (*B*). Both recall of studied items and recall of retrieved and nonretrieved items showed time-dependent forgetting, described by a power function of time. Right after the selective retrieval, recall of both the retrieved and the nonretrieved items was enhanced relative to recall of the studied items (highlighted by ovals). Studied and nonretrieved items showed similar forgetting rates, whereas the forgetting rate of the retrieved items was reduced relative to the other items. Error bars represent ±1 SE.

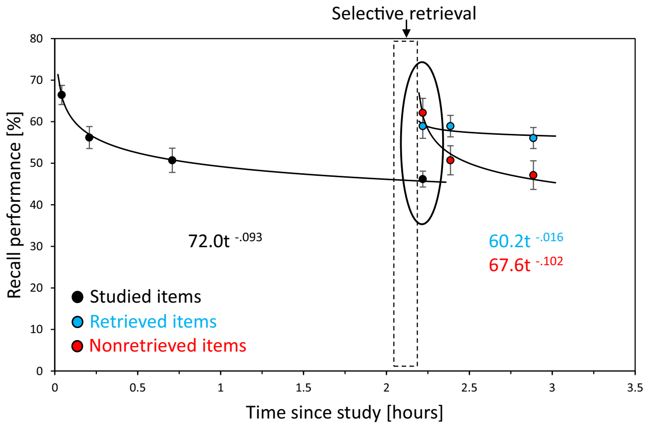

Fig. 4. Results of experiment 3, which employed a prose passage as study material. Both recall of studied items and recall of retrieved and nonretrieved items showed time-dependent forgetting, described by a power function of time. Selective retrieval enhanced recall of both the retrieved and the nonretrieved items right after the selective retrieval (highlighted by the oval). Again, studied and nonretrieved items showed similar forgetting rates, whereas the forgetting rate of the retrieved items was reduced relative to the other items. Error bars represent ±1 SE.

increased, time-dependent forgetting reemerged mainly for the nonretrieved items. Consistently, recall of the nonretrieved items was lower after the longest compared with the shortest retention interval [$t(54) = 3.07$, $P = 0.003$], whereas retention interval did not significantly influence recall of the retrieved items [$t(54) = 0.74$, $P = 0.464$]. A Bayes factor analysis of the retrieved items of all three experiments provided strong evidence for the null hypothesis [$B_{01} = 14.954$ (25, 26)].

Recall rates of the three item types were again well-described by a power function of time (*SI Appendix*, Table S1). The function's two parameters did not differ between nonretrieved and studied items [parameter a: $\chi^2(1) = 0.43$; parameter b: $\chi^2(1) = 2.15$], indicating that time-dependent forgetting of nonretrieved items after selective retrieval mimicked time-dependent forgetting directly after study. Retrieved and nonretrieved items also did not differ in parameter a [$\chi^2(1) = 0.99$]. However, forgetting rate b was smaller for the retrieved than the nonretrieved items [$\chi^2(1) = 4.55$], suggesting reduced forgetting for the retrieved items. The forgetting rate of the retrieved items was also reduced relative to the forgetting rate of the studied items [$\chi^2(1) = 6.22$] (*SI Appendix*, Table S2) and again did not differ significantly from $b = 0$ [$\chi^2(1) = 0.43$].

Discussion

This study demonstrates that selective retrieval can interrupt time-dependent forgetting by inducing a recall boost for both the retrieved and the nonretrieved information. On this enhanced recall level, the nonretrieved information reveals subsequent time-dependent forgetting that mimics time-dependent forgetting directly after study. The finding provides evidence that the initial recall boost for the nonretrieved information goes beyond a transient discontinuity in the information's time-dependent forgetting and selective retrieval rather creates a restart of time-dependent forgetting for this information. The retrieved information shows time-dependent forgetting that is even slowed relative to the forgetting directly after study—and is slowed relative to the time-dependent forgetting of the nonretrieved information. Because retrieved and nonretrieved items showed comparable recall boosts in response to selective retrieval, this finding suggests an additional effect of selective retrieval on the memory representation of the retrieved items themselves.

Our findings are consistent with the idea that selective retrieval induces context retrieval that updates context by adding the retrieved items' study context to the current state of temporal context (13, 14). Our findings extend the account by indicating that this updating reflects a lasting effect that entails a restart of time-dependent forgetting. For the nonretrieved information, this explains why selective retrieval does not only induce an immediate recall boost for the nonretrieved information but creates new time-dependent forgetting for this information that parallels time-dependent forgetting directly after study. For the retrieved information, the account provides evidence that context updating is not yet sufficient to explain time-dependent forgetting for this information. Rather, an additional factor is required to explain the attenuated time-dependent forgetting of the retrieved information. Such factor may be elaborative retrieval or retrieval-induced strengthening of the retrieved items (24, 27, 28), but may also be a difference in consolidation processes.

Indeed, time-dependent forgetting in this study was well-described by a power function of time, which implies a decreasing proportional rate of forgetting with the passage of time (29). This characteristic of the function fits with the proposal that older memories are forgotten more slowly than younger memories (30, 31) and may be a manifestation of memory consolidation (29), the process by which newly encoded information is transformed into a stable long-term memory representation (32, 33). From such perspective, the present results for the retrieved items are consistent with the view that, due to context retrieval, selective retrieval enhanced the accessibility of the retrieved items and did so in such a way that it inherited the current consolidation state of the items, thus creating reduced forgetting of the retrieved relative to the studied items. In contrast, the nonretrieved items may have reflected altogether new memories that were consolidated anew (34) or, as a result of context retrieval, may have become destabilized, requiring reconsolidation of the items (35). Differences in consolidation processes may thus have contributed to the observed differences in time-dependent forgetting.

Selective retrieval can boost recall of nonretrieved information when there are several hours between study and selective retrieval, but it can also boost recall when there are several days before selective retrieval occurs (5, 6). While for lags on the order of hours the recall boost can lead to recall levels that are similar to the recall levels of the studied items shortly after the encoding (Figs. 3 and 4), the size of the recall boost can be reduced for prolonged lag intervals. This finding suggests that context updating becomes incomplete as more and more time before selective retrieval passes (7, 36). Such incompleteness in context updating, however, need not necessarily influence the forgetting rate of the nonretrieved items after selective retrieval. If context updating effectively shifted the study context closer to the later time-of-test context (20) and incomplete updating shifted the study context less close to the test context than a complete updating, then the size of the initial recall boost may well vary with the lag between study and selective retrieval but the forgetting rate after selective retrieval may remain relatively unaffected by lag condition. Indeed, such shifting hypothesis predicts (horizontally) parallel forgetting curves across different lag conditions and thus separates the forgetting rate from the degree of the completeness of context updating (37).

Not only the lag between study and selective retrieval but also the retention interval between selective retrieval and test can influence the size of the recall enhancement for the nonretrieved items. In fact, the size of the recall enhancement will often decline as the retention interval between selective retrieval and test increases (Fig. 3*B*). This decline follows naturally if studied and nonretrieved items show comparable and typical time-dependent forgetting. In such case, recall of the studied items will undergo a high degree of forgetting soon after study but show a moderate decline only with the further passage of time—and thus also after the time when the selective retrieval occurred. In contrast, if nonretrieved items show similar time-dependent forgetting after selective retrieval as the studied items show directly after study, then recall of the nonretrieved information will decline rapidly soon after the selective retrieval, which will necessarily reduce the recall enhancement of this information. The recall boost induced by selective retrieval will therefore be highest right after the selective retrieval and then gradually attenuate as the retention interval increases.

Selective retrieval does not always improve recall of the nonretrieved information but can also impair the information's recall performance (38, 39). Such retrieval-induced forgetting often arises when selective retrieval follows shortly upon study, a time when time-dependent forgetting of the studied information has barely emerged. At this time, interference between studied items can be high and inhibitory processes then reduce the interference of the nonretrieved items to guarantee successful retrieval of the target information (40, 41). The relative contribution of inhibitory processes to recall performance decreases and that of context retrieval increases as the time interval between study and selective retrieval increases, and retrieval-induced forgetting can then reverse into retrieval-induced enhancement (5, 8). Retrieval-induced enhancement has also been observed when selective retrieval follows shortly upon study, though mainly if the nonretrieved information is well-integrated with the target information at the time of initial learning, and the retention interval is long (42–44). Factors other than context retrieval are likely to mediate this beneficial effect (43).

Memories suffer from time-dependent forgetting. This study shows that selective retrieval can revive forgotten memories. Selective retrieval can enhance recall of nonretrieved information to a level that is similar to the one right after study and, from this enhanced recall level, induce a complete reset of time-dependent forgetting. The finding supports the view that selective retrieval triggers context retrieval that updates context by adding the retrieved study context to the current state of temporal context. Whereas previous studies left it open whether such context updating reflects a transient or a lasting effect, this study demonstrates that selective retrieval induces a more permanent updating of context. In the real world, retrieval of encoded episodes is often selective and is often lagged, like in educational settings when a student prepares for an upcoming examination or in eyewitness testimony situations when a witness is interrogated by a police officer about specific details of an observed event. Our findings suggest that selective retrieval can improve people's memory in such situations.

Materials and Methods

Experiment 1.

Participants. The participants (224 students of different German universities, mean age 23.03 y, 77.23% females) were divided into two groups, each consisting of four subgroups ($n = 28$). Sample size was determined on the basis of a power analysis (45) using alpha = 0.05 and beta = 0.20 as well as effect sizes of $d = 0.80$ for expected time-dependent forgetting and expected effects of selective retrieval (5–7, 46). The participants were tested individually in an online video conference hosted by the software Zoom (Zoom Video Communications, 2016). Instructions were given by the experimenter, who was present for the entire period of the experiment.

Materials. A list of 15 unrelated concrete German nouns was employed as study material (7). Each item had a unique initial letter. The items served as studied items when selective retrieval was absent and as retrieved and nonretrieved items when selective retrieval was present (Fig. 2). Ten items of the list served as the retrieved items and the other five items served as the nonretrieved items. Within each selective retrieval condition, each item served as a retrieved item for $n = 18$ or $n = 19$ participants and as a nonretrieved item for $n = 9$ or $n = 10$ participants.

Procedure. Each participant in this experiment—as well as in experiments 2 and 3—provided informed consent prior to participation. The protocol employed in this study was reviewed and deemed exempt by the ethical review board of Regensburg University. The experiments were carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki. The same four delay intervals (0, 10, 20, and 30 min) were employed after study and selective retrieval. Selective retrieval began 30 min after study. During study, the items of the list were presented individually and in a random order for 6 s each on the computer screen. The delay intervals were filled with neutral distractor tasks as was the lag of 30 min that preceded the selective retrieval (*SI Appendix*). During selective retrieval, there were two rounds of retrieval practice. Within each round, the participants were asked to recall 10 of the 15 items (the retrieved items). The items' initial letters served as retrieval cues and were presented in a random order for 6 s each. Responses were given orally. Participants who did not engage in selective retrieval took part in a counting task for the equivalent amount of time immediately after study. At test, both groups of participants were asked to recall all 15 items. Order of tested items was random but, in the selective retrieval group, the nonretrieved items were always tested first and the retrieved items last (5, 6, 38, 39) (*SI Appendix*).

Experiment 2.

Participants. The participants (308 students, mean age 23.67, 81.82% females) were again divided into two groups. The groups consisted of five subgroups when selective retrieval was absent and six subgroups when selective retrieval was present. Three subgroups of the retrieval group engaged in selective retrieval 1.5 h after study, and the remaining three subgroups 3 h after study. Each subgroup consisted of $n = 28$ participants.

Materials. Another list of 15 unrelated concrete German nouns was employed as study material (7). Again the items had unique initial letters. The division of the items into studied, retrieved, and nonretrieved items followed experiment 1.

Procedure. The procedure differed in five aspects from experiment 1: 1) Selective retrieval took place either 1.5 or 3 h after study; 2) the delay intervals after selective retrieval were changed to 0, 10, and 40 min; 3) the delay intervals after study were changed to 0 min, 10 min, 40 min, 1.5 h, and 3 h; the 1.5- and 3-h intervals were included to demonstrate the expected initial recall boost for the nonretrieved items right after the selective retrieval; because participants, in both delay interval conditions, did not engage in selective retrieval, they took part in a distractor task for the equivalent time; 4) during selective retrieval, the first two letters of the items were provided as retrieval cues; and 5) immediately after study and immediately after selective retrieval, there was a 2-min counting task. The delay intervals of 10 and 40 min were again filled with neutral distractor tasks. For the delay intervals of 1.5 and 3 h, the participants were dismissed for this period of time and rejoined the experiment later.

Experiment 3.

Participants. The participants (196 students, mean age 24.37, 70.92% females) were again divided into two groups. The groups consisted of four subgroups when selective retrieval was absent and three subgroups when selective retrieval was present. Each subgroup consisted of $n = 28$ participants.

Materials. The text passage "Sea Otters" (21, 47) served as study material. The passage consisted of 275 words. We selected 15 idea units from the text to serve as studied items when selective retrieval was absent and as retrieved and nonretrieved items when selective retrieval was present.

Procedure. The procedure differed in four aspects from experiment 2: 1) Participants studied the text passage through two 5-min study cycles; 2) selective retrieval took place 2 h after study; 3) the delay intervals after study were changed to 0 min, 10 min, 40 min, and 2 h; and 4) during selective retrieval and at test, participants were provided with gapped sentences from the text as retrieval cues for 20 s each (e.g., "Sea otters sleep often on masses of _____" [answer: kelp] or "Sea otters are _____ long" [answer: 4 to 5 ft]), and they were asked to fill in the missing item from the text.

Data Availability. The study materials employed in the present experiments as well as the data from the single experiments are available on the Open Science Framework, Center for Open Science (https://osf.io/uytds/?view_only=e1a45f329d864316990988602d737f39) (48). All experiments reported in this manuscript were implemented using the software PowerPoint 2019 (Microsoft) and the software Zoom (Zoom Video Communications, 2016). The software was run on standard desktop computers with the operating system Windows 10 (Microsoft). Data were analyzed using SPSS Statistics for Windows, version 27.0 (IBM), G*Power 3.1 (45), as well as C program code that was used to fit power functions to the recall rates. The program code used to fit the single power functions is also available on the Open Science Framework.

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1. H. Ebbinghaus, *Über das Gedächtnis* (Duncker & Humblot, Leipzig, Germany, 1885).
2. N. J. Slamecka, B. McElree, Normal forgetting of verbal lists as a function of their degree of learning. *J. Exp. Psychol. Learn.* **9**, 384–397 (1983).
3. J. T. Wixted, E. Ebbesen, On the form of forgetting. *Psychol. Sci.* **2**, 409–415 (1991).
4. D. C. Rubin, A. E. Wenzel, One hundred years of forgetting: A quantitative description of retention. *Psychol. Rev.* **103**, 734–760 (1996).
5. K.-H. T. Bäuml, A. Schlichting, Memory retrieval as a self-propagating process. *Cognition* **132**, 16–21 (2014).
6. K.-H. T. Bäuml, I. M. Dobler, The two faces of selective memory retrieval: Recall specificity of the detrimental but not the beneficial effect. *J. Exp. Psychol. Learn. Mem. Cogn.* **41**, 246–253 (2015).
7. L. Wallner, K.-H. T. Bäuml, Beneficial effects of selective item repetition on the recall of other items. *J. Mem. Lang.* **95**, 159–172 (2017).
8. K.-H. T. Bäuml, Context retrieval as a critical component in selective memory retrieval. *Curr. Dir. Psychol. Sci.* **28**, 177–182 (2019).
9. W. K. Estes, Statistical theory of spontaneous recovery and regression. *Psychol. Rev.* **62**, 145–154 (1955).
10. G. H. Bower, "A selective review of organizational factors in memory" in *Organization of Memory*, E. Tulving, W. Donaldson, Eds. (Academic Press, New York, 1972), pp. 93–137.
11. J. G. W. Raaijmakers, R. M. Shiffrin, Search of associative memory. *Psychol. Rev.* **88**, 93–134 (1981).
12. G. J. M. Mensink, J. G. W. Raaijmakers, A model for interference and forgetting. *Psychol. Rev.* **95**, 434–455 (1988).
13. M. W. Howard, M. J. Kahana, A distributed representation of temporal context. *J. Math. Psychol.* **46**, 269–299 (2002).
14. S. M. Polyn, K. A. Norman, M. J. Kahana, A context maintenance and retrieval model of organizational processes in free recall. *Psychol. Rev.* **116**, 129–156 (2009).
15. E. Tulving, D. M. Thomson, Encoding specificity and retrieval processes in episodic memory. *Psychol. Rev.* **80**, 352–373 (1973).
16. M. W. Howard, M. J. Kahana, Contextual variability and serial position effects in free recall. *J. Exp. Psychol. Learn. Mem. Cogn.* **25**, 923–941 (1999).
17. S. M. Polyn, V. S. Natu, J. D. Cohen, K. A. Norman, Category-specific cortical activity precedes retrieval during memory search. *Science* **310**, 1963–1966 (2005).
18. S. M. Polyn, M. J. Kahana, Memory search and the neural representation of context. *Trends Cogn. Sci.* **12**, 24–30 (2008).
19. M. Lehman, K. J. Malmberg, A buffer model of memory encoding and temporal correlations in retrieval. *Psychol. Rev.* **120**, 155–189 (2013).
20. L. J. Lohnas, S. M. Polyn, M. J. Kahana, Contextual variability in free recall. *J. Mem. Lang.* **64**, 249–255 (2011).
21. S. Folkerts, U. Rutishauser, M. W. Howard, Human episodic memory retrieval is accompanied by a neural contiguity effect. *J. Neurosci.* **38**, 4200–4211 (2018).
22. H. L. Roediger 3rd, J. D. Karpicke, Test-enhanced learning: Taking memory tests improves long-term retention. *Psychol. Sci.* **17**, 249–255 (2006).
23. J. D. Karpicke, H. L. Roediger III, The critical importance of retrieval for learning. *Science* **319**, 966–968 (2008).
24. N. Kornell, R. A. Bjork, M. A. Garcia, Why tests appear to prevent forgetting: A distribution-based bifurcation model. *J. Mem. Lang.* **65**, 85–97 (2011).
25. M. E. J. Masson, A tutorial on a practical Bayesian alternative to null-hypothesis significance testing. *Behav. Res. Methods* **43**, 679–690 (2011).
26. A. E. Raftery, "Bayesian model selection in social research" in *Sociological Methodology*, P. V. Marsden, Ed. (Blackwell, Cambridge, MA, 1995), pp. 111–196.
27. S. K. Carpenter, Cue strength as a moderator of the testing effect: The benefits of elaborative retrieval. *J. Exp. Psychol. Learn. Mem. Cogn.* **35**, 1563–1569 (2009).
28. M. A. Pyc, K. A. Rawson, Why testing improves memory: Mediator effectiveness hypothesis. *Science* **330**, 335 (2010).
29. J. T. Wixted, On common ground: Jost's (1897) law of forgetting and Ribot's (1881) law of retrograde amnesia. *Psychol. Rev.* **111**, 864–879 (2004).
30. A. Jost, Die Assoziationsfestigkeit in ihrer Abhängigkeit von der Verteilung der Wiederholungen [The strength of associations in their dependence on the distribution of repetitions]. *Z. Psychol. Physiol. Sinnesorgane* **16**, 436–472 (1897).
31. W. A. Wickelgren, Single-trace fragility theory of memory dynamics. *Mem. Cognit.* **2**, 775–780 (1974).
32. G. E. Müller, A. Pilzecker, *Experimentelle Beiträge zur Lehre vom Gedächtnis* [*Experimental Contributions to the Science of Memory*] (Zeitschrift für Psychologie Ergänzungsband, J. A. Barth, Leipzig, Germany, 1900).
33. Y. Dudai, A. Karni, J. Born, The consolidation and transformation of memory. *Neuron* **88**, 20–32 (2015).
34. L. Nadel, M. Moscovitch, Memory consolidation, retrograde amnesia and the hippocampal complex. *Curr. Opin. Neurobiol.* **7**, 217–227 (1997).
35. Y. Dudai, The restless engram: Consolidations never end. *Annu. Rev. Neurosci.* **35**, 227–247 (2012).
36. P. I. Pavlik Jr., J. R. Anderson, Practice and forgetting effects on vocabulary memory: An activation-based model of the spacing effect. *Cogn. Sci.* **29**, 559–586 (2005).
37. J.-C. Falmagne, Psychometric functions theory. *J. Math. Psychol.* **25**, 1–50 (1982).
38. M. C. Anderson, R. A. Bjork, E. L. Bjork, Remembering can cause forgetting: Retrieval dynamics in long-term memory. *J. Exp. Psychol. Learn. Mem. Cogn.* **20**, 1063–1087 (1994).
39. M. C. Anderson, B. A. Spellman, On the status of inhibitory mechanisms in cognition: Memory retrieval as a model case. *Psychol. Rev.* **102**, 68–100 (1995).
40. M. C. Anderson, Rethinking interference theory: Executive control and the mechanisms of forgetting. *J. Mem. Lang.* **49**, 415–445 (2003).
41. K.-H. T. Bäuml, O. Kliegl, "Retrieval-induced remembering and forgetting" in *Cognitive Psychology of Memory, Vol. 2 of Learning and Memory: A Comprehensive Reference*, J. T. Wixted, J. H. Byrne, Eds. (Academic Press, Oxford, ed. 2, 2017), pp. 27–51.
42. J. C. K. Chan, K. B. McDermott, H. L. Roediger III, Retrieval-induced facilitation: Initially nontested material can benefit from prior testing of related material. *J. Exp. Psychol. Gen.* **135**, 553–571 (2006).
43. J. C. K. Chan, When does retrieval induce forgetting and when does it induce facilitation? Implications for retrieval inhibition, testing effect, and text processing. *J. Mem. Lang.* **61**, 153–170 (2009).
44. T. R. Jonker, H. Dimsdale-Zucker, M. Ritchey, A. Clarke, C. Ranganath, Neural reactivation in parietal cortex enhances memory for episodically linked information. *Proc. Natl. Acad. Sci. U.S.A.* **115**, 11084–11089 (2018).
45. F. Faul, E. Erdfelder, A. G. Lang, A. Buchner, G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* **39**, 175–191 (2007).
46. O. Kliegl, T. Carls, K.-H. T. Bäuml, How delay influences search processes at test. *J. Exp. Psychol. Learn. Mem. Cogn.* **45**, 2174–2187 (2019).
47. L. Wallner, K.-H. T. Bäuml, Part-list cuing with prose material: When cuing is detrimental and when it is not. *Cognition* **205**, 104427 (2020).
48. K.-H. T. Bäuml, L. Trißl, Selective memory retrieval can revive forgotten memories. Open Science Framework. https://osf.io/uytds/?view_only=e1a45f329d864316990988602d737f39. Deposited 22 July 2021.