Chapter 25

Retrieval-induced forgetting

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Does retrieval of a specific episode in memory affect the remembering of related episodes? For instance, is it advisable, immediately prior to an exam, to retrieve some of the course material to co-activate the other material, or does such selective memory retrieval rather have a detrimental effect on memory of the related information? Intuitively, one may assume that the effect of selective memory retrieval should mostly promote retrieval of related episodes, and indeed, prominent models of memory from the 1960s and 1970s are well in line with such a notion, suggesting that activation of a specific episode in memory facilitates activation of related episodes (Collins & Loftus, 1975). Moreover, empirical evidence from eyewitness memory research suggests that active retrieval of some previously experienced episodes or events can benefit memory of other episodes or events (Geiselman, Fisher, MacKinnon, & Holland, 1985). However, since the early 1970s, numerous studies have also found evidence for the seemingly paradoxical feature of human memory that, in a variety of situations, recalling previously learned information can impede our ability to recall related information. Evidence for such retrieval-induced forgetting (RIF) has arisen mainly from two experimental tasks: the output-interference task (Roediger, 1974) and the retrieval-practice task (Anderson, Bjork, & Bjork, 1994).

Experimental tasks

RIF was first examined employing the output-interference task, in which it is shown that RIF can occur in the course of a recall test. In this task, participants are often asked to study a categorized list and, after a delay that is usually filled with an unrelated distractor task, to recall the list's items. At test, the list's category labels are successively provided as retrieval cues and participants are asked to recall a category's items. The typical finding with this task is that recall performance declines as a function of the category's testing position, indicating that the act of retrieving some items from the study list decreases chances for the list's other items to be successfully retrieved (Roediger, 1974). Most of the more recent research on RIF, however, has employed the retrieval-practice task, which was first introduced by Anderson et al. (1994). In this task, a subset of previously studied material is repeatedly retrieved, and the effect of this manipulation on later recall of the practiced and unpracticed material is examined. Often participants study items from different semantic categories (e.g., FRUIT-Orange, FRUIT-Banana, FURNITURE-Table), before, in a subsequent retrieval-practice phase, they are asked to repeatedly retrieve half of the items from half of the categories using a word stem completion task (e.g., FRUIT-Or___). After a delay, typically filled with an unrelated distractor task, recall performance for all initially studied items is tested. The selective retrieval practice phase between study and test creates three types of items, usually labelled Rp+ items, Rp- items, and control items. Rp+ items refer to practiced items from practiced categories (Orange), Rp- items refer to unpracticed items from practiced categories (Banana), and control items refer to items from unpracticed categories (see Figure 25.1). Figure 25.1 also illustrates the typical finding with this task. Recall of the Rp+ items is improved on the final test relative to the control items, and, more

important, recall of the Rp- items is impaired relative to the control items, which reflects the RIF finding.

(Insert Figure 25.1 about here)

RIF is a very general phenomenon and has been observed over a wide range of study materials - like verbal, visuospatial, or autobiographical materials - and also over a variety of experimental settings. For instance, Shaw, Bjork, and Handal (1995) found RIF in eyewitness memory by showing that repeated questions on specific details of a previously observed scene improved subsequent recall of these details but reduced subsequent recall of related details. In another study employing an impression formation task, participants were shown personality characteristics of two men, Bill and John (e.g., JOHN-creative, BILL-romantic, JOHN-skillful), before participants' memory for half of the personality traits of one of the two characters was tested (e.g., JOHN-cr___). When participants were asked to recall all personality traits that they had previously seen in a subsequent surprise recall test, typical RIF arose, that is, recall of the unpracticed traits from the practiced person (e.g., John) was impaired relative to the unpracticed traits from the other, unpracticed person (e.g., Bill; Macrae & MacLeod, 1999). In a recent series of experiments, RIF has even been shown to arise in social groups. In these studies, pairs of individuals studied a list of items, and, subsequently, only a single member of the pair (the "speaker") selectively retrieved some of the items, while the other member (the "listener") simply listened to the speaker's responses, monitoring their accuracy. When the listener was subsequently asked to recall

the remaining items, memory for the related items was impaired (for a review, see Hirst & Echterhoff, 2012).

A CLASSROOM CEMONSTRATION OF RETRIEVAL-INDUCED FORGETTING

As a classroom demonstration of retrieval-induced forgetting, we suggest a version of the retrieval-practice task employed by Anderson et al. (1994). Text box 25.1 provides all necessary details to set up a simplified classroom experiment.

(Insert Text box 25.1 about here)

MECHANISMS OF RIF

Several theoretical accounts have been suggested to explain RIF. The two most prominent accounts are the inhibition account (Anderson, 2003) and the blocking account (Raaijmakers & Jakab, 2012). According to the inhibition account, RIF arises because the memory representation of the unpracticed items is impaired during retrieval practice. This account suggests that during retrieval practice of some of the studied items, related not-to-be-practiced items interfere and compete for conscious recall. To reduce the interference and facilitate selection of the to-be-practiced items, the memory representation of the not-to-be-practiced items becomes suppressed. For instance, when participants are cued with FRUIT-Or___ during the retrieval-practice phase, other fruits, like Banana, may come to mind and compete for conscious recall. To reduce the interference from Banana, the memory representation of the item is suppressed and, as a result, recall of that item in the subsequent final test is impaired.

While the inhibition account thus assumes that RIF arises due to an inhibitory process that acts to overcome interference, the blocking account claims that RIF arises as a direct consequence of interference. According to this account, the associations between the practiced items and their category cues are strengthened during retrieval practice, and such strengthening introduces interference of these items when at test participants are asked to recall the unpracticed items, thus reducing these items' recall relative to the control items. For instance, successful retrieval of Orange in the retrieval-practice phase may lead to a stronger association between Orange and its category label FRUIT. At test, when the participant attempts to retrieve another studied exemplar from the category FRUIT, like Banana, Orange may then interfere and block successful recall of that exemplar, thus creating RIF (for an alternative noninhibitory account of RIF, see Jonker, Seli, & MacLeod, 2013).

In the last two decades, a large number of studies have been conducted designed to contrast the inhibition and blocking accounts of RIF (for a meta-analytic review, see Murayama et al., 2014). In most of this research, some version of the retrieval-practice task was employed. These studies can be divided into studies that (1) manipulated the format of retrieval practice, (2) manipulated how RIF was assessed during the final test phase, (3) and examined individual differences in RIF. The following sections will provide a short overview of this research.

Retrieval-practice phase

Retrieval specificity

A central prediction of the inhibition account is that RIF should be retrieval specific, which means that only a practice phase that involves active retrieval of previously studied items should reduce recall of the unpracticed items. Thus, retrieval practice, but not restudy of the practiced items, should induce interference and inhibition of the unpracticed items, and thus impair memory for the unpracticed items. In contrast, the blocking account suggests that the strengthening of the cue-item associations of some of the studied items, be it through retrieval practice or restudy, should always induce blocking during the final memory test and thus impair recall of the unpracticed items.

Early studies that sought to determine whether or not RIF is retrieval specific employed two variants of the retrieval-practice task: restudy and noncompetitive retrieval practice. In both methods, the to-be-practiced "Rp+" items are reexposed intact with the goal of strengthening the items' associations to their cue without inducing interference and inhibition of the unpracticed items. In the restudy method, some of the originally studied category-item pairs are reexposed (e.g., FRUIT-Orange) and participants are asked to study the word pairs once again. In the noncompetitive retrieval practice method, some of the originally studied items are reexposed and participants are asked to recall the items' category label given the category's word stem as a retrieval cue (e.g., FR___-Orange). The typical finding with these methods is that RIF arises in the (competitive) retrieval practice condition, but no RIF-like impairment is observed following restudy or noncompetitive retrieval practice (e.g., Anderson, Bjork & Bjork, 2000; Bäuml & Aslan, 2004), which suggests that RIF is retrieval specific.

However, findings from more recent studies seem to indicate that at least some reexposure formats can induce RIF very similar to how retrieval practice does. Raaijmakers and Jakab (2012), for instance, employed a variant of the noncompetitive retrieval-practice method, in which the word stems of the category labels were not presented during reexposure (e.g., ___-Ball) and exemplars with a relatively low frequency within their categories were used. The results showed reliable RIF-like impairment after noncompetitive retrieval practice, indicating that retrieval may not be necessary to induce RIF. These results, however, do not generalize to other testing formats, like item recognition (for more details on RIF in item recognition, see the subsection *Final Test Phase* later in this chapter). Indeed, when examining retrieval specificity in both recall and item recognition, two recent studies found that, in recall, RIF arises after both competitive and noncompetitive retrieval practice, whereas in item recognition, it arises after competitive retrieval practice only (Grundgeiger, 2014; Rupprecht & Bäuml, 2016). These findings support retrieval specificity. In particular, they challenge the blocking account of RIF by demonstrating that, in general, the strengthening of cue-item associations is not sufficient to induce RIF.

Divided attention

In recent years, there have been several attempts to specify the nature of the suppression mechanism which, according to the inhibition account of RIF, underlies RIF. For instance, Anderson (2003) argued that inhibition in memory retrieval is caused by executive-control mechanisms that are not limited to controlling memory. Along these lines, it was suggested that inhibition is a general executive process that also operates to control overt behavior or

to ignore irrelevant stimuli. In contrast, other authors proposed that inhibition is mostly an automatic suppression mechanism that acts whenever irrelevant information is coactivated with relevant information, and suppresses the irrelevant information (Conway & Fthenaki, 2003).

Róman, Soriano, Gómez-Ariza, and Bajo (2009) put these two variants of the inhibition account to a test by stressing participants' attentional resources during the retrieval-practice phase with a secondary, concurrent updating task. The idea was that if the suppression mechanism underlying RIF needs executive control, then overloading attentional resources with a secondary task during retrieval practice should impair the action of the suppression mechanism and thus reduce RIF. On the other hand, if the suppression mechanism was mainly an automatic process, then stressing participants' attention during retrieval practice should not affect RIF. The results showed that, relative to a standard retrieval-practice condition, there was no RIF effect when the secondary task was performed during retrieval practice, but there was reliable facilitation of the Rp+ items. This pattern of results is hard to reconcile with the view that an automatic suppression mechanism underlies RIF. Furthermore, it is inconsistent with the blocking account, because, according to this account, the successful strengthening of Rp+ items in the secondary-task condition should have resulted in impaired memory for the Rp- items. As a whole, the findings suggest that RIF requires attentional control, thus supporting the executive-control version of the inhibition account.

Neural correlates

Several studies have investigated the neural processes underlying RIF by examining neural correlates of the forgetting effect during the retrieval-practice phase. According to the executive-control version of the inhibition account (Anderson, 2003), frontally mediated executive control processes should be recruited to suppress competing items during retrieval practice, which leads to the expectation of enhanced activation in such frontal areas during retrieval practice. No such expectation arises on the basis of the blocking account, which explains RIF through processes that act during the final test phase, and not during the retrieval-practice phase.

Employing electrophysiological measures of brain activity (EEG), Johansson, Aslan, Bäuml, Gäbel, and Mecklinger (2007) compared neural activity in a retrieval-practice condition with neural activity in a restudy baseline condition. Stronger positivity over frontal electrodes was elicited in the retrieval-practice condition relative to the restudy condition, and the stronger positivity was correlated with the amount of RIF arising at the final test. Consistently, a functional magnetic resonance imaging (fMRI) study by Kuhl, Dudukovic, Kahn, and Wagner (2007) showed that the BOLD signal in the prefrontal cortex decreases with increasing retrieval practice trials, indicating a decrease of cognitive control demands with repeated selective retrieval. Activity in ventro-lateral portions of the prefrontal cortex predicted the subsequent forgetting. Most recently, another fMRI study reported even more direct evidence for a critical role of inhibition in RIF, revealing that retrieval practice of some items measurably reactivates competing (Rp-) items and then progressively suppresses those interfering competitors (Wimber, Alink, Charest, Kriegeskorte, & Anderson, 2015). The competitors' cortical traces were even suppressed

below the activity observed for the control items, which supports the inhibition account. Overall, the findings from both fMRI and EEG studies suggest that inhibitory processes operate during retrieval practice, inducing RIF at the final memory test.

Final test phase

Cue independence

The inhibition account suggests that RIF should arise regardless of whether, during the final test, participants' memory for a particular item is assessed with the category label that was presented during study, or with a novel test cue that was not present at study or during the retrieval-practice phase. This cue-independence assumption is based on the idea that RIF arises from suppression of the competing memory itself, rather than from strengthening-induced blocking processes. Thus, after study of FRUIT-Orange and FRUIT-Banana, retrieval practice of FRUIT-Orange should weaken the memory representation of Banana, and recall of Banana should be impaired irrespective of which type of cue was provided for recall of the item. In contrast, according to the blocking account, employing novel cues on the final test should generally prevent Rp+ items from interfering with the recall of the Rp- items, and no RIF should arise. Whether or not RIF is observed thus should depend on the nature of the particular retrieval cue.

To test the cue-independence assumption, Anderson and colleagues developed the independent probe test in which, on the final test, an Rp- item (e.g., Banana) is not tested with its original study cue (FRUIT-B___) but with a novel test cue (YELLOW-B___). The rationale behind this method is that, in the presence of the novel retrieval cue, participants

may not draw on the original study cue to retrieve the Rp+ item, thus preventing possible blocking effects arising from the Rp+ items. Several studies have indeed found RIF with independent probes, thus supporting the inhibition account (Anderson & Spellman, 1995; see also Murayama et al., 2014). Arguably, however, employing independent probes may not necessarily avoid blocking effects at test, because, when participants receive an independent probe, they may not limit themselves to those probes but may instead covertly recall the original cues that went with the Rp+ items, which may then induce blocking at test. Weller, Anderson, Gómez-Ariza, and Bajo (2013) addressed the issue by asking participants to engage in covert cuing during independent-probe testing. In contrast to the prediction of the blocking account, such instruction decreased RIF, thus supporting cue independence and the inhibition account of RIF.

Item recognition and implicit tests

Further studies supported the proposal that RIF does not reflect blocking by showing that the forgetting effect also arises in further types of memory tests that supposedly do not leave room for blocking, like item recognition. Here the argument is that the presentation of the "old" items from the study phase during item recognition directly cues the episodic representations of those items without activating the shared categories, thus bypassing any form of blocking from the Rp+ items. Indeed, several studies found that memory of Rp- items was still impaired relative to the control items when RIF was assessed through item recognition, a finding regarded as evidence for inhibition (e.g., Hicks & Starns, 2004; Spitzer & Bäuml, 2007).

The argument that, in RIF, blocking is absent in item recognition has been criticized by some researchers, because, in general, interference effects can be present in item recognition (Raaijmakers & Jakab, 2013). However, there is evidence that not all types of interference effects arise in item recognition and that, for instance, strength-based interference effects, like the list-strength effect – the demonstration that restudy of a subset of studied items can impair memory of the not restudied material –, are absent in item recognition (Shiffrin, Ratcliff, & Clark, 1990). Grundgeiger (2014) and Rupprecht and Bäuml (2015) addressed the issue directly by examining the effects of competitive and noncompetitive retrieval practice in recall and item recognition. They found both forms of retrieval practice to induce RIF in recall, but found competitive retrieval practice only to induce RIF in item recognition. Because the effects of noncompetitive retrieval practice have been attributed to blocking (Raaijmakers & Jakab, 2012), these findings support the view that blocking effects may be present in recall but that they are absent in item recognition, thus supporting the proposal of a critical role of inhibition in RIF.

RIF has also been assessed with implicit memory tests. In these types of tests, participants are not directly required to deliberately or consciously recollect the study items and therefore the shared category cue is assumed to be bypassed here. Veling and van Knippenberg (2004), for instance, employed a lexical decision task, in which participants were presented with letter strings and were asked to indicate for each string whether it was a word or a nonword. Critically, some of the letter strings were items from the earlier study phase. The results showed that the word/nonword judgments were impaired (that is, slowed) for Rp- items relative to control items, thus demonstrating RIF. Other implicit tests have

also been shown to impair recall of Rp- items, like category generation or category matching, although there is also evidence that not all types of implicit tests may produce a RIF effect (see Murayama et al., 2014).

The findings from cue independence, item recognition, and (some) implicit memory tests point to a critical role of inhibition in RIF. In addition, blocking may also contribute to RIF, at least in tests that leave room for interference effects, like free recall or category-cued recall tests. Further support for this suggestion comes from Murayama et al.'s (2014) recent meta analysis, which found that the size of the RIF effect is typically larger in free recall and category-cued recall than in independent-probe tests and item recognition, suggesting that in the former type of tests, not only inhibition but also blocking may play some role. Indeed, in both free recall and category-cued recall, there is no control of the items' output order and participants tend to recall the (stronger) practiced items before the (weaker) unpracticed items. This output order bias can induce interference for the unpracticed items and thus lead to an increase in the size of the RIF effect.

Neural correlates

A few studies also searched for neural markers of RIF during the final memory test. On the basis of the inhibition account, one may expect to find neural markers of RIF that reflect the suggested reduced memory strength signal of the unpracticed items. The results from two studies point to such neural markers. The fMRI study by Wimber, Bäuml, Bergström, Markopoulos, Heinze, and Richardson-Klavehn (2008), for instance, found the retrieval of Rp- items to be associated with increased activation in the left anterior region of the

ventro-lateral prefrontal cortex. This finding is consistent with the inhibition account, because, in prior neuroscientific work, increased activity in this region was found to reflect the retrieval of weak memory traces. In another study, Spitzer, Hanslmayr, Opitz, Mecklinger, and Bäuml (2009) examined electrophysiological correlates of RIF on recognition memory and found that recognition of Rp- items was associated with reduced power in certain frequency bands. The findings of both studies are in line with the inhibition account, because both effects have previously been suggested to index a reduced memory signal.

Individual differences

On the basis of the view that a frontally mediated executive control process is critically involved in RIF (see above), there is reason to expect that populations that are supposed to suffer from deficient executive control processes show a reduction in the size of the RIF effect. Several studies examined this prediction of the inhibition account, for instance, by examining the relation between RIF and individuals' working memory capacity and by examining the relation between RIF and participants' age.

Working memory capacity

The efficiency of executive control processes is moderated by individuals' working-memory capacity (WMC), so that individuals with higher WMC are better able to deal with interference and inhibit task-irrelevant information than individuals with lower WMC (Redick, Heitz, & Engle, 2007). Indeed, measures of WMC have been found to predict performance in a number of cognitive tasks supposed to require controlled

inhibition, including the Stroop task and the antisaccade task. Because RIF does also seem to depend on executive control processes (Kuhl et al., 2007; Róman et al., 2009), the prediction arises that RIF should be more pronounced in participants with high WMC than in participants with low WMC.

Aslan and Bäuml (2011) addressed the issue. They measured participants' RIF by employing the retrieval-practice task and assessed participants' WMC by means of the operation span task. The operation span task is a widely used tool in individual-differences research; it requires participants to simultaneously store and process information and provides reliable and valid measures of individuals' WMC. When relating participants' WMC with participants' retrieval-induced enhancement of the practiced items (recall rate of Rp+ items minus recall rate of C items), these researchers found the enhancement to be largely unaffected by participants' WMC. In contrast, when relating participants' WMC with participants' RIF (recall rate of control items minus recall rate of Rp- items), they found a positive relationship between the two measures, indicating that participants with larger WMC show more RIF than participants with lower WMC. This pattern of results is in line with the executive-control-processes view and supports the inhibition account of RIF.

Age

Executive control processes also vary with participants' age, and both young children and older adults often suffer from impaired executive control processes. On the basis of this finding, there is reason to expect that both young children and older adults show less well developed inhibitory function and thus reduced RIF. Aslan and Bäuml (2010, 2012)

examined this issue and indeed found RIF to be absent in younger children and older adults, though the absence arose for very young children (i.e., kindergartners) and very old adults (above 75 years) only. Ortega, Gómez-Ariza, Román, and Bajo (2012) replicated the finding for older adults and additionally showed that, when a secondary task was introduced during retrieval practice, RIF did no longer arise for young-old adults (60-75 years). This finding suggests that young-old adults may not be "old enough" to show a general reduction in the size of the RIF effect, but that there may be a partial deficit in their inhibitory function that becomes manifest when participants' attentional resources are stressed during retrieval practice.

(Insert Figure 25.2 about here)

The two faces of selective memory retrieval

In most studies that examine the RIF effect, the retention interval between study and retrieval practice is very short and lasts a few minutes at best. Due to this, there is typically hardly any change in participants' internal context between study and retrieval practice. On the basis of this, several recent studies examined whether the effects of retrieval practice remain the same when retrieval occurs in a context that differs from the study context, thus making access to the study context during retrieval practice more difficult. Different methods were employed in these studies to impair access to the study context, like the presentation of a forget cue (e.g., Bäuml & Samenieh, 2010, 2012), imagination tasks conducted immediately after study (e.g., Bäuml & Samenieh, 2012; Schlichting, Aslan,

Holterman, & Bäuml, 2015), and prolonged retention intervals (e.g., Bäuml & Dobler, 2015; Bäuml & Schlichting, 2014). Also, both the output interference and the retrieval practice tasks were used to examine the role of study context access for the effects of selective memory retrieval.

Bäuml and Schlichting (2014), for instance, let participants study a list of unrelated items consisting of predefined target and nontarget items, which was followed by either a short retention interval of 4 min or a prolonged retention interval of 48 hours. While the short retention interval is typically assumed to maintain participants' access to the study context, the prolonged retention interval is supposed to impair access to the study context due to increasing context drift (e.g., Estes, 1955). Subsequently, there was retrieval practice of the predefined nontarget items (retrieval practice) or there was no such retrieval practice (control). Participants were then asked to recall the predefined target items. When nontarget recall had preceded target recall, the target items served as Rp- items; in the absence of the preceding nontarget recall, the target items served as control items. In the short retention interval condition, the results showed typical RIF, that is, selective retrieval of the nontargets impaired target recall. In contrast, in the prolonged retention interval condition,selective retrieval of the nontargets improved target recall. These results suggest two faces of selective memory retrieval, with a detrimental (RIF) face when the study context is easily accessed during retrieval, and a beneficial face when access is more difficult (see Figure 25.2).

Bäuml and Samenieh (2012) proposed a two-factor account to explain the two faces of selective memory retrieval. The core assumptions of the account are that (1) in general, selective retrieval triggers two processes, inhibition of competing memories and reactivation of the original study context, and (2) which of the two processes dominates in a certain situation, depends on study context access. When access to the study context is (largely) maintained - like after a short retention interval -, interference between items may be high enough to trigger inhibition, whereas not much room is left for context reactivation processes; as a net result, prior nontarget recall may reduce recall of the target (that is, Rp-) items and RIF may arise. In contrast, when access to the study context is impaired and interference between the single items is low - as may occur after a prolonged retention interval -, not much room is left for inhibition and more room is left for context reactivation. Preceding retrieval of the nontargets may reactivate the study context, which may then serve as a retrieval cue for the remaining target items and thus improve target recall.

To date, the two faces of selective retrieval have been shown for both word lists and prose material (Bäuml & Schlichting, 2014) and for both individuals and social groups (Abel & Bäuml, 2015). Also, there is evidence that individual differences do not only modulate the detrimental (RIF) effect but do also modulate the beneficial effect. Schlichting et al. (2015), for instance, examined the relation between individuals' WMC and the beneficial effect of selective retrieval and found a positive relation between the two measures; participants with higher WMC showed a more pronounced effect than participants with lower WMC. Aslan and Bäuml (2014) examined the developmental trajectory of the effect and found seventh graders but not second and forth graders to show the beneficial effect. Aslan, Schlichting,

John, and Bäuml (in press) examined the effect in older age and found the beneficial effect to be present in younger adults but to be absent in older adults. Together with the results from the previous RIF studies, these findings suggest that some groups of people, like young children, older adults, or individuals with low WMC, can not only show impaired retrieval-induced inhibition but can also show impaired retrieval-induced context reactivation. As a result, they show both a reduced detrimental (RIF) effect and a reduced beneficial effect of selective retrieval.

SUMMARY

- Selective retrieval of some memories can induce forgetting of other memories, a phenomenon referred to as retrieval-induced forgetting (RIF).
- RIF is a very robust finding and has been shown for a wide range of study materials and settings.
- The inhibition account of RIF assumes that during selective retrieval of some studied list items the list's not-to-be-retrieved items interfere and are inhibited to reduce the interference.
- The blocking account explains RIF by assuming that the selective retrieval of some items blocks recall of the remaining items at test due to increased interference from the practiced items.
- Findings from numerous RIF studies indicate that inhibitory processes play a critical role for the RIF effect, thus supporting the inhibition account.

- Some other findings suggest that blocking can also contribute to RIF, although only when RIF is assessed via memory tests that leave much room for interference, like free recall or category-cued recall.
- Typically, RIF has been observed when the context during retrieval practice is similar to the context at test; if access to the study context is impaired, however, the RIF effect can be reversed and retrieval practice can improve recall of the other items.

FURTHER READING

For readers looking for a very basic and concise overview about the research on RIF, we recommend Bäuml (2008). Storm et al. (2015) recently provided a very general and more detailed review of RIF, covering the phenomenon as it arises in a variety of situations, like in eyewitness memory or creative cognition. Anderson (2003) gives a detailed overview of the theoretical properties of the inhibition account of RIF, and also addresses critical factors that can modulate or mask inhibitory processes. Murayama et al. (2014) offer a very comprehensive meta analysis of RIF, which does also allow evaluation of the inhibition and blocking accounts of RIF.

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APPENDIX

Categories and exemplars for the classroom demonstration (material adapted from Kliegl & Bäuml, in press).

HOBBY	FRUIT	ANIMAL	MUSICAL INSTRUMENT
Painting	Plum	Elephant	Flute
Dancing	Cherry	Lion	Trumpet
Running	Orange	Scorpion	Organ
Sailing	Lemon	Tiger	Bass
Basektball	Guava	Roach	Cello
Tennis	Banana	Mouse	Drums
BODY PART	**PROFESSION**	**FLOWER**	**KITCHEN DEVICE**
Finger	Architect	Aster	Knife
Nose	Policeman	Violet	Skillet
Hair	Teacher	Narcissus	Whisk
Elbow	Carpenter	Orchid	Fork
Knee	Gardener	Marguerite	Teapot
Belly	Soldier	Sunflower	Plate

TEXT BOX

Text box 25.1

Classroom experiment

Method

Participants

A recent meta-analysis revealed that effect sizes in the retrieval-practice task are usually between small and medium (see Murayama, Miyatsu, Buchli, & Storm, 2014). Estimating the required number of participants to optimally test for a small to medium effect size (d = .4) with the help of the program G*power (Faul, Erdfelder, Lang, & Buchner, 2007) reveals that the experiment needs 40 participants when α is set at 0.05 and β is set at .20.

Material and Design

A list of 48 items, consisting of 6 exemplars from 8 semantic categories, are used as material. Within each category, each item has a unique initial letter (see Appendix). The experiment is conducted in 3 main phases. In the study phase, participants study all of the items and then, in the retrieval-practice phase, half of the items from 4 of the 8 semantic categories are practiced, before in the final test phase, all items from the study phase have to be recalled. This design creates 3 types of items: The practiced items from the 4 practiced categories define the Rp+ items, the unpracticed items from the 4 practiced categories define the Rp-items, and the items from the 4 unpracticed categories define the control items.

Procedure

Prior to the experiment, participants are informed that they should study each to-be-presented word together with its category label. Following the initial instruction, all 48 items are shown to the participants via presentation software (such as Microsoft Powerpoint or Apple Keynote). Each category-exemplar pair (e.g. FRUIT-Orange) is presented on an individual slide for 5 s per pair. The order of the exemplars consists of a sequence of 6 blocks, consisting of one exemplar from each of the 8 categories, with the restriction that no two exemplars from the same category are presented on adjacent slides. In a subsequent 1 min distractor phase, participants solve simple arithmetic tasks (e.g., (8+32) x 9 = ?), before in the retrieval-practice phase, they are shown another set of slides, with each slide containing the test of a single category exemplar. Overall, three exemplar from four of the eight semantic categories are practiced. All exemplars are tested twice, with an average spacing of 12 trials between the first and the second test. The category label appears centered on the slide with the first two letters of the exemplar printed to the right of it (e.g. FRUIT-Or___). No two category members are tested on adjacent slides. Participants are given 6 s to complete each of the fragments on an empty sheet of paper. After another 2 min of solving arithmetic tasks as a distractor, participants are shown a final set of slides, in which they are tested on all the items that were shown to them during the original study phase. On each slide, participants are provided with the category label plus the unique initial letter of one of the initially learned items (e.g. FRUIT-O___) and are given 6 s to complete the fragment. Within those categories from which items were retrieved in the retrieval-practice phase, the three Rp+ items and the three Rp- items are blocked, and the three Rp- exemplars are recalled prior to the Rp+ exemplars, thus ensuring that

output-interference effects at test are avoided (see explanations later in this chapter). Table 25.1 summarizes the procedure. The whole experiment should take approximately 15 min.

(Insert Table 25.1 about here)

Results

First, you should verify whether participants' repeated retrieval of Rp+ items during the retrieval-practice phase was successful. The percentage of correctly recalled items should be relatively high, typically in the order between 75 and 100 percent. Regarding final-test performance, a paired t-test should show that the percentage of correctly recalled Rp+ items is higher than the percentage of correctly recalled control items, which would be line with the results of the Anderson et al. (1994) study and numerous further RIF studies and demonstrate the expected positive effect of retrieval practice on memory of Rp+ items. More importantly, a second paired t-test should reveal that the percentage of correctly recalled Rp- items is lower than the percentage of correctly recalled control items, thus reflecting the RIF effect as originally demonstrated by Anderson et al. (1994) in the retrieval-practice task.

TABLE

Table 25.1

Overview of the procedural phases of the classroom demonstration

Study phase	• Participants are presented with the study list, which consists of 6 items from each of 8 semantic categories. • All 48 items of the study list are shown individually together with their category cues (e.g., FRUIT – Orange).
Retrieval-practice phase	• Participants are tested twice on half of the exemplars from half of the categories, that is, 3 exemplars from each of 4 of the categories. • For this retrieval-practice task, the category label is presented together with the first two letters of the exemplar and participants are asked to complete the fragment (e.g. FRUIT-Or___).
Final test phase	• Participants are tested on all 48 items from the original study list. • For this final test, the category label is presented together with the unique first letter of the exemplar and participants are asked to complete the fragment (e.g. FRUIT-O___).

FIGURE CAPTIONS

Figure 25.1

Retrieval-induced forgetting. (A) Experimental procedure. Participants study a categorized item list. In a subsequent retrieval-practice phase, half of the items from half of the studied categories are repeatedly retrieved. On the final memory test, participants are asked to recall all previously studied items. (B) Typical pattern of results. Practiced (Rp+) items show higher recall rates and unpracticed (Rp-) items from retrieval-practiced categories show lower recall rates than control (C) items from not retrieval-practiced categories.

Figure 25.2

The two faces of selective memory retrieval. (A) Experimental procedure. Participants study a list of unrelated items consisting of target and nontarget items, and afterwards, participants' mental context is either changed or left unchanged. Subsequently, participants repeatedly retrieve the nontarget items or are engaged in an unrelated distractor task. On the final memory test, participants are asked to recall the target items. (B) Typical pattern of results. When there is no change in context after study, target recall is higher in the absence (C items) than in the presence (Rp- items) of prior nontarget retrieval practice. In contrast, when there is a change in context after study, target recall is lower in the absence (C items) than in the presence (Rp- items) of the retrieval practice.

[Note to the publisher: Please try to place the figure captions into the lower right corner of each figure.]