Retrieval from Episodic Memory: Beneficial and Detrimental Effects of Selective Memory Retrieval

Inaugural-Dissertation zur Erlangung der Doktorwürde
der Philosophischen Fakultät II
(Psychologie, Pädagogik und Sportwissenschaft)
der Universität Regensburg

vorgelegt von

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Regensburg 2014

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Zweitgutachter: Prof. Dr. Klaus W. Lange

Acknowledgement

First and foremost, I want to thank my supervisor and the initiator of this thesis, Karl-Heinz Bäuml, for sharing his scientific knowledge and experience with me, for his helpful suggestions regarding memory research and teaching, and for being always available for questions and concerns. Particularly, I want to thank him for supporting me in pursuing not only an academic but also a clinical career.

Special thanks go to my colleagues at the Bäuml lab for always lending me their helping hands and for mixing work and pleasure. Alp Aslan, Bernhard Pastötter, Simon Hanslmayr, Anuscheh Kirchner, Magdalena Abel, Oliver Kliegl, Andreas Schlichting, Christoph Holterman, and Julia Rupprecht were not only workmates, but also became friends over the years. I'll miss sharing my coffee and lunch breaks with them, having after-work drinks, attending conferences together, and, above all, talking about everything and anything. Many thanks go also to Margit Frimberger and Petra Witzmann, who fought my battles with red tape and were always available for diverting and entertaining chats. Moreover, I want to thank the lab's research assistants (e. g., Anna Karl, Christina Bauer, Rebecca Zack, Franziska Czeicke, and Lisa Wallner) for their help with collecting the present data.

In a completely different way, I want to thank my partner Michael for supporting me in everything I do, and for cheering me up whenever I need it.

Last but certainly not least, my sincere thanks go to my parents for always standing behind me, no matter what decision I am making, and to my friends, who bring so much fun and joy into my life.

Preface

"The key process in memory is retrieval", Endel Tulving once declared in a 1991 interview with Michael Gazzaniga. Without retrieval, encoding and storage would be of little value for us. If we were not able to retrieve previously experienced information, a good deal of our lives would be characterized by trial and error, over and over again. We would have to scour the whole parking area for our car in the morning, not being able to retrieve where we parked it yesterday. Not to mention that we wouldn't even know that we own a car or the route to the parking area in the first place. Thus, retrieving information, i. e., reactivating a particular existing memory, can help us to assess a situation and to modulate our current behavior according to the state of our knowledge. Besides this important function, autobiographical memories directly affect our personality and identity formation. By retrieving our past experiences, we develop a conception of who we are and how we differ from others. These examples show very plainly how important retrieval processes are for our everyday lives (for a review, see Rajaram & Barber, 2008).

After it had been philosophically discussed and scientifically investigated for centuries, Tulving (1972) introduced a prominent concept for the form of memory, which consists of all individual experiences a person made at a certain time in a certain place, and called it episodic memory. Ever since Ebbinghaus (1885), purpose-built lists of items (e. g., consisting of words, syllables, shapes) have been used to examine this type of memory in laboratory settings. When participants study these lists, it is assumed that all types of information (e. g., time, space, emotion, perception) available at that particular moment are associated with the presented items and, thus, constitute an entry in episodic memory. When participants are asked to recall the previously studied items later on, they virtually travel back in time and reconstruct the spatiotemporal encoding context of the earlier experienced episode in order to retrieve the requested information (for a review, see Kahana, Howard, & Polyn, 2008).

Memory performance for previously studied items has been shown to depend strongly on the availability of adequate retrieval cues (e. g., Tulving, 1985; Tulving & Osler, 1968; Tulving & Psotka, 1971). For instance, after studying a categorized item list participants recall significantly more list exemplars if category names are provided as cues (Tulving & Pearlstone, 1966). As a boundary condition, however, retrieval cues at test seem to help us only if they match the cues provided in the study phase, i. e., if the cue at test is able to reactivate the original encoding context (e. g., Thomson & Tulving, 1970; Tulving & Thomson, 1973). As a very intriguing example of this so-called *encoding specificity principle*, Godden and Baddeley (1975) asked participants to study a list of items either on dry land or under water. Later on, participants completed a free recall test either in the same place as the encoding condition (e. g., study on dry land, test on dry land) or in a place mismatching the encoding condition (e. g., study on dry land, test under water). Recall performance was best, when there was a match between place at encoding and place at test, a finding which has become known as the context-dependent memory effect (for related results, see also Eich, 1980; Eich & Metcalfe, 1989; Goodwin, Powell, Bremer, Hoine, & Stern, 1969; S. M. Smith, Glenberg, & Bjork, 1978).

However, not only retrieval cues like category names can facilitate recall, but also recall itself can be a self-propagating process (e. g., J. R. Anderson, 1972; Raaijmakers & Shiffrin, 1981). When we are for example looking back on our last summer vacation, at first, a beautiful beach we liked very much may come to our mind. Recalling this, we may remember that there was a nice little restaurant near that beach where we ate a delicious fish platter. Thinking of this, we recall that the next day we went hiking in the mountains, before we went to the next bigger city, and so forth. This example shows that already recalled information can cue yet-to-be-remembered memories, and thus foster memory performance. Geiselman and colleagues applied this knowledge by introducing a new technique to interrogate eyewitnesses called cognitive interview, and investigated its effect on recall of the relevant information (Geiselman, Fisher, MacKinnon, & Holland, 1985). Participants were asked to view films showing simulated crimes before being interviewed by specially trained law-enforcement staff 48 hours later. The cognitive interview technique aims to reactivate the internal and external context of the encoding situation by, inter alia, recounting the observed crime in different orders (e. g., forwards, backwards) or by shifting the perspective and imagining, what other involved persons might have observed. Participants who were interrogated employing this new technique recalled significantly more relevant details of the previously observed incident than witnesses who were questioned employing a standard police interview technique (see also, Fisher & Geiselman, 1988; Fisher, Geiselman, & Amador, 1989).

Context-retrieval theories provide an explanation for this beneficial effect of retrieval on related memories. According to these theories, during study items become associated with the temporal, spatial and situational context accompanying the study material (e. g., Bower, 1972; Estes, 1955; Greene, 1989; Howard & Kahana, 2002). When a previously studied item is repeated at a later point in time, be it by virtue of reexposure or its successful recall, it retrieves the context in which it was originally presented, which may then serve as a retrieval cue for the recall of the remaining information. Techniques like the cognitive interview are supposed to facilitate this process by helping people to actively reactivate the original encoding context of, for instance, a crime scene. These theories are also in line with the idea of spreading activation (e. g., Collins & Loftus, 1975; Loftus & Loftus, 1974; Slamecka, 1968; Warren, 1977), which explains, how recall can be self-propagating. It is assumed that as soon as a particular item is recalled, all related memories become activated, which in turn makes recall of these active memories more likely.

In the 70s, however, researchers reported a somewhat surprising and puzzling finding: recall of some previously studied items impaired recall of the remaining items (e. g., Roediger, 1974; Roediger, 1978; A. D. Smith, 1971). Evidence for this self-limiting property of memory retrieval has arisen mainly from two experimental paradigms: the output-interference paradigm and the retrieval-practice paradigm (for reviews, see M. C. Anderson, 2003; Bäuml, Pastötter, & Hanslmayr, 2010; Roediger & Neely, 1982). In the output-interference paradigm, it is examined how the recall of studied items varies as a function of the items' serial position in the testing sequence. The general result is that an item's recall chances decline with its testing position, suggesting that the preceding recall of other list items can impair recall of remaining target information (e. g., Roediger, 1974; A. D. Smith, 1971). In the retrieval-practice paradigm, participants study a list of items, practice retrieval of a subset of the items, and then are tested on all originally studied items. The typical result is that, relative to an appropriate control condition, recall of the practiced items is enhanced but recall of the unpracticed items is impaired, suggesting that repeated retrieval of some list items can impair later recall of the other items (e. g., M. C. Anderson, Bjork, & Bjork, 1994; M. C. Anderson & Spellman, 1995). Since M. C. Anderson et al. (1994), the latter finding is termed retrieval-induced forgetting (RIF).

There is ongoing debate in the literature about whether this detrimental effect of selective memory retrieval is mediated by inhibition or blocking (e. g., M. C. Anderson, 2003; Raaijmakers & Jakab, 2012; Verde, 2013). According to the blocking account, retrieval strengthens the memory representations of the retrieved material. As a consequence, during test already recalled items are stronger and therefore easier to retrieve. Persistent retrieval of stronger items then blocks access to the remaining (weaker) items (Rundus, 1973). In contrast, according to the inhibition account, the detrimental effect of memory retrieval is due to direct suppression of not-yet-recalled items. It is assumed that during recall of some items related memories interfere and may get inhibited to make selection of the relevant material easier (e. g., M. C.

Anderson, 2003).

Recently, Bäuml and Samenieh (2010; 2012a; 2012b) succeeded in showing both the self-limiting and the self-propagating property of memory retrieval within one single experimental setup. They suggested that whether selective memory retrieval is detrimental or beneficial for the recall of related other items, strongly depends on the degree to which the original encoding context is accessible. When access to the original study context was (largely) maintained, prior selective retrieval of some (nontarget) items reduced subsequent recall of the remaining (target) items. In contrast, when access to the original study context was impaired after an implicit context change or after a cue to forget previously studied material, prior selective retrieval of nontarget items improved subsequent target recall.

Bäuml and Samenieh (2012b) introduced a two-factor account to explain these two faces of selective memory retrieval and suggested that the detrimental effect of selective retrieval is caused by inhibition or blocking (e. g., M. C. Anderson, 2003; Roediger & Neely, 1982), while the beneficial effect is due to a reactivation of the retrieved items' original encoding context (e. g., Howard & Kahana, 1999, 2002). According to this two-factor account, quite different processes underlie the two opposing effects of selective memory retrieval, thus indicating that the beneficial and detrimental effects of memory retrieval should be dissociable from one another. The present thesis is dedicated to investigating the two faces of memory retrieval in more detail. Experiment 1 was designed to examine whether the delay between preceding nontarget and subsequent target recall influences the beneficial and detrimental effects of selective memory retrieval differently. Experiment 2A and Experiment 2B were designed to examine whether the two opposing effects of selective memory retrieval differ in recall specificity. Finally, Experiments 3A and 3B focus on the detrimental effect of selective retrieval, particularly on possible dynamic effects between selective retrieval and restudy.

Section 1 of this dissertation starts by introducing the output-interference and retrieval-practice paradigm, followed by relevant findings regarding the detrimental effect of memory retrieval. Subsequently, findings are outlined which show that the detrimental effect is recall specific and boundary conditions for output interference and retrieval-induced forgetting are discussed. Then, Bäuml and Samenieh's recent findings concerning the two faces of selective memory retrieval are reported and possible accounts for the two effects including Bäuml and Samenieh's two-factor account of selective memory retrieval are explained. Section 2 introduces the goal of the present thesis, and sections 3 - 5 contain the methods and results of five experiments, each of which is briefly introduced and discussed. Finally, in section 6, the main results of this dissertation are summarized and discussed.

Contents

Parts of the present thesis are published as:

Dobler, I. M. & Bäuml, K.-H. T. (2012). Dissociating the two faces of selective memory retrieval. *Memory, 20*, 478-486.

Dobler, I. M. & Bäuml, K.-H. T. (2013). Retrieval-induced forgetting: Dynamic effects between retrieval and restudy trials when practice is mixed. *Memory & Cognition, 41*, 547-557.

Bäuml, K.-H. T. & Dobler, I. M. (in press). The two faces of selective memory retrieval: recall specificity of the detrimental but not the beneficial effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition.*

Abstract

Selective retrieval can be detrimental for related memories if access to the original study context is (largely) maintained, or beneficial if access to the original encoding context is impaired. Prior work has shown that the detrimental effect is typically recall specific and not disrupted by the presence of a delay between prior nontarget retrieval and subsequent target retrieval, whereas neither the influence of a delay nor recall specificity of the beneficial effect have been examined to date. The two-factor account of selective memory retrieval, which attributes the detrimental effect to inhibition/blocking and the beneficial effect to reactivation of the original study context, suggests that the delay between prior nontarget retrieval and subsequent target recall as well as recall specificity might affect the two opposing effects differently. Experiment 1 demonstrated detrimental effects regardless of delay but beneficial effects only if target recall was undelayed. Experiments 2A and 2B showed that the detrimental effect is recall specific, while the beneficial effect generalizes to restudy trials. Pointing to different underlying mechanisms, the demonstration that delay between nontarget and target recall and recall specificity affect the detrimental and the beneficial effect differently, supports the two-factor account of selective memory retrieval. Experiments 3A and 3B focused on the robustness of recall specificity of the detrimental effect and showed that selective restudy - like selective retrieval - can induce forgetting of related memories when practice is mixed, i. e., when retrieval and restudy trials are randomly interleaved. Thus, the present thesis provides first evidence for dynamic effects between retrieval and restudy trials when practice is mixed.

Chapter 1

Effects of selective memory retrieval

1.1 Retrieval as a self-limiting process

Everyday experiences show that selective retrieval of some memories can aid retrieval of related information. Telling a friend about our last birthday party, our last holidays, or yesterday's business lunch activates all memories which are related to the respective event. One memory then leads to another so that in this case recall can be seen as a self-propagating process. Geiselman and colleagues, for instance, confirmed this intuitive impression by showing a beneficial effect of selective retrieval on related information in eyewitness testimony (e. g., Fisher & Geiselman, 1988; Fisher et al., 1989; Geiselman et al., 1985). During the past four decades, however, researchers have repeatedly argued that retrieval is a self-limiting process (Roediger, 1978). This view assumes that selective retrieval of some memories impairs retrieval of related information (for reviews, see M. C. Anderson, 2003; Bäuml et al., 2010; Roediger & Neely, 1982). The detrimental effect of selective memory retrieval has been repeatedly shown in studies employing the output-interference paradigm (e. g., Roediger, 1974; A. D. Smith, 1971) and the retrieval-practice paradigm (M. C. Anderson et al., 1994).

The output-interference paradigm

Output-interference refers to the finding that the recall probability of a particular item decreases the later this item is to be recalled during a testing sequence (e. g. Roediger, 1974; Roediger & Schmidt, 1980; A. D. Smith, 1971; Tulving & Arbuckle, 1963, 1966). In a typical output-interference paradigm, participants study a list of items and are later asked to retrieve the previously studied items. During recall, item-specific cues are presented to control output order and to specifically investigate the effect of previously recalled items on later recalled (target) items. Output-interference has been found in short-term memory (e. g., Tulving & Arbuckle, 1963, 1966), in semantic memory

(e. g., Blaxton & Neely, 1983; A. S. Brown, 1981), using paired-associate lists (Roediger & Schmidt, 1980, Experiment 4), and categorized item lists (e. g., Dong, 1972; Roediger & Schmidt, 1980, Experiments 1-3; A. D. Smith, 1971). Roediger and Schmidt (1980), for instance, asked participants to successively study ten different categories together with their associated category exemplars. Finally, after they had conducted a short distractor task, participants were to complete a recall test. Category names were presented in a predetermined order and participants were asked to recall as many of the previously studied category exemplars as possible before moving on to the next category name. Roediger and Schmidt were able to show that the number of recalled category exemplars declined with testing position of the corresponding category. Employing categorized lists, they also emphasized the robustness of the output-interference effect by showing constant output-interference across a number of different experimental conditions, e. g, when categories in the list were semantically related (Experiment 3).

In short, the output-interference paradigm can be used to investigate retrieval-induced forgetting (RIF) within a single testing sequence. In this paradigm, prior recall of items leads to forgetting of later (target) items during the same recall test session. Based on this, M. C. Anderson and colleagues designed a new paradigm to demonstrate that retrieval-induced forgetting can be a lasting effect, which is not confined to a single testing sequence (M. C. Anderson et al., 1994).

The retrieval-practice paradigm

To examine long-term effects of selective retrieval, M. C. Anderson and colleagues included a retention interval between retrieval of some memories and recall of the remaining (target) items in their new paradigm (M. C. Anderson et al., 1994). This so-called retrieval-practice paradigm consists of three experimental phases: a study phase, a retrieval-practice phase, and a test phase. In the study phase, they asked participants to study category-exemplar pairs (e. g., WEAPONS-*arrow*, FRUITS-*banana*, WEAPONS-*pistol*). In the subsequent retrieval-practice phase, participants were instructed to practice retrieval of half of the items from half of the categories (e. g., WEAPONS-*ar*____). After they had completed a causal reasoning task for 20 minutes, participants then were asked to complete a final category-cued recall test, i. e., a category name was presented (e. g., WEAPONS) and participants were instructed to recall all previously studied category exemplars associated with that category name. The finding was that retrieval-practice enhances later recall of the practiced items (e. g., *arrow*) relative to unpracticed exemplars from unpracticed categories (control items; e. g., *banana*), but induces forgetting of unpracticed items from practiced categories (e. g., *pistol*) relative to the control items. This also holds when output interference is controlled: M. C. Anderson and colleagues found the detrimental effect of selective retrieval when unpracticed items were tested prior to practiced items within each category in a final category-plus-stem-cued recall test (M. C. Anderson et al., 1994, Experiment 2; for similar findings, see Bäuml & Aslan, 2004; Kuhbandner, Bäuml, & Stiedl, 2009; Staudigl, Hanslmayr, & Bäuml, 2010). This finding suggests that RIF is caused by the manipulation during the intermediate retrieval-practice phase and does not occurr in consequence of biased output order during the final recall test.

Practice effects, as they have been examined in the retrieval-practice paradigm, are theoretically interesting because they provide information about beneficial and detrimental effects of retrieval and their underlying mechanisms, and they are of practical relevance because retrieval-practice as well as relearning can play an important role in educational settings. Memory improvement of the practiced material by means of (repeated) retrieval-practice has, for example, frequently been shown in studies concerning the so-called testing effect (e. g., Hogan & Kintsch, 1971; Roediger & Karpicke, 2006; for reviews, see Karpicke, 2012; Roediger & Butler, 2011). These studies suggest that retrieval-practice can be a very effective learning strategy by showing that testing material through recall tests is even superior to repeated study of the same material in healthy humans as well as in clinical populations (e. g., Haslam, Hodder, & Yates, 2011; Karpicke & Blunt, 2011; Sumowski, Chiaravalloti, & DeLuca, 2010).

M. C. Anderson and colleagues, as well as numerous researchers before and after them, however, focused on the less obvious detrimental effect of selective retrieval (for reviews, see M. C. Anderson, 2003; Bäuml et al., 2010; Storm & Levy, 2012). By now, it has been shown in a broad variety of settings that repeated retrieval can induce forgetting of related material (e. g., Dunn & Spellman, 2003; Bäuml & Kuhbandner, 2003; Saunders & MacLeod, 2002). Shaw, Bjork, and Handal (1995) for example found RIF in eyewitness memory by showing that repeated questioning concerning specific details of a previously observed scene enhanced memory for these details but attenuated recall of the remaining information. Moreover, potential eyewitnesses may be more susceptible for misinformation when they have been selectively interrogated beforehand (Saunders & MacLeod, 2002). Macrae and MacLeod (1999) also showed RIF in social cognition. Within an impression formation task, they presented participants personality characteristics of two men, Bill and John, without giving any explicit study instructions (e. g., JOHN-*creative*, BILL-*romantic*, JOHN-*skillful*). Subsequently, participants' memory for half of the traits for one of the two men (e. g., JOHN-*cr*____) was probed. In a later surprise cued recall test, in which participants were asked to recall all previously presented personality traits belonging to John and Bill, the typical pattern emerged: recall of unpracticed traits from the practiced person (e. g., John) was impaired relative to unpracticed traits from the other, unpracticed person (e. g., Bill).

Furthermore, RIF has been found in a wide range of different memory tests, including free recall, category-cued, and initial-letter-cued recall tasks (e.g, M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995; Bäuml & Aslan, 2004; Macrae & MacLeod, 1999), implicit memory tests (e. g., Perfect, Moulin, Conway, & Perry, 2002; Veling & van Knippenberg, 2004), free-flowing conversations (e. g., Cuc, Koppel, & Hirst, 2007), and recognition tests (e. g., Gómez-Ariza, Lechuga, Pelegrina, & Bajo, 2005; Hicks & Starns, 2004; Spitzer & Bäuml, 2007; Verde, 2004). Moreover, Bäuml (2002) showed that semantic generation can cause epsiodic forgetting of previously studied material, and RIF has been shown in tests employing the independent-probe technique. In studies employing this technique, items are not cued with the previously studied category-names but with novel, independent stimuli (e. g., M. C. Anderson & Bell, 2001; Aslan, Bäuml, & Grundgeiger, 2007; Veling & van Knippenberg, 2004). Both, the findings of RIF in recognition and independent-probe tests, have theoretical implications for the underlying mechanisms of the detrimental effect of selective memory retrieval and will be discussed in section 1.3.

In addition, RIF has been shown with different item materials, including visual materials with only episodic and no semantic inter-item relations (e. g., Ciranni & Shimamura, 1999), and meaningful items that typically occur in eyewitness situations (MacLeod, 2002). Moreover, emotional and unemotional autobiographical memories are susceptible to RIF (e. g., Barnier, Hung, & Conway, 2004; Stone, Barnier, Sutton, & Hirst, 2013), even if well-rehearsed and emotionally intense information, for instance about the terror attacks on 9/11/2001, or trauma-related stimuli are concerned (Coman, Manier, & Hirst, 2009; A. D. Brown, Kramer, Romano, & Hirst, 2011). RIF is also observable in young children (e. g., Zellner & Bäuml, 2005) and in older adults (e. g., Aslan, Bäuml, & Pastötter, 2007; Moulin et al., 2002), as well as in patients who suffer from Alzheimer's disease (Moulin et al., 2002).

Lately, a number of studies showed that the detrimental effect of selective retrieval is not only observable within but also between individuals, i. e., RIF can be socially shared (e. g., A. D. Brown et al., 2011; Cuc et al., 2007; Coman et al., 2009; Stone, Barnier, & Sutton, 2010; Stone et al., 2013). Particularly, these studies suggest that listening to a speaker who selectively remembers some information can induce forgetting of related material in the listener. This so-called socially-shared retrieval induced forgetting has also been found in free-flowing conversations (e. g., Cuc et al., 2007) and in studies using emotional item material (e. g., Coman et al., 2009; Stone et al., 2013). A. D. Brown and colleagues (2011) even found that selective retrieval of trauma-related stimuli enhances within-individual and socially-shared RIF for patients who suffer from Post-Traumatic Stress Disorder (PTSD).

Retrieval-induced forgetting as a recall specific mechanism

RIF has proven to be a recall specific effect and to typically arise if participants actively retrieve the to-be-practiced items, but not if they just strengthen these items through reexposure. Ciranni and Shimamura (1999) reported such a pattern using visual material. Participants learned the locations of uniquely colored items that could be categorized by shape (e. g., circles, crosses). Retrieval-practice on the locations of half of the objects from a shape category facilitated memory performance for practiced items but impaired recall of the unpracticed objects' locations. In contrast, a second practice condition, in which a subset of the items was repeatedly reexposed instead of being retrieval-practiced, induced recall improvement for the practiced items but no forgetting of the related unpracticed items. Similar demonstrations have been reported in numerous other studies employing verbal material (e. g., M. C. Anderson, Bjork, & Bjork, 2000; Bäuml, 2002; Bäuml & Aslan, 2004; Hanslmayr, Staudigl, Aslan, & Bäuml, 2010; Hulbert, Shivde, & Anderson, 2012; for an exception, see Raaijmakers & Jakab, 2012; Verde, 2013). Bäuml (2002) generalized this finding from episodic retrieval-practice to semantic generation. After participants had studied a categorized item list (e. g., FRUIT-*apple*, FRUIT-*orange*), they either studied further category exemplars (e. g., FRUIT-*kiwi*), or the participants completed a semantic generation task, in which they were instructed to repeatedly generate related items from the already known semantic categories (e. g., FRUIT-*ki*____). Only semantic generation but not presentation of further items caused forgetting of related study phase items.

While Ciranni and Shimamura (1999) directly compared the effects of retrieval-practice of a subset of the previously studied items with the effects of restudy of these items to investigate recall specificity of the detrimental effect of selective retrieval (see also, Bäuml & Aslan, 2004; Hulbert et al., 2012), others compared so-called competitive and noncompetitive retrieval-practice conditions (referring to previously studied items as contestants, which compete for successful recall) to address this issue (e. g., M. C. Anderson, Bjork, et al., 2000; Hanslmayr, et al., 2010; see also Raaijmakers & Jakab, 2012; Verde, 2013). M. C. Anderson, Bjork and colleagues (2000), for instance, asked participants to study a categorized item list (e. g., FRUIT-*orange*). Subsequently, participants either practiced retrieval of some category exemplars (e. g., FRUIT-*or*____ ; competitive condition), or they practiced retrieval of the category names (e. g., FR____-*orange*; noncompetitive condition). Despite comparable strengthening of the practiced items, only the competitive retrieval-practice induced forgetting of related material suggesting that RIF arises due to a recall specific process. These findings also have theoretical implications for the underlying mechanisms of the detrimental effect of selective memory retrieval (see section 1.3).

Boundary conditions

Previous sections showed that RIF is a notably robust finding. Nonetheless, some boundary conditions for this detrimental effect of selective memory retrieval have been reported in the last decade. One moderating factor which alters the amount of forgetting after previous selective retrieval is the integration of the relevant material (e. g., M. C. Anderson, Green, & McCulloch, 2000; M. C. Anderson & McCulloch, 1999; Bäuml & Hartinger, 2002; R. E. Smith & Hunt, 2000). Studies which manipulated integration of the employed item material show that RIF is greatly attenuated, or even eliminated, when participants strengthen associations between practiced and unpracticed items. M. C. Anderson and McCulloch (1999), for instance, asked participants to find inter-item-associations between category exemplars during the encoding phase. Participants who were encouraged to look for linking characteristics suffered significantly less RIF than participants who completed a traditional study phase without such an instruction (for similar findings, see M. C. Anderson, Green, et al., 2000). Related results were found using propositional material (M. C. Anderson & Bell, 2001) and DRM lists (Bäuml & Kuhbandner, 2003; for information about DRM lists, see Roediger & McDermott, 1995). Moreover, Bäuml and Hartinger (2002) showed elimination of RIF using study material with strong preexperimental associations (e. g., *lion* and *tiger*).

Secondly, the delay between retrieval-practice of some items and later recall of the related items seems to moderate the RIF effect. MacLeod and Macrae (2001) showed that RIF is a transient effect, which is gone after a delay of 24 hours between preceding retrieval-practice and a final recall test (but see, Garcia-Bajos, Migueles, & Anderson, 2009). Additionally, Bäuml and Kuhbandner (2007) identified the affective state during retrieval as a boundary condition for RIF. They asked participants to study emotionally neutral category exemplars. Before participants practiced retrieval of a subset of these items, a mood induction was carried out using either positive, negative, or neutral pictures. In a later final recall test, RIF of related unpracticed items was observable in the neutral and positive mood condition but it was nonexistent after the negative mood induction. Similarly, stress (Koessler, Engler, Riether, & Kissler, 2009) and performing a divided-attention task during retrieval of the nontarget items (Román, Soriano, Gomez-Ariza, & Bajo, 2009) can eliminate the detrimental effect of selective memory retrieval.

Chan, McDermott, and Roediger (2006) even found a beneficial effect of selective retrieval on related material combining well integrated prose material and a 24-hours delay between retrieval-practice and final recall test (for similar results, see Chan, 2009; but see Abel & Bäuml, 2012). Additionally, real-life experience as well as applied studies concerning eyewitness testimony suggest that retrieval-practice can sometimes enhance recall of related information

(e. g., Fisher & Geiselman, 1988; Fisher et al., 1989; Geiselman et al., 1985). Consequently, in the last years several studies focused on the question of whether there may be different faces of selective memory retrieval by addressing the issue of whether selective retrieval may be detrimental for recall of related items under some circumstances and beneficial under others.

1.2 The two faces of selective memory retrieval

As described above, research of the past four decades has repeatedly shown that selective retrieval of some (nontarget) memories can impair subsequent retrieval of other (target) information, which is a very robust finding known as retrieval-induced forgetting (for reviews, see M. C. Anderson, 2003; Bäuml et al., 2010; Storm & Levy, 2012). Nevertheless, this finding seems to be in conflict with everyday experiences, in which one memory sometimes seems to lead to another and selective retrieval rather appears to have self-propagating characteristics. Moreover, several studies identified boundary conditions for the detrimental effect of selective retrieval (e. g., M. C. Anderson & McCulloch, 1999; Bäuml & Kuhbandner, 2007). Recently, Bäuml and colleagues were able to show both a self-limiting and a self-propagating face of selective memory retrieval within one experimental setup (Aslan & Bäuml, 2014; Bäuml & Samenieh, 2010, 2012a, 2012b). Using the listwise directed-forgetting task (e. g., R. A. Bjork, 1970), Bäuml and Samenieh (2010) asked participants to study a list of items (e. g., *rose, dragon, wool, hunter*) and then provided the participants a cue either to forget or to continue remembering the previously studied item list. After study of a second list, participants' memory for predefined target items (e. g., *rose, wool*) from the first list was tested. Testing differed in whether participants were asked to retrieve 0, 4, 8, or 12 of the list's remaining (nontarget) items (e. g., *dragon, hunter*) before they recalled the list's target items. The results showed that, as more and more of the nontarget items were previously retrieved, target recall decreased linearly in the remember condition but increased linearly in the forget condition, indicating that selective memory retrieval can both impair and improve recall of related memories.

In a second study, Bäuml and Samenieh (2012b) replicated this basic finding and extended it by demonstrating the self-propagating property of memory retrieval also for memories that are subject to context-dependent forgetting. Again, they asked participants to study two lists of unrelated items. This time, however, they employed a diversion task (e. g., Sahakyan & Kelley, 2002) in lieu of a forget cue between study of List 1 and study of List 2. In particular, participants studied a first list of items, then conducted an imagination task to change their mental contextual state, or performed a counting task as a baseline control, and subsequently studied a second list of items. In the counting condition, prior retrieval of nontargets attenuated recall of the target items, whereas retrieval of nontargets improved target recall in the imagination condition (for an extension of the results from selective memory retrieval to part-list cuing, see Bäuml & Samenieh, 2012a).

Lately, Aslan and Bäuml (2014) investigated the developmental trajectory of both faces of selective memory retrieval in second, fourth, and seventh graders. Again, participants studied a first list of items, then received a cue to either continue remembering or to forget this first list, and studied a second list of items. While preceding nontarget recall in the final memory test impaired subsequent recall of predefined to-be-remembered target items regardless of age (see also, Zellner & Bäuml, 2005), the results suggest a later maturation of the beneficial effect of selective retrieval. Preceding nontarget retrieval facilitated recall of the remaining to-be-forgotten target items in seventh graders but not in the younger age groups.

In sum, Bäuml and colleagues showed both the detrimental and the beneficial face of memory retrieval combining a variant of the output-interference task with the listwise-directed forgetting or the context-change task (Aslan & Bäuml, 2014; Bäuml & Samenieh, 2010, 2012a, 2012b). Because both a forget cue and an imagination task seem to impair access to the original study context (e. g., Geiselman, Bjork, & Fishman, 1983; Sahakyan & Kelley, 2002), the results were interpreted as evidence that selective retrieval is detrimental in the absence of impaired context access but can be beneficial if access to the study context is impaired.

1.3 Underlying mechanisms

Accounts for the detrimental effect of memory retrieval

During the last decades, there has been ongoing debate about the underlying mechanisms of output interference and retrieval-induced forgetting. The two most prominent accounts of the detrimental effect of selective memory retrieval, the strength-dependent competition account and the inhibition account, are premised on a competition principle. The assumption is that all studied items which are associated to a shared cue (e. g., category exemplars which are associated to the category name) become activated and compete for conscious recall when the cue is available (e. g., J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Rundus, 1973).

The strength-dependent competition account assumes that studying new material, which becomes linked to the same cue, as well as strengthening the association between some items and the shared cue increases competition. This increased competition then again reduces recall probability of the single items associated with the shared cue (e. g., Camp, Pecher, & Schmidt, 2007; Jakab & Raaijmakers, 2009; Rundus, 1973; Williams & Zacks, 2001). Applied to a typical RIF experiment, this account suggests that selective retrieval during the retrieval-practice phase strengthens the associations between practiced items and the category cues, which increases recall chances for these practiced items in the later final recall test. As a consequence, however, the associations of unpracticed items of retrieval-practiced categories become relatively weaker, leading to reduced recall chances for unpracticed items.

Transferred to output-interference situations, previous retrieval of (nontarget) items at the beginning of the recall test strengthens these items, and, as a consequence, these strengthened items come to mind more easily and, thus, block weak items during the recall test (e. g., Roediger & Neely, 1982; Rundus, 1973). To sum up, the strength-dependent competition account attributes RIF and output-interference to a relative attenuation of unpracticed (target) items because of previous relative strengthening of other (nontarget) items associated to the same cue. Hence, forgetting occurs in the wake of changes in the effectiveness of a cue to retrieve a certain item (e. g., Camp et al., 2007).

Recently, a further noninhibitory account, the context-change account, was introduced to explain RIF effects (e. g., Jonker, Seli & MacLeod, 2013; Perfect et al., 2004). According to this account, participants create distinct learning contexts during study and retrieval-practice. At test, when the category name of a practiced category is presented to cue related category exemplars, paticipants are assumed to focus their search on the retrieval-practice phase because it happened more recently, the encoding has been more elaborative in the retrieval-practice phase and/or the retrieval-practice context matches the test context to a larger extent than the study context. Consequently, recall of practiced items is improved, while recall of unpracticed items from practiced categories, which are tied only to the study phase, is relatively reduced. In contrast, when the category name from an unpracticed (control) category is presented in the final recall test, this cue reinstates the study context because this category solely occurred in the study phase. As a consequence, all category exemplars from unpracticed categories should profit from context reinstatement. According to this account, participants are supposed to unswervingly jump between the study and the retrieval-practice context during the final recall test depending on when the to-be-recalled category was presented, which seems to be implausible and requires further investigation.

Despite some results supporting the noninhibitory competition accounts (e. g., Camp et al., 2007; Jakab & Raaijmakers, 2009), they have been hard to reconcile with findings of RIF in item-specific tests (e. g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995; Bäuml & Aslan, 2004), item recognition tests (e. g., Hicks & Starns, 2004; Spitzer & Bäuml, 2007; Verde, 2004), and independent-probe tests (e. g., M. C. Anderson & Bell, 2001; Aslan et al., 2007; Veling & van Knippenberg, 2004). To explain these results, an inhibitory account was introduced, which assumes that the detrimental effect of selective memory retrieval is mediated by item suppression (e. g., M. C. Anderson, 2003; M. C. Anderson & Spellman, 1995). According to this inhibition account, not-to-be-practiced items from to-be-practiced categories interfere and compete for conscious recall during retrieval-practice of the to-be-practiced items. To reduce this interference and make selection of the relevant to-be-practiced material easier, the unpracticed items become suppressed. Hence, the unpracticed items' memory presentation is assumed to be directly affected, thus, in a subsequent memory test, recall of the unpracticed items is reduced. Transferred to output-interference situations, not-yet-to-be-recalled (target) items interfere during recall of (nontarget) items at the beginning of the memory test and get suppressed to facilitate retrieval of to-be-recalled (nontarget) items. This inhibition then leads to lower recall chances for the later tested remaining (target) items. Thus, in the inhibition account, forgetting is the result of reduced availability of the item itself.

Because, according to the inhibition account, the items' memory representation is directly affected, forgetting of related unpracticed items should also be present when these items are cued with new, independent probes or when the items are tested via a recognition test. This assumption has been confirmed in several studies during the last years (e. g., M. C. Anderson & Bell, 2001; Aslan et al., 2007; Spitzer & Bäuml, 2007; Verde, 2004). Moreover, the finding of RIF as a recall specific mechanism has been used as confirmation for item suppression (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml & Aslan, 2004; Ciranni & Shimamura, 1999). According to the inhibition account, only selective retrieval but not restudy causes interference of not-to-be-practiced material and, consequently, only retrieval should induce inhibition and, thus, forgetting of related unpracticed material. However, Raaijmakers and Jakab (2012) recently argued that recall specificity of the RIF effect is also consistent with blocking, at least if one assumes that retrieval-practice leads to much higher levels of strengthening of practiced items and thus to more forgetting of unpracticed items than restudy does. Such assumption, however, is not supported by data to date.

Several further findings support the idea of inhibitory mechanisms mediating the detrimental effect of selective retrieval. For instance, Spitzer and Bäuml (2007) presented data suggesting that RIF in an item recognition test was caused by a reduction in unpracticed items' general memory strength, and mensuration of recall frequencies and response latencies provided additional evidence for the inhibition account (Bäuml, Zellner, & Vilimek, 2005). Moreover, studies addressing the neural correlates of RIF by analyzing fMRI or EEG data are consistent with the inhibition account and support the view that the memory representations of unpracticed items are affected in consequence of selectively practicing retrieval of related items beforehand (e. g., Johansson, Aslan, Bäuml, Gäbel, & Mecklinger, 2007; Kuhl, Dudukovic, Kahn, & Wagner, 2007; Spitzer, Hanslmayr, Opitz, Mecklinger, & Bäuml, 2009; Wimber et al., 2008; Wimber, Rutschmann, Greenlee, & Bäuml, 2009; for a review, see Bäuml et al., 2010). These studies suggest, inter alia, that the anterior cingulate cortex (ACC) detects emerging interference of not-to-be-practiced item material during the retrieval-practice phase, whereas dorsolateral and ventrolateral prefrontal cortex areas are responsible for reducing this interference by strengthening practiced material and suppressing not-to-be-practiced items. For instance, Kuhl and colleagues (2007) showed that, with increasing retrieval-practice trials, the activity of the ACC and prefrontal regions declines, reflecting reduced demands on cognitive control mechanisms. Additionally, a higher level of interference during the retrieval-practice phase is indexed by more thetaband activity (Staudigl et al., 2010). These results also suggest that the dissolution of this interference is attended by a reduction in theta amplitude.

A two-factor account for the two faces of memory retrieval

Bäuml and Samenieh (2012b) suggested a two-factor account to explain why selective memory retrieval is detrimental under some circumstances but is beneficial under others. According to this account, selective memory retrieval generally triggers two processes, inhibition or blocking of interfering memories (e. g., M. C. Anderson, 2003; Roediger & Neely, 1982) and reactivation of the retrieved items' original encoding context (e. g., Howard & Kahana, 1999, 2002). Which of the two types of processes dominates in an experimental situation is assumed to depend on whether access to the study context is (largely) maintained or impaired. When access to the original study context is (largely) maintained - as it may occur after a remember cue or an intervening counting task -, then interference between items may be high enough to trigger inhibition or blocking processes, whereas not much room may be left for context reactivation processes (for further explanation, see preceding subsection). As a net result, prior (nontarget) recall may reduce subsequent recall of related (target) items. In contrast, if access to the original encoding context is impaired and the activation level of the to-be-retrieved memories is reduced - as, for instance, it may be the case in listwise directed forgetting and context-dependent forgetting (e. g., E. L. Bjork & Bjork, 1996; Geiselman et al., 1983; Sahakyan & Kelley, 2002) - not much room is supposed to be left for interference and inhibition (e. g., M. C. Anderson et al., 1994; Storm, Bjork, & Bjork, 2007) but much room may be left for context reactivation; preceding retrieval of the (nontarget) items may result in reactivation of the retrieved items' encoding context (e. g., Howard & Kahana, 1999, 2002), and this reactivated context may then serve as a retrieval cue for the target items. As a net result, prior (nontarget) recall may enhance subsequent recall of (target) items.

The expectation that the recall of an item can induce a reactivation of the item's original encoding context arises from context retrieval theory (e. g., Greene, 1989; Thios & D'Agostino, 1976) and more recent computational models that embody variants of the theory (Howard & Kahana, 2002; Polyn, Norman, & Kahana, 2009). Context retrieval theory assumes that an internal context representation is associated with each studied item and is used to guide memory search. When a previously studied item is repeated, be it by virtue of reexposure or its successful recall in a later experimental phase, it is assumed to activate the experimental encoding context (Howard & Kahana, 2002). In other words, retrieval of an item is supposed to update the current state of context, which in turn is used to cue recall. Results on the contiguity effect and the spacing effect, for instance, support such proposal (e. g., Greene, 1989; Howard & Kahana, 1999; Kahana & Howard, 2005).

Chapter 2

Goals of the present study

During the past four decades, researchers have repeatedly shown that selective retrieval of some memories can induce forgetting of other memories (for reviews, see M. C. Anderson, 2003; Bäuml et al., 2010; Roediger & Neely, 1982). Evidence for such retrieval-induced forgetting has arisen mainly from the output-interference paradigm and the retrieval-practice paradigm. Research employing the output-interference paradigm typically shows that recall performance at test declines as a function of the items' testing position, suggesting that the prior recall of other (nontarget) list items can impair subsequent recall of target information (e. g., Roediger, 1974; A. D. Smith, 1971). Research employing the retrieval-practice paradigm demonstrates that intervening retrieval-practice on a subset of previously studied items can cause forgetting of related unpracticed items on a later memory test (e. g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995). However, selective memory retrieval can not only impair but also improve recall of other items (Aslan & Bäuml, 2014; Bäuml & Samenieh, 2010, 2012b). Employing the listwise directed-forgetting task (e. g., R. A. Bjork, 1970), Bäuml and Samenieh (2012b) showed that prior retrieval of nontarget items impaired subsequent recall of to-be-remembered targets, but improved recall of to-be-forgotten target items. In the same study, similar results arose when employing a diversion task (e. g., Sahakyan & Kelley, 2002) in lieu of a forget cue.

Because both the forget cue and the imagination task seem to impair access to the original study context (e. g., Geiselman et al., 1983; Sahakyan & Kelley, 2002), the results were interpreted as evidence that selective retrieval is detrimental in the absence of impaired context access, but can be beneficial if access to the study context is impaired. Based on this understanding, Bäuml and Samenieh (2012b) suggested a two-factor account to explain the two opposing effects of selective memory retrieval. According to this account, selective memory retrieval generally triggers two processes, inhibition or blocking of interfering memories (e. g., M. C. Anderson, 2003; Roediger & Neely, 1982) and reactivation of the study context (e. g., Howard & Kahana, 1999, 2002). Which of the two types of processes dominates in an experimental situation is assumed to depend on whether access to the study context is impaired or (largely) maintained. Hence, the two-factor account of selective memory retrieval suggests that quite different processes underlie the two faces of selective memory retrieval, thus indicating that the beneficial and detrimental effects of memory retrieval should be dissociable from one another.

One major goal of the present study was to identify dissociating factors of the detrimental and the beneficial effect of selective memory retrieval on the basis of Bäuml and Samenieh's (2012b) two-factor account. Prior work suggests that the delay between preceding nontarget and subsequent target recall might be a factor dissociating the two faces of selective memory retrieval. Using both the output-interference and the retrieval-practice paradigm, several studies reported lasting detrimental effects of selective retrieval by showing robust RIF after a delay of 5 to 20 minutes between retrieval-practice and test (e. g., M. C. Anderson et al., 1994; Chan, 2009; MacLeod & Macrae, 2001), a finding which is consistent with both the inhibitory and the blocking account of RIF (e. g., M. C. Anderson et al., 1994; Roediger & Neely, 1982). In contrast, to date beneficial effects of selective memory retrieval have been demonstrated mainly by employing the output-interference paradigm (Bäuml & Samenieh, 2010, 2012b), in which target recall follows nontarget recall immediately. Consequently, these results are silent on whether beneficial effects occur when target recall is delayed. Bäuml and Samenieh's (2012b) two-factor account suggests that the beneficial effect of selective retrieval might be present primarily when target recall follows nontarget recall immediately, and be reduced, if not eliminated, when target recall is delayed. According to this account, the beneficial effect arises because preceding nontarget recall reactivates the retrieved items' original encoding context (e. g., Bäuml & Samenieh, 2012b; Howard & Kahana, 2002). This reactivated context, however, may only be an effective cue for the remaining target items if the retrieval process was not interrupted, for instance, by means of an interpolated distractor task between retrieval-practice of nontarget items and target recall. Hence, Experiment 1 was designed to examine whether the delay between preceding nontarget and subsequent target recall influences the beneficial and detrimental effects of selective memory retrieval differently. Following Bäuml and Samenieh's (2012b) two-factor account and the comprised view that the detrimental effect of selective retrieval is mediated by inhibition/blocking and the beneficial effect is caused by a reactivation of the original encoding context, it was expected that the detrimental effect of selective retrieval occurs regardless of delay between retrieval-practice and target recall, whereas beneficial effects were expected to be present with undelayed recall but to be reduced, or even eliminated, when target recall is delayed.

Following prior work, another possible factor dissociating the two faces of selective memory retrieval might be recall specificity. Results from numerous studies suggest that the detrimental effect of memory retrieval is recall specific. These studies, for instance, compared the effects of retrieval practice with the effects of restudy of the same previously studied items on later recall of related unpracticed items. Typically, retrieval-practice, but not restudy, impaired recall of the unpracticed items (e. g., Bäuml, 2002; Ciranni & Shimamura, 1999; Hulbert et al., 2011; for related results comparing competitive with noncompetitive retrieval-practice, see M. C. Anderson, Bjork, et al., 2000, or Hanslmayr et al., 2010). Recall specificity of the detrimental effect of memory retrieval is consistent with the inhibition account of the effect (e. g., M. C. Anderson, 2003). Recall specificity of the effect is also consistent with blocking accounts, at least if one assumes that retrieval-practice leads to much higher levels of strengthening of practiced items and thus to more blocking of unpracticed items than restudy does (e. g., Raaijmakers & Jakab, 2012). To date, however no study has yet examined recall specificity of the beneficial effect of selective memory retrieval. Bäuml and Samenieh's (2012b) two-factor account, which attributes the beneficial effect to a reactivation of the items' original study context, suggests that the beneficial effect is not recall specific, and that both retrieval and restudy of previously studied items can improve recall of other items. This expectation is based on context retrieval theory (e. g., Howard & Kahana, 2002; Greene, 1989; Polyn et al., 2009;

Thios & D'Agostino, 1976), which assumes that when a previously studied item is repeated, be it by virtue of reexposure or its successful recall, it retrieves the context in which it was originally presented. Such retrieval is then supposed to update the current state of context, which in turn is used to cue recall. Hence, Experiment 2A and Experiment 2B were designed to examine whether the two opposing effects of selective memory retrieval differ in recall specificity. Following the prior work and Bäuml and Samenieh's (2012b) two-factor account, recall specificity was expected to arise for the detrimental but not the beneficial effect of selective memory retrieval.

A second major goal of the present study was to investigate the robustness of recall specificity in selective memory retrieval. Experiments 3A and 3B focus on the detrimental effect of selective memory retrieval and examine possible dynamic effects between selective retrieval and selective restudy trials. To date, practice effects have exclusively been examined employing pure practice conditions. In these prior studies, for instance, one group of the participants completed a retrieval-practice phase, whereas another group restudied some items of the original study list (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999; Bäuml & Aslan, 2004). However, in none of the studies practice was mixed, so that retrieval-practice and restudy trials were randomly interleaved within a single experimental block. Thus, the question arises if the findings from pure retrieval and pure restudy practice generalize to mixed practice situations. Results of a previous study suggest that mixed practice might affect the influence of selective retrieval and selective restudy on memory of related material. Bäuml and Aslan (2004) replicated the basic finding that selective retrieval impairs recall for the remaining items. Going beyond the prior work, however, they showed that the effect of reexposure of some of the previously studied items on later recall of the remaining items can vary with the setting of the task. Moreover, studies investigating task switching repeatedly found impaired processing of stimuli after switching between different tasks (e. g., Allport, Styles, & Hsieh, 1994; Jersild, 1927; Rogers & Monsell, 1995). These switching effects can be asymmetric when switching between tasks varying in difficulty (e. g., Campbell, 2005; Meuter & Allport, 1999). Switching back and forth between (more effortful) retrieval trials and (less effortful) restudy trials during mixed practice might also cause asymmteric dynamic effects that influence the processing of items after switching, particularly after switching from retrieval to restudy trials. Experiments 3A and 3B addressed the issue by examining whether the effects from pure retrieval-practice and pure restudy generalize to mixed practice situations in which retrieval-practice and restudy trials were randomly interleaved within a single experimental block. Following the prior work on RIF (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999), it was expected that, with pure practice, selective retrieval but not selective restudy induces forgetting of the related unpracticed item material. Following Bäuml and Aslan's (2004) finding that the effect of reexposure can depend on the setting of the task and the suggestion that switching between retrieval and restudy trials may lead to dynamic effects, in the mixed practice conditions, both practice types were expected to impair recall for unpracticed items in a later memory test.

Overall, the present experiments aim to deepen our understanding of the two faces of memory retrieval and may have theoretical implications concerning the supposed underlying mechanisms of the detrimental and the beneficial effect of selective memory retrieval. The results of the Experiments 1, 2A and 2B might provide first evidence for dissociating factors which affect the two faces of selective memory differently. Moreover, the present thesis might extend prior work on the recall specific detrimental effect of selective retrieval by showing that selective restudy can also induce forgetting of related items when practice is mixed. This finding would be the first demonstration of dynamic effects between retrieval and restudy trials, and could provide new knowledge about the interplay between retrieval and restudy practice. The results may also have practical relevance because both retrieval and restudy processes play an important role in educational settings (see literature on the testing effect, e. g., Karpicke & Roediger, 2008; Roediger & Karpicke, 2006).

Chapter 3

Experiment 1: Delay between nontarget and target recall as a dissociating factor

According to Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval the detrimental effect of selective retrieval is caused by inhibition or blocking (e. g., M. C. Anderson, 2003; Roediger & Neely, 1982), while the beneficial effect is due to a reactivation of the retrieved items' original encoding context (e. g., Howard & Kahana, 1999, 2002), thus indicating that the beneficial and detrimental effects of memory retrieval should be dissociable from one another. One possible factor dissociating the two faces of memory retrieval might be the delay between preceding nontarget and subsequent target recall. By using both the output-interference and the retrieval-practice paradigm, numerous studies have shown that the detrimental effect of memory retrieval is not restricted to cases in which target recall follows nontarget recall immediately but generalizes to situations in which a delay is introduced between retrieval-practice and test; in fact, several studies reported robust RIF if retrieval-practice and test were separated by a delay of 5 to 20 minutes (e. g., M. C. Anderson et al., 1994; Chan, 2009; MacLeod & Macrae, 2001), suggesting that the detrimental effect of memory retrieval can be lasting, a result which is consistent with both inhibitory and blocking accounts of RIF. According to the inhibition account, RIF is caused by direct impairment of the nonretrieved items' memory representation and should therefore last for quite a while (M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995). According to blocking accounts, items which are strengthened through retrieval-practice block unpracticed items in a later recall test (e. g., Roediger & Neely, 1982). Because strengthening through retrieval or relearning still causes higher recall rates for practiced items after days or weeks (e. g., Karpicke, 2012; Roediger & Karpicke, 2006), practiced items should be able to block relatively weaker (unpracticed) items after a delay between retrieval-practice of nontarget items and later target retrieval. In contrast, to date, beneficial effects of selective memory retrieval have been demonstrated mainly by using the output-interference paradigm (Bäuml & Samenieh, 2010, 2012b). Because, in this paradigm, target recall follows nontarget recall immediately, these results are silent on whether the existence of beneficial effects generalizes to situations in which target recall is delayed.

On the basis of the view that beneficial effects occur because preceding nontarget recall reactivates the retrieved items' original encoding context (e. g., Bäuml & Samenieh, 2012b; Howard & Kahana, 2002), the expectation may arise that the beneficial effects will not generalize to situations in which target recall is delayed. Indeed, although reactivation of the retrieved items' original encoding context may make this context a potentially powerful retrieval cue for target recall, the reactivated context cue may be effective only if the retrieval process was not interrupted, for instance, by means of an interpolated distractor task. Such disruption might reduce the context's activation level and, thus, reduce the cue's effectiveness in reactivating the target items. If so, the beneficial effect of selective retrieval might be present primarily when target recall follows nontarget recall immediately, and be reduced, if not eliminated, when target recall is delayed.

Experiment 1 was designed to examine whether the delay between preceding nontarget and subsequent target recall influences the beneficial and detrimental effects of selective memory retrieval differently. The retrieval-practice paradigm was used to examine the effects of selective memory retrieval. To study the effects of selective retrieval both when access to the original encoding context is impaired and when it is (largely) maintained, a listwise directed-forgetting task (e. g., Bäuml & Samenieh, 2010) was employed. Participants completed a three-phase experiment. In the first phase, they studied a first list of items, consisting of predefined target and nontarget items, which were determined by the experimenter but were unknown to the participants, then received a cue to either forget or remember the list for an upcoming test, and subsequently studied a second list of items. In the second phase, participants either repeatedly retrieved the first list's nontarget items (*prior retrieval condition*), or they completed an unrelated distractor task (*control condition*). In the third phase, participants were asked to recall the first list's target items. Participants differed in the delay that separated the second and third phase of the experiment, which was 1 minute or 10 minutes. In addition, a 0-minute delay condition was included to serve as a replication of the prior work.

Following Bäuml and Samenieh (2010, 2012b), it was expected that, if target recall succeeded nontarget recall immediately, repeated retrieval of the nontarget items would impair target recall in the remember condition but improve target recall in the forget condition. Following the prior work that found the detrimental effects of memory retrieval to be still present after a delay of 5 to 20 minutes between nontarget and target recall (e. g., M. C. Anderson et al., 1994; MacLeod & Macrae, 2001), impaired target recall across all three delay conditions of the remember condition was expected.[1] Following the two-factor account of selective memory retrieval and the view that preceding nontarget recall reactivates the retrieved items' original encoding context in the forget condition (e. g., Bäuml & Samenieh, 2012b; Howard & Kahana, 2002), it was expected that the beneficial effects are present with undelayed recall but are reduced, or even eliminated, when target recall was delayed.

Methods

Participants. A total of 144 undergraduates participated in the experiment (mean age = 22.65 years, range 19-30 years, 109 females), all of them speaking German as native language. They took part on a voluntary basis, were tested individually, and received monetary reward for participation.

Materials. Four study lists (A-D) were constructed, each containing 15 unrelated concrete German nouns (e. g., Bäuml & Samenieh, 2010). Lists A and B were designated to be used as List 1, whereas Lists C and D were

[1]Migueles and Garcia-Bajos (2007) also found RIF after a delay of 24 hours in eyewitness memory. However, they asked participants to complete an initial recall test shortly after the retrieval-practice phase and, then again, 24 hours later. Because more control items than unpracticed items were recalled in this initial test (RIF) and the testing effect literature (e. g., Roediger & Karpicke, 2006) suggests that successfully recalling an item makes recall of the same item in a later recall test more likely, the results after 24 hours may have been influenced by the recall difference in the initial test and, thus, not reflect lasting item suppression (for similar results, see Saunders, Fernandes, & Kosnes, 2009; Storm, Bjork, Bjork, & Nestojko, 2006; for a discussion, see Abel & Bäuml, 2012).

designated to be used as List 2. Lists A and B consisted of 5 target and 10 nontarget items each. Among all items, each target item began with a unique initial letter and each nontarget item had a unique word stem.

Design. The experiment had a 2 x 2 x 3 mixed factorial design. cue (remember vs. forget) was manipulated within participants, whereas practice type (prior retrieval vs. control) and delay (0 minutes vs. 1 minute vs. 10 minutes) were varied between participants. In the remember condition, List 1 was followed by a cue to remember the list for an upcoming test. In the forget condition, List 1 was followed by a cue to forget the list; a software crash was simulated and participants were told that the wrong data file was opened and the preceding items should be forgotten. Order of conditions as well as assignment of lists to conditions were counter-balanced (e. g., Bäuml & Samenieh, 2010, 2012b). Prior retrieval conditions differed in whether participants were asked to repeatedly retrieve the 10 nontargets during the practice phase, or whether they completed a distractor task instead. Between nontarget and target recall participants were either distracted for 0 minutes, 1 minute, or 10 minutes.

Procedure. In the study phase, for each of the two cuing conditions, the items of the two lists were presented individually and in random order for 4 seconds each. After study of the two lists, there was a 30-second backward counting task as a recency control. In the practice phase, participants either retrieved the first list's nontarget items (prior retrieval condition), or they solved arithmetic problems as a distractor task (control condition). Each of the nontarget items was cued with its word stem to increase recall chances and thus boost possible detrimental or beneficial effects of nontarget recall on subsequent target recall. The cues were presented individually and in random order for 6 seconds. Each item was practiced twice. Then, participants were either asked to immediately recall the first list's target items (0-minute delay condition), or to solve arithmetical problems for 1 minute (1-minute delay condition) respectively complete several distractor tasks (e. g., arithmetical problems) for a period of 10 minutes (10-minute delay condition), before attending the test of the target items. Recall order of target items was controlled through presentation of the items' unique initial letter. The item cues were presented successively and in random order, for 6 seconds each. Responses were given orally. Finally, participants were asked to recall the first list's nontarget items. Conditions were identical to the testing of the list's target items with the only difference that the nontarget items' unique word stems were provided as retrieval cues. List 2 items were tested as well, but the results are not reported (see Bäuml & Samenieh, 2012b).[2] Participants completed the two cue conditions successively, with a 10-minute break between conditions (see Figure 1 for an illustration of the experimental procedure and conditions).

Results

A 2 x 2 x 3 analysis of variance with the within-participants factor of CUE (remember vs. forget), the between-participants factor of PRACTICE TYPE (prior retrieval vs. control), and the between-participants factor of DELAY (0 minutes vs. 1 minute vs. 10 minutes) showed a significant main effect of CUE, $F(1, 138) = 6.269$, $MSE = 0.035$, $p = .013$, partial $\eta^2 = .043$, and a significant interaction between CUE and PRACTICE TYPE, $F(1, 138) = 33.164$, $MSE = 0.035$, $p < .001$, partial $\eta^2 = .194$. There were no main effects of DELAY, $F(2, 138) = 1.975$, $MSE = 0.061$, $p = .143$, and PRACTICE TYPE, $F(1, 138) = 0.444$, $MSE = 0.061$, $p = .506$, and no further interactions, $ps > .13$.

0-minute delay condition. Nontarget recall in the practice phase was high and did not vary with cue condition (remember: 86.3%, forget: 82.9%), $t(23) = 1.138$, $p = .267$. Figure 2A shows the results for target recall. A 2 x 2 ANOVA with the within-participants factor of CUE (remember vs. forget) and

[2]Typically, presenting a forget cue after the first list does not only cause List 1 forgetting but also List 2 enhancement (e. g., Geiselman et al., 1983). In Experiment 1 and in Experiment 2A, the main focus was on the forgetting of the first list, so participants were always asked to recall List 1 items first and List 2 items second. However, because prior List 1 recall typically influences List 2 enhancement (Golding & Gottlob, 2005; Pastötter, Kliegl, & Bäuml, 2012), List 2 recall data were ignored in these experiments.

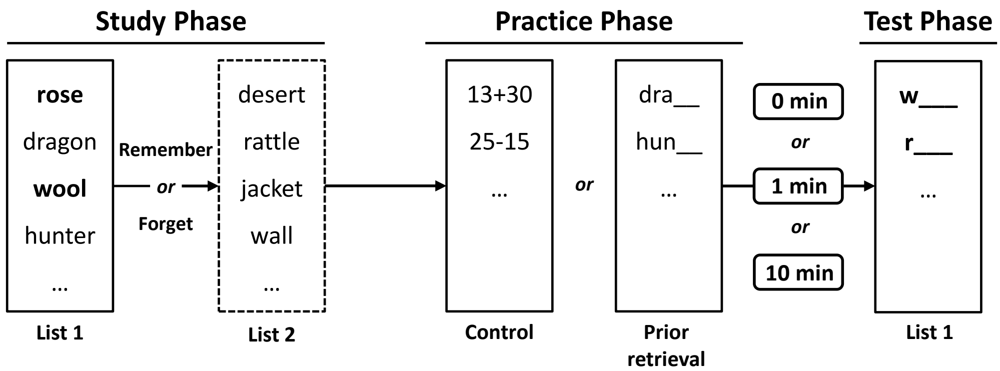

Figure 1. Procedure and conditions employed in Experiment 1. In the study phase, participants studied a first list of items, received a cue either to forget or to continue remembering the list, and then studied a second list of items. In the practice phase, participants either solved arithmetic problems as a distractor task (control), or they retrieved the first list's nontarget items (prior retrieval). Then, participants were either asked to immediately recall the first list's target items (0-minute delay), or to complete a distractor task for 1 minute (1-minute delay), or for a period of 10 minutes (10-minute delay) before attending the test of the target items. Predefined target items are depicted in bold letters.

the between-participants factor of PRACTICE TYPE (prior retrieval vs. control) revealed a significant interaction between CUE and PRACTICE TYPE, $F(1, 46) = 51.370$, $MSE = 0.019$, $p < .001$, partial $\eta^2 = .528$; no main effects of CUE, $F(1, 46) < 1$, or PRACTICE TYPE, $F(1, 46) < 1$, arose. Planned comparisons revealed that, if no prior retrieval took place, target recall was higher in the remember condition than in the forget condition (43.3% vs. 24.2%), $t(23) = 5.468$, $p < .001$, $d = 1.120$, thus showing the standard directed-forgetting effect for the target items. Prior retrieval also affected recall rates, though with opposing effects in the two cuing conditions. In the remember condition, prior retrieval impaired recall of the target items (43.3% vs. 26.7%), $t(46) = 3.325$, $p = .002$, $d = .961$, thus showing RIF, whereas in the forget condition, prior selective retrieval improved recall of the target items (24.2% vs. 48.3%), $t(46) = 4.618$, $p < .001$, $d = 1.337$.

1-minute delay condition. Nontarget recall in the practice phase was again high and unaffected by cue condition (remember: 83.3%, forget: 78.8%), $t(23) = 1.44$, $p = .163$. Figure 2B shows the results for target recall. A 2 x 2 ANOVA with the within-participants factor of CUE (remember vs. forget), and the between-participants factor of PRACTICE TYPE (prior retrieval vs. control) showed a significant interaction between the two factors, $F(1, 46) = 5.465$, $MSE = 0.044$, $p = .024$, partial $\eta^2 = .106$; no main effects of CUE, $F(1, 46) = 1.366$, $MSE = 0.044$, $p = .248$, or PRACTICE TYPE, $F(1, 46) < 1$, were found. Planned comparisons revealed that, if no prior retrieval took place, target recall was higher in the remember condition than in the forget condition (41.7% vs. 26.7%), $t(23) = 2.584$, $p = .017$, $d = .540$, thus showing again standard directed forgetting. Again, prior retrieval affected recall rates differently in the two cuing conditions. In the remember condition, prior retrieval impaired recall of the target items, (41.7% vs. 27.5%), $t(46) = 2.057$, $p = .046$, $d = .607$, thus showing RIF, whereas in the forget condition, it did not affect target recall (26.7% vs. 32.5%), $t(46) < 1$.

10-minute delay condition. Nontarget recall in the practice phase was again high and did not vary with cue condition (remember: 84.2%, forget: 78.8%),

$t(23) = 1.701$, $p = .102$. Figure 2C shows the results for target recall. A 2 x 2 ANOVA with the within-participants factor of CUE (remember vs. forget) and the between-participants factor of PRACTICE TYPE (prior retrieval vs. control) revealed a significant main effect of CUE, $F(1, 46) = 8.036$, $MSE = 0.044$, $p = .007$, partial $\eta^2 = .149$, indicating that target recall was higher in the remember than in the forget condition, and a significant interaction between the two factors, $F(1, 46) = 4.214$, $MSE = 0.044$, $p = .046$, partial $\eta^2 = .084$; no main effect of PRACTICE TYPE arose, $F(1, 46) = 1.421$, $MSE = 0.066$, $p = .239$. Planned comparisons showed that, if no prior retrieval took place, target recall in the remember condition exceeded target recall in the forget condition, (42.5% vs. 21.7%), $t(23) = 3.037$, $p = .006$, $d = .623$, thus showing directed forgetting. Once again, prior retrieval affected recall rates in the two cuing conditions differently. In the remember condition, prior nontarget recall impaired recall of the target items, (42.5% vs. 27.5%), $t(46) = 2.073$, $p = .044$, $d = .603$, thus showing RIF, whereas in the forget condition, it did not affect subsequent target recall (21.7% vs. 24.2%), $t(46) < 1$.

The results shown in Figure 2 suggest that the effect of preceding nontarget recall on subsequent target recall varied with delay in the forget condition but did not vary with delay in the remember condition. Indeed, whereas target recall impairment was roughly constant across the three delay conditions in the remember condition (0 minutes: 16.7%, 1 minute: 14.2%, 10 minutes: 15.0%), target recall improvement strongly decreased with delay in the forget condition (0 minutes: 24.2%, 1 minute: 5.8%, 10 minutes: 2.5%). Additional analysis supported the numerical impression. Analysis of variance with the between-participants factor of PRACTICE TYPE (prior retrieval vs. control) and the between-participants factor of DELAY (0 minutes vs. 1 minute vs. 10 minutes) revealed a significant interaction between the two factors in the forget condition, $F(2, 138) = 3.554$, $MSE = 0.046$, $p = .031$, partial $\eta^2 = .049$, but no such interaction in the remember condition, $F(2, 138) < 1$, thus indicating that delay influenced the beneficial but not the detrimental effect of selective memory retrieval. The finding of a significant interaction between PRACTICE

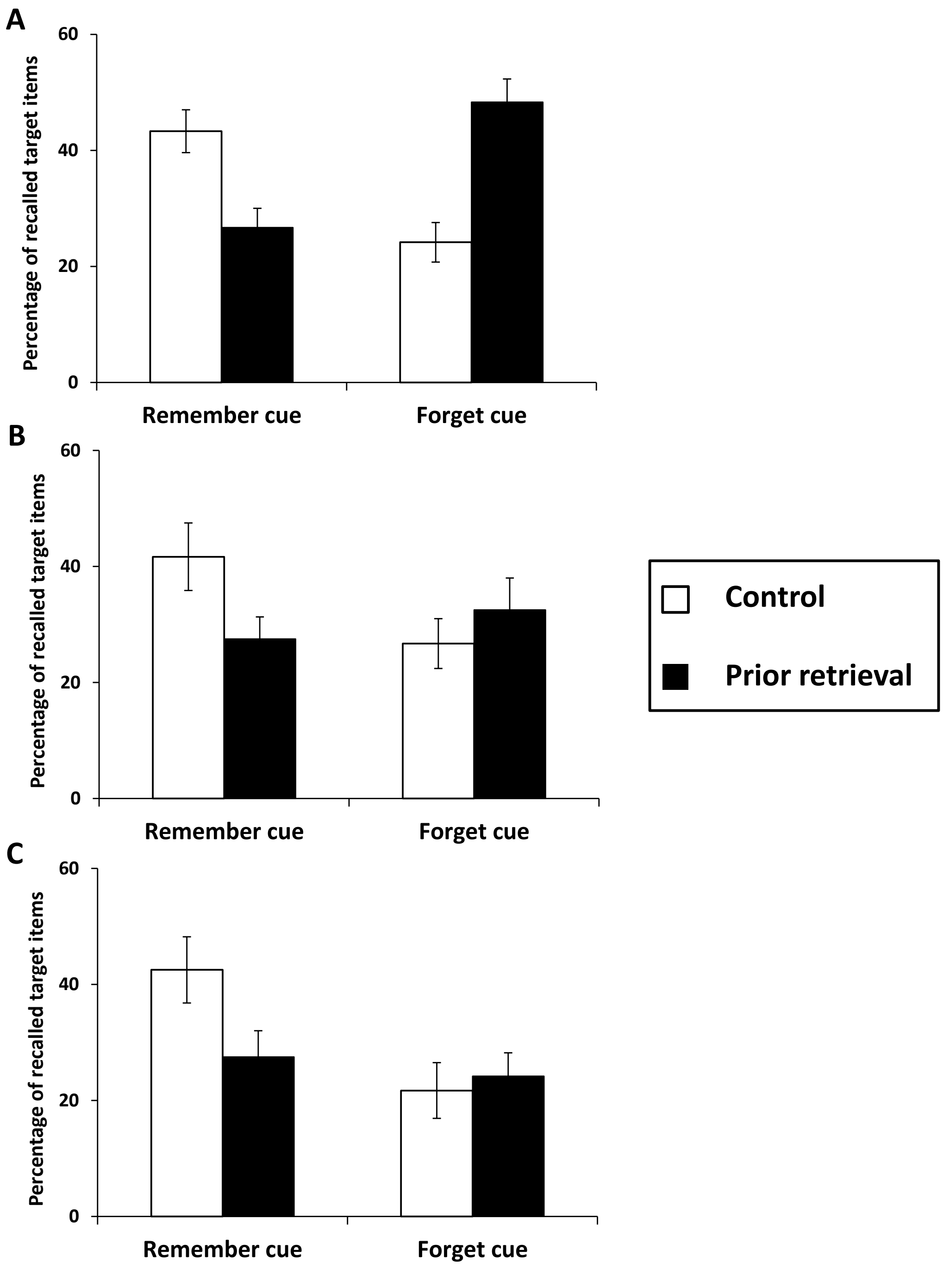

Figure 2. Results of Experiment 1. Mean recall rates for predefined target items are shown as a function of cue (remember, forget) and practice type (prior retrieval, control) for the 0-minute delay condition (A), the 1-minute delay condition (B), and the 10-minute delay condition (C). Error bars represent standard errors.

TYPE (prior retrieval vs. control), DELAY (0 minute vs. 1 and 10 minutes), and CUE (remember vs. forget), $F(1, 140) = 5.480$, $MSE = 0.036$, $p = .021$, partial $\eta^2 = .038$, supports the indication.

Further analyses. Prior work on RIF showed that repeated retrieval of the nontarget items in the retrieval-practice phase enhances the items' later recall at test (e. g., M. C. Anderson et al., 1994). The present results on nontarget recall replicate the finding. In both the remember and the forget condition, an ANOVA with the between-participants factor of PRACTICE TYPE (prior retrieval vs. control) and the between-participants factor of DELAY (0 minutes vs. 1 minute vs. 10 minutes) revealed main effects of PRACTICE TYPE (remember: $F(1, 138) = 20.133$, $MSE = 0.016$, $p < .001$, partial $\eta^2 = .127$; forget: $F(1, 138) = 12.369$, $MSE = 0.027$, $p = .001$, partial $\eta^2 = .082$), but no main effects of DELAY (remember: $F(2, 138) = 1.730$, $MSE = 0.016$, $p = .181$; forget: $F(2, 138) = 2.294$, $MSE = 0.027$, $p = .105$), and no interactions between the two factors, $Fs(2, 138) < 1$. The effect of PRACTICE TYPE did not vary with cue condition (remember: 76.5% vs. 86.1%, forget: 70.3% vs. 79.9%), $F(1, 142) < 1$, suggesting that repeated retrieval of the nontarget items improved the items' later recall regardless of delay and cue condition.

In the present experiment, PRACTICE TYPE and DELAY were manipulated between participants, whereas CUE was manipulated within participants. Importantly, none of the reported statistical effects interacted with participants' testing order, all $ps > .230$, and there was also no main effect of testing order, $ps > .393$, which is consistent with the prior work (e. g., Bäuml & Samenieh, 2010, 2012b).

Discussion

Prior work reported evidence for the self-limiting property of selective memory retrieval by using the output-interference paradigm, i. e., when target recall followed nontarget recall immediately (e. g., Roediger, 1974; A. D. Smith, 1971), and by using the retrieval-practice paradigm, i. e., when typically preceding nontarget and subsequent target recall were separated by a delay of several minutes (e. g., M. C. Anderson et al., 1994; Chan, 2009). The results from the present Experiment 1 replicate both lines of work by showing detrimental effects of memory retrieval for to-be-remembered information in the absence and the presence of a delay between nontarget and target recall. In addition, the results show that the amount of RIF is not reduced when target recall is delayed by several minutes. Thus, possible reductions in RIF with delay, as they have been reported repeatedly in the literature when nontarget and target recall were separated by 24 hours (e. g., Chan, 2009; MacLeod & Macrae, 2001; but see Garcia-Bajos et al., 2009), should be restricted to longer delay intervals.

To date, evidence for the self-propagating property of selective memory retrieval has arisen mainly in the output-interference paradigm, i. e., when target recall follows nontarget recall immediately (Bäuml & Samenieh, 2010, 2012b). Employing the retrieval-practice paradigm and varying the delay between nontarget and target recall, the present results replicate the prior finding by showing beneficial effects of selective retrieval on to-be-forgotten information when target recall is undelayed. Going beyond the prior work, the results also show that such beneficial effects do not generalize to conditions in which there is a delay of at least 1 minute between recall of the two types of items. Although numerical evidence for beneficial effects arose in the 1-minute and 10-minute delay conditions as well, the effects were small and not reliable. These results indicate that the beneficial effects of selective memory retrieval are mainly present if target recall follows nontarget recall immediately, and are strongly reduced, if existent at all, if target recall is delayed.[3]

[3]In the retrieval-practice phase of all three delay conditions of this study, nontarget recall in the forget condition was numerically (though not statistically) below nontarget recall in the remember condition (on average, 80.1% vs. 84.6%). One might ask the question of whether this difference has affected the results. On the one hand, there is evidence that RIF does not depend much on retrieval success in the retrieval-practice phase (Storm et al., 2006), indicating that the detrimental effects in this study would have been similar if success rates in the remember condition had been slightly reduced. On the other hand, there is evidence that the beneficial effect of selective memory retrieval increases with number of recalled nontarget items (Bäuml & Samenieh, 2010), indicating that the beneficial effects

Altogether the present results provide a first dissociation between the two faces of selective memory retrieval by showing that the delay between retrieved nontarget items and still-to-be-retrieved target items influences the two effects of memory retrieval differently. The results are consistent with Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval, which assumes that selective memory retrieval generally triggers two processes, inhibition or blocking of interfering memories and reactivation of the retrieved items' original encoding context. Crucially, the account assumes that whether inhibition/blocking or context reactivation dominate in an experimental situation depends on whether the to-be-retrieved memories are subject to impaired context access, or not. If access to the original context is still maintained - as should be the case in the remember condition of Experiment 1 - inhibitory or blocking processes should dominate and not much room should be left for context reactivation processes; in contrast, if access to the original context is impaired - as should be the case in the forget condition of Experiment 1 - context reactivation processes should dominate and not much room should be left for inhibition or blocking. However, a disruption of the retrieval process because of an interpolated distractor task should reduce the context's activation level and, thus, reactivation of target items should decrease. Consequently, beneficial effects of selective memory retrieval should occur mainly when target recall follows nontarget recall immediately. By showing the pattern of beneficial and detrimental effects of selective retrieval in the forget and remember conditions of the present experiment when target recall was undelayed, and by showing persisting detrimental effects in the remember condition but transient beneficial effects in the forget condition, the present results support the suggested two-factor account.

might have been slightly enhanced if success rates in the forget condition had been higher.

Chapter 4

Experiments 2A and 2B: Recall specificity as a dissociating factor

Prior work has shown that the detrimental effect of memory retrieval is typically recall specific and does not arise after restudy trials (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml, 2002; Ciranni & Shimamura, 1999), a finding which is consistent with the inhibition account of the effect. According to this proposal, the not-to-be practiced items interfere during retrieval-practice, and are inhibited to reduce this interference (e. g., M. C. Anderson, 2003). Recall specificity of the detrimental effect is also consistent with blocking, at least if one assumes that retrieval-practice leads to much higher levels of strengthening of practiced items and, thus, to more forgetting of unpracticed items than restudy does (e. g., Raaijmakers & Jakab, 2012). To date, no study has yet examined recall specificity of the beneficial effect of selective memory retrieval. On the basis of Bäuml and Samenieh's (2012b) two-factor account and the comprised view that the beneficial effect is driven by reactivation of the retrieved items' study context, one may expect that the beneficial effect is not recall specific, and that both retrieval and restudy of previously studied items can improve recall of other items. This expectation arises from context retrieval theory (e. g., Greene, 1989; Thios & D'Agostino, 1976) and more recent computational models that embody variants of the theory (Howard & Kahana, 2002; Polyn et al., 2009). Context retrieval theory assumes that when a previously studied item is repeated, be it by virtue of reexposure or its successful recall, it retrieves the context in which it was originally presented. Such retrieval is then supposed to update the current state of context, which in turn is used to cue recall.

Addressing the issue, the results of two experiments are reported designed to examine whether the two opposing effects of selective memory retrieval differ in recall specificity. Concretely, the hypothesis was tested that the detrimental effect of memory retrieval is recall specific but the beneficial effect is not. Experiment 2A employed the retrieval-practice task to study recall specificity (e. g., Ciranni & Shimamura, 1999) and the listwise directed-forgetting task to create impaired access to the study context (e. g., R. A. Bjork, 1970). Participants studied a list of items, consisting of predefined target and nontarget items, and then received a cue to either forget or remember the list. After subsequent study of a second list, participants either repeatedly retrieved the first list's nontarget items (*prior retrieval condition*), restudied the nontarget items (*prior restudy condition*), or completed an unrelated distractor task (*control condition*). Finally, participants were asked to recall the first list's target items.

The goal of Experiment 2B was to replicate Experiment 2A, using a different experimental setup. While in Experiment 2A the retrieval-practice task was used, in Experiment 2B the output-interference task was employed (e. g., Bäuml & Samenieh, 2012b). Prior work examined the two opposing effects of selective memory retrieval by impairing context access through the presentation of a forget cue or the insertion of a diversion task (e. g., Bäuml & Samenieh, 2012b). Experiment 2B impaired access to the study context by means of a prolonged retention interval, assuming that considerable contextual change occurs during prolonged retention intervals, and external as well as internal contextual elements of the study phase become inaccessible over time (e. g., J. R. Anderson, 2000). Participants studied a list of target and nontarget items and were then tested on the target items after a short (4 minutes) or a prolonged (48 hours) retention interval. In both retention interval conditions, participants recalled the target items after prior retrieval of the nontarget items (*prior retrieval condition*), after prior restudy of the nontarget items (*prior restudy condition*), or without any repetition of the nontarget items (*control condition*).

On the basis of the two-factor account of memory retrieval and prior work indicating that the detrimental effect is recall specific (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999), selective retrieval but not restudy was expected to impair recall of the other items when access to the original study context was (largely) maintained, i. e., after a remember cue was provided (Experiment 2A) and in the short-delay condition (Experiment 2B). In contrast, on the basis of the two-factor account and context retrieval theory (e. g., Greene, 1989; Howard & Kahana, 1999), both retrieval and restudy were expected to improve recall of other items when access to the original study context was impaired, i. e., after a forget cue was provided (Experiment 2A) and in the long-delay condition (Experiment 2B). If so, in both experiments, recall specificity would arise for the detrimental but not the beneficial effect of selective memory retrieval.

4.1 Experiment 2A

Methods

Participants. Ninety-six undergraduates participated in the experiment (mean age = 22.68, range 18-29 years, 67 females). All participants spoke German as native language, took part on a voluntary basis, and received monetary reward or course credits for participation.

Materials. Materials were identical to Experiment 1. Again, Lists A and B were designated to be used as List 1, and Lists C and D were designated to be used as List 2.

Design. The experiment had a 2 x 3 mixed factorial design. Cue (remember vs. forget) was manipulated within participants and practice type (prior retrieval vs. prior restudy vs. control) was varied between participants. Practice conditions differed in activity during the intermediate practice phase: participants repeatedly retrieved the 10 nontargets, repeatedly restudied the nontarget items, or completed an unrelated distractor task. In all other respects, Experiment 2A was identically designed to Experiment 1.

Procedure. The study phase of Experiment 2A was identical to the study phase of Experiment 1. In the subsequent practice phase, participants either repeatedly retrieved the first list's nontarget items (prior retrieval condition),

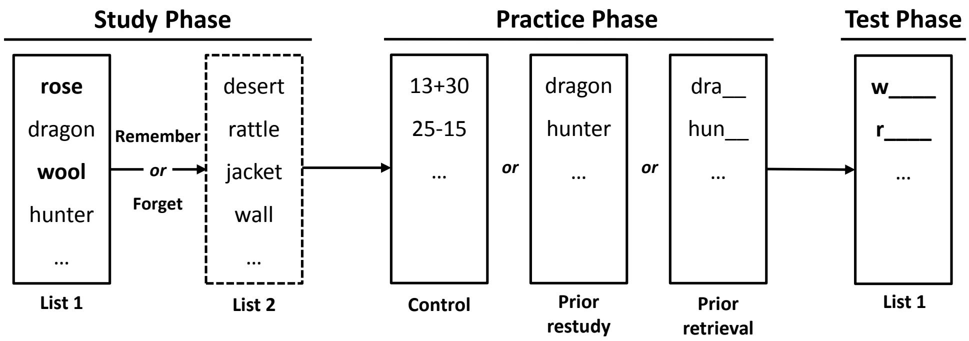

Figure 3. Procedure and conditions employed in Experiment 2A. In the study phase, participants studied a first list of items, received a cue either to forget or to continue remembering the list, and then studied a second list of items. In the practice phase, participants completed a distractor task (control), restudied predefined nontarget items from List 1 (prior restudy), or practiced retrieval of these nontarget items (prior retrieval). In the test phase, participants were asked to recall the predefined target items from List 1. Predefined target items are depicted in bold letters.

repeatedly restudied these nontargets (prior restudy condition), or solved arithmetic problems as a distractor task (control condition). In the prior retrieval condition, each nontarget item was cued with its word stem to increase recall chances and thus boost possible detrimental or beneficial effects on later target recall. The cues were presented individually and in random order for 5 seconds. There were two successive practice cycles, in each of which retrieval of all nontargets was practiced. In the prior restudy condition, participants were exposed to each single nontarget item for additional learning, for 5 seconds each and across two successive practice cycles. Finally, in the third phase, participants were asked to recall the studied items. The procedure of the test phase was identical to Experiment 1 (see Figure 3 for an illustration of the experimental procedure and conditions).

Results

Practice Phase. Mean success rates for the nontarget items in the practice phase were high. Rates were numerically higher in the remember condition than in the forget condition (remember: 87.5%; forget: 81.6%), $t(31) = 1.953$, $p = .06$.

Test Phase - Target Recall. Figure 4 shows mean recall rates for the target items. A 2 x 3 ANOVA with the within-participants factor of CUE (remember vs. forget) and the between-participants factor of PRACTICE TYPE (prior retrieval vs. prior restudy vs. control) showed no main effects of CUE, $F(1, 93) < 1$, and PRACTICE TYPE, $F(2, 93) = 1.943$, $MSE = 0.063$, $p = .149$, but revealed a significant interaction between the two factors, $F(2, 93) = 13.615$, $MSE = 0.032$, $p < .001$, partial $\eta^2 = 0.226$, reflecting that CUE condition affected target recall in the three practice type conditions differently. Planned comparisons showed that, in the control condition, target recall was higher after a remember cue than after a forget cue (40.6% vs. 23.8%), $t(31) = 4.190$, $p < .001$, $d = 0.754$, thus showing the standard directed-forgetting effect for the target items. More important, both prior retrieval and prior restudy of nontargets affected target recall rates. In the remember condition, prior retrieval impaired recall of the target items relative to the control items (40.6% vs. 28.1%), $t(62) = 2.248$, $p = .028$, $d = 0.562$, thus showing RIF, whereas prior restudy did not affect target recall (40.6% vs. 40.6%), $t(62) = 0$, $p = 1.00$. Consistently, participants recalled significantly more target items after restudy than after retrieval of nontarget items (40.6% vs. 28.1%), $t(62) = 2.341$, $p = .022$, $d = 0.585$. In contrast, in the forget condition, both prior retrieval (23.8% vs. 44.4%), $t(62) = -4.114$, $p < .001$, $d = 1.034$, and prior restudy (23.8% vs. 41.3%), $t(62) = -3.231$, $p = .002$, $d = 0.818$, improved recall of the target items relative to the control items, and there was no difference in recall level between retrieval and restudy conditions

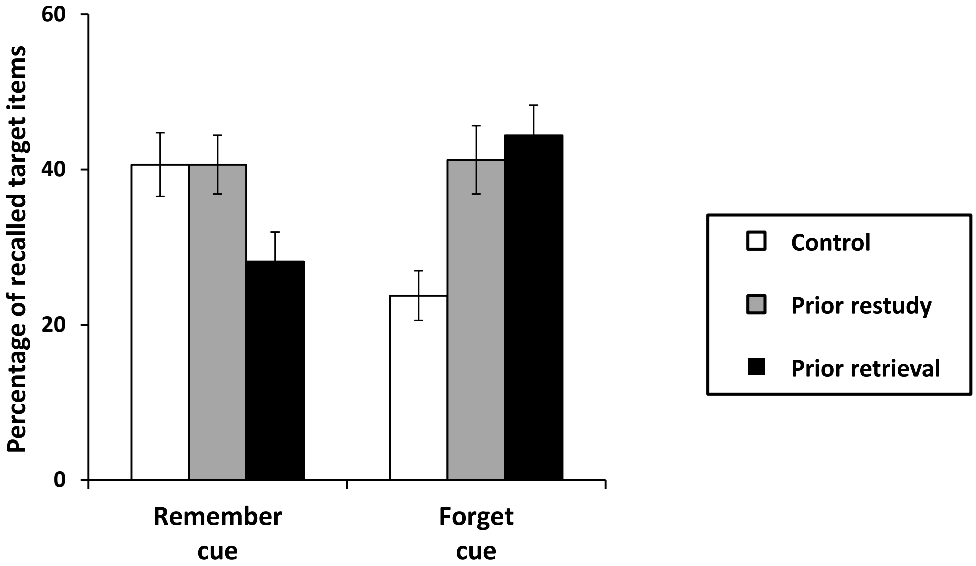

Figure 4. Results of Experiment 2A. Mean recall rates for predefined target items are shown as a function of cue (remember, forget) and practice type (prior retrieval, prior restudy, control). Error bars represent standard errors.

(44.4% vs. 41.25%), $t(62) = 0.533$, $p = .596$.

Test Phase - Nontarget Recall. Table 1 shows mean recall rates for the nontarget items. A 2 x 3 ANOVA with the within-participants factor of CUE (remember vs. forget) and the between-participants factor of PRACTICE TYPE (prior retrieval vs. prior restudy vs. control) showed no main effect of CUE, $F(1, 93) = 3.070$, $MSE = 0.011$, $p = .083$, a main effect of PRACTICE TYPE, $F(2, 93) = 44.866$, $MSE = 0.020$, $p < .001$, partial $\eta^2 = 0.491$, and a significant interaction between the two factors, $F(2, 93) < 1$. Planned comparisons showed that for both cue conditions prior retrieval (remember: 88.8%; forget: 83.4%) and prior restudy (remember: 96.6%; forget: 94.4%) enhanced later recall of nontarget items compared to the control condition (remember: 72.5%; forget: 71.9%), all $ps < .003$. In both cue conditions, the enhancement after restudy of nontargets was significantly larger than after

Table 1. Results of Experiment 2A. Mean recall rates for predefined nontarget items (standard errors are displayed in parentheses).

	control	**prior restudy**	**prior retrieval**
remember	72.5 (3.0)	96.6 (1.0)	88.8 (1.9)
forget	71.9 (2.9)	94.4 (1.0)	83.4 (2.5)

prior retrieval, both *ps* < .001.

Further Analyses. In the present experiment, PRACTICE TYPE was manipulated between participants, whereas CUE was manipulated within participants (e. g., Bäuml & Samenieh, 2010; 2012b). Importantly, none of the reported statistical effects for target and nontarget items interacted with participants' testing order, all *ps* > .184.

Discussion

The results of Experiment 2A replicate prior work by showing that retrieval of previously studied nontargets can impair subsequent target recall if the items are to be remembered, but can improve subsequent target recall if the items are to be forgotten (e. g., Bäuml & Samenieh, 2010, 2012b). Going beyond the prior work, the results show that selective restudy of nontargets may not affect recall of to-be-remembered targets but can improve recall of to-be-forgotten targets. These findings confirm prior work by showing a recall specific detrimental effect of selective memory retrieval (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml, 2002; Ciranni & Shimamura, 1999), and they extend prior work by showing a beneficial effect of selective memory retrieval that is not recall specific. These results are consistent with the two-factor account of selective memory retrieval (Bäuml & Samenieh, 2012b), which attributes the detrimental effect to inhibition or blocking and the beneficial effect to context reactivation processes.

4.2 Experiment 2B

Methods

Participants. A total of 192 undergraduates participated in the experiment (mean age = 22.14, range 18-29 years, 154 females). All participants spoke German as native language, took part on a voluntary basis, and received monetary reward for their participation.

Materials. Two new study lists (A and B) were constructed, each containing 15 unrelated concrete German nouns (e. g., Bäuml & Samenieh, 2010). Again the lists consisted of 5 target and 10 nontarget items each. Half of the participants studied List A, the other half studied List B. Again, each target item began with a unique initial letter and each nontarget item had a unique word stem.

Design. The experiment had a 2 x 3 design with the between-participants factors of retention interval (short vs. long) and practice type (prior retrieval vs. prior restudy vs. control). In the short retention interval condition, participants were tested on the study list 4 min after study, whereas they were tested after an interval of 48 hours in the long retention interval condition. At test, participants were either asked to recall the nontargets first and the targets second (prior retrieval), to restudy the nontargets before recalling the targets (prior restudy), or to recall the targets immediately (control). Assignment of lists to conditions was counterbalanced.

Procedure. Items were studied individually and in random order for 5 s each. After a short unrelated distractor task (4 min), half of the participants

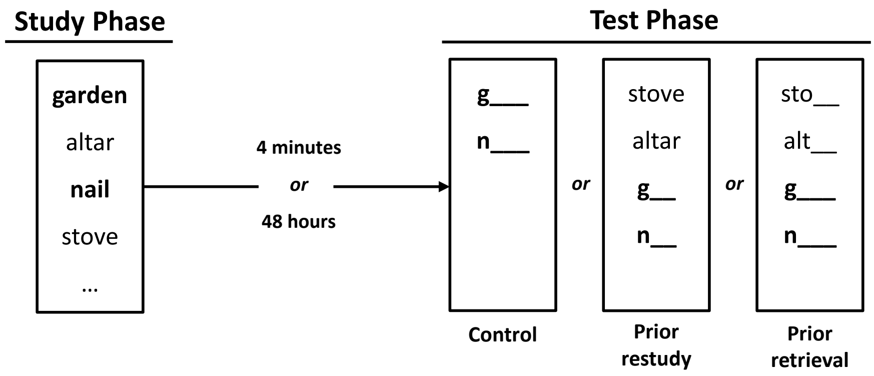

Figure 5. Procedure and conditions employed in Experiment 2B. Participants studied a list of items. After 4 minutes (short retention interval) or 48 hours (long retention interval) participants were asked to recall predefined target items from List 1. The target items were tested immediately (control), after prior restudy of the list's nontarget items, or after prior retrieval of the nontarget items. Predefined target items are depicted in bold letters.

were tested immediately on the study list, whereas the other half was dismissed with the stipulation to participate in a second part of the experiment 48 hours later. At test, in all three practice conditions, recall order of target items was controlled through presentation of the items' unique initial letters, which were presented successively and in random order, for 6 s each. Responses were given orally again. In the prior retrieval condition, nontargets were tested before target items, providing the nontargets' word stems as cues; the stems were also presented successively and in random order, for 6 s each. In the prior restudy condition, participants were asked to study the list's nontarget items a second time, for 6 s each, before being tested on the list's target items. In the control condition, targets were tested immediately at the beginning of the test phase. In the restudy and control condition, target recall was followed by nontarget recall, with the nontargets' unique word stems being provided as retrieval cues (see Figure 5 for an illustration of the experimental procedure and conditions).

Results

Target Recall. Figure 6 shows recall rates for the target items. A 2 x 3 ANOVA with the between-participants factors of RETENTION INTERVAL (short vs. long) and PRACTICE TYPE (prior retrieval vs. prior restudy vs. control) revealed a main effect of RETENTION INTERVAL, $F(1, 186) = 58.049$, $MSE = 0.046$, $p < .001$, partial $\eta^2 = 0.238$, and a significant interaction between the two factors, $F(2, 186) = 17.598$, $MSE = 0.046$, $p < .001$, partial $\eta^2 = 0.159$. There was no main effect of PRACTICE TYPE, $F(2, 186) < 1$. The main effect of RETENTION INTERVAL reflects higher recall rates after the short than after the long retention interval (54.4% vs. 30.83%); the interaction reflects that the length of the retention interval affected target recall in the three practice type conditions differently. Planned comparisons showed that, in the control condition, target recall was lower after the long retention interval than after the short retention interval (18.1% vs. 61.9%), $t(62) = 10.221$ $p < .001$, $d = 2.558$, thus revealing typical time-dependent forgetting. Prior retrieval and restudy of nontargets also affected target recall rates. In the short retention interval condition, prior retrieval impaired recall of the target items relative to control items (61.9% vs. 44.4%), $t(62) = 3.890$, $p < .001$, $d = 0.976$, thus showing typical output-interference, whereas prior restudy left target recall unaffected (61.9% vs. 56.9%), $t(62) = 1.026$, $p = .309$. Consistently, participants recalled significantly more target items after restudy than after retrieval of nontarget items (56.9% vs. 44.4%), $t(62) = 2.393$, $p = .020$, $d = 0.599$. After the long retention interval, both prior retrieval (18.1% vs. 45.0%), $t(62) = -4.832$, $p < .001$, $d = 1.228$, and prior restudy (18.1% vs. 29.4%), $t(62) = -2.078$, $p = .042$, $d = 0.526$, improved recall of the target items relative to the control items. Participants recalled significantly more target items after prior retrieval than after prior restudy of the nontarget items (45.0% vs. 29.4%), $t(62) = 2.461$,

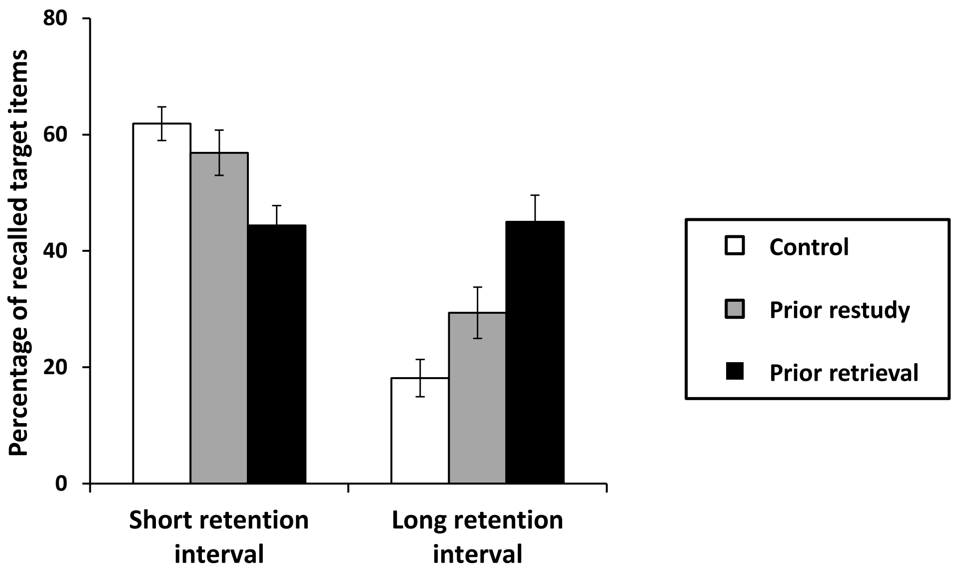

Figure 6. Results of Experiment 2B. Mean recall rates for predefined target items are shown as a function of retention interval (short, long) and practice type (prior retrieval, prior restudy, control). Error bars represent standard errors.

$p = .017$, $d = 0.615$.[4]

Nontarget Recall. In the prior retrieval condition, nontarget retrieval rates were high and did not vary with retention interval condition (short: 84.1%; long: 88.8%), $t(62) = -1.251$, $p = .216$. In both retention interval conditions, prior restudy of nontarget items enhanced later nontarget recall (short: 95.6%; long: 97.5%) compared to the control condition (short: 84.1%, long: 80.3%), both $ps < .001$. Nontarget retrieval rates after prior restudy and in the control condition did not vary with retention interval, both $ps > .143$.

[4]In both Experiment 2A and Experiment 2B, mean success rates for the nontarget items in the prior retrieval conditions were high (84.5% and 86.5%) and did not differ between cue conditions, $t(31) = 1.953$, $p = .060$, respectively retention-interval conditions, $t(62) = -1.251$, $p = .216$.

Discussion

The results of Experiment 2B replicate the results of Experiment 2A by showing that, after a short retention interval in which no forget cue is provided and no change in mental context is induced, retrieval of target items can be impaired by prior nontarget recall but is left unaffected by prior restudy of nontarget items, thus providing another demonstration of recall specificity of RIF. More importantly, the results of Experiment 2B extend the prior work by showing that, after a prolonged retention interval, prior retrieval of nontarget items improves recall of the target items and such improvement is not recall specific. Indeed, both retrieval and restudy of nontargets proved beneficial for target recall, although the benefits were more pronounced after retrieval than restudy of nontarget items. These results mimic the findings of Experiment 2A in the forget condition, indicating that after contextual change between study and test both retrieval and restudy can be beneficial for other items.[5]

Altogether, the results of Experiments 2A and 2B replicate and extend prior work on the two faces of selective memory retrieval. They replicate prior work by demonstrating that selective memory retrieval can impair memory for other to-be-remembered items but can improve memory for other to-be-forgotten items (Bäuml & Samenieh, 2010, 2012b). They extend prior work by showing that the two opposing effects of selective memory retrieval are also present when retention interval is varied; selective memory retrieval can be detrimental for other items when the retention interval is short, and be beneficial when the retention interval is prolonged. Selective memory retrieval has recently been shown to be beneficial if participants' mental context is changed between encoding and test (Bäuml & Samenieh, 2012b). Because the presentation of a

[5]In principle, forgetting after prolonged retention intervals can be attributed to a number of factors, but contextual change and increased interference are supposed to play a particularly critical role (e. g., J. R. Anderson, 2000). Using short retention intervals, Bäuml and Samenieh (2012b) recently showed that increased interference at test causes detrimental effects of selective retrieval, whereas inducing a context change between study and test induces beneficial effects. The present results in the long retention-interval condition parallel the previous finding after contextual change, indicating that the beneficial effect is due to contextual change rather than variation in interference level.

forget cue impairs access to the study context as well (Geiselman et al., 1983; Sahakyan & Kelley, 2002) and such impairment is also present with prolonged retention interval (e. g., J. R. Anderson, 2000), results support the view that selective memory retrieval is detrimental when access to the study context is (largely) maintained but is beneficial when context access is impaired.

In particular, the results of the two experiments replicate and extend prior work on recall specificity of the effects of memory retrieval. Consistent with prior work, they show that retrieval-induced forgetting is recall specific, i. e., the forgetting arises after selective retrieval but not after prior restudy of nontarget items (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml, 2002; Ciranni & Shimamura, 1999). Going beyond the prior work, the results show that the beneficial effect is not recall specific. In fact, both selective retrieval and restudy induced beneficial effects in the present study which were equivalent in amount in Experiment 2A but were larger after retrieval than after restudy in Experiment 2B. In summary, these findings provide another dissociation between the two opposing effects of selective memory retrieval by demonstrating that the detrimental but not the beneficial effect is recall specific.

The findings of Experiment 2A and 2B are also in line with Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval. This account assumes that the detrimental effect is caused by inhibition or blocking of the target items and arises if access to the study context is still maintained - as should be the case in the remember condition of Experiment 2A and in the short retention interval condition of Experiment 2B. In such situations, interference between items may be high and retrieval of the nontargets may inhibit or block recall of the target items. Inhibition is generally assumed to be recall specific (e.g., M. C. Anderson, 2003), and even blocking may be recall specific, at least if retrieval strengthened the nontargets to a much higher degree than restudy does (e.g., Raaijmakers & Jakab, 2012). In addition, the two-factor account assumes that the beneficial effect of selective memory retrieval is caused by reactivation of the targets' study context and arises if access to the study context is impaired - as should be the case in the forget condition of Experiment 2A and in the long retention interval condition of Experiment 2B. In such situations, interference between items should be low and recall of the nontargets retrieves the study context, which may then serve as a retrieval cue for recall of the target items. Following context retrieval theory (e.g., Greene, 1989; Howard & Kahana, 2002; Thios & D'Agostino, 1976), such reactivation should not be recall specific and arise both after retrieval and restudy of nontarget items. By showing that the detrimental but not the beneficial effect of memory retrieval is recall specific, the present results thus support the two-factor account.

Chapter 5

Experiments 3A and 3B: Dynamic effects between selective restudy and selective retrieval

Results from numerous previous studies adressing RIF suggest that when participants study items from different categories and then repeatedly retrieve, or restudy, some of the items from some of the categories, repeated retrieval, but not repeated study, induces forgetting of related unpracticed items (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml & Aslan, 2004; Ciranni & Shimamura, 1999). In contrast, Experiments 2A and 2B of the present thesis showed no recall specificity for the beneficial effect of selective memory retrieval, that is selective retrieval as well as selective restudy induced beneficial effects on related material. Experiments 3A and 3B were designed to investigate the robustness of recall specificity in selective memory retrieval. Because of the findings in Experiment 2A and Experiment 2B that the detrimental but not the beneficial effect of selective memory retrieval is recall specific, the present experiments focus on the detrimental effect of selective memory retrieval and examine possible dynamic effects between selective retrieval and restudy.

To date, practice effects have exclusively been examined employing pure practice conditions. In fact, in some studies, one group of the participants were engaged in retrieval-practice trials, whereas another group completed restudy trials (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml, 2002; Bäuml & Aslan, 2004; Ciranni & Shimamura, 1999). In other studies, type of practice was manipulated within-participants and participants were engaged in retrieval practice trials in one experimental block and in restudy trials in another, separate block (e. g., Hanslmayr et al., 2010; Johansson et al., 2007; Wimber et al., 2009). However, in none of the studies practice was mixed, so that retrieval-practice and restudy trials were randomly interleaved within a single experimental block. Thus the question arises of whether the findings from pure retrieval and pure restudy practice generalize to mixed practice situations.

Results of a previous study examining the effects of retrieval and reexposure of some studied items on later recall of the remaining studied items suggest that mixed practice might affect the influence of retrieval and restudy on memory of related items. In this prior work, Bäuml and Aslan (2004) replicated the basic finding that retrieval-practice on a subset of previously studied items can impair recall of the list's remaining items. In particular, they showed that the effect of reexposure of some of the studied items on later recall of remaining list items can vary with the setting of the task. When participants were instructed to use reexposure of items to enhance their learning of the reexposed items, reexposure did not affect recall of the remaining items. In contrast, when participants were instructed to use the reexposed items as retrieval cues for recall of the remaining items, reexposure impaired recall of the remaining items. This pattern arose both when there was a delay between reexposure and test, and when reexposure occurred immediately before the recall test. Because the two reexposure conditions did not differ in material and procedural detail, the findings indicate that the effect of reexposure can depend on task setting, inducing no forgetting of related material in a restudy context but inducing forgetting of the material in a retrieval context.

Although Bäuml and Aslan's (2004) finding per se does not imply that mixed practice can influence the effect of restudy on recall of related not restudied items, it raises such a possibility, at least if mixed practice created some dynamic effects between retrieval and restudy trials. Numerous studies examining task switching have shown that switching back and forth between single tasks can cause switching effects, leading to impaired processing of stimuli after switching (e. g., Allport et al., 1994; Jersild, 1927; Rogers & Monsell, 1995). Moreover, such dynamic effects can be asymmetric: when switching between tasks varying in difficulty, there is often a larger switching effect for the easy task than for the difficult task (Allport et al., 1994), as has been observed with various combinations of tasks, like, for instance, switching between first and second language in bilinguals (Campbell, 2005; Meuter & Allport, 1999). Switching back and forth between (more effortful) retrieval trials and (less effortful) restudy trials may also cause asymmetric dynamic effects, and participants may, for instance, engage in more retrieval during restudy trials when the trials are mixed than when restudy trials occur in the absence of intermittent retrieval trials. If so, with mixed practice, reexposure trials might trigger similar processes as retrieval trials, creating beneficial effects for the restudied items but detrimental effects for the related, not reexposed items. In such case, pure and mixed practice might not differ in the effects of retrieval-practice, but they might differ in the effects of restudy. The issue of possible dynamic effects between retrieval and restudy trials has not been addressed in the literature to date.

Experiments 3A and 3B were designed to investigate whether the effects of retrieval and restudy in pure practice conditions differ from the effects of retrieval and restudy in a mixed practice condition. In both experiments, a variant of the retrieval-practice paradigm was employed. In Experiment 3A, participants studied a categorized list of items followed by an intermediate practice phase, in which they were asked to either repeatedly retrieve some of the previously studied items from some of the studied categories, to repeatedly restudy some of the items from some of the categories, or to repeatedly retrieve some items from some categories of the study list and to repeatedly restudy other items from other categories of the list in random order. After a short distractor task, memory for all initially studied items was tested employing a cued recall test.

Following prior work that indicates that retrieval-induced forgetting is a recall specific effect (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999), forgetting of the unpracticed items from the practiced categories was expected in the pure retrieval condition but not in the pure restudy condition. In contrast, in the mixed practice condition, one may expect forgetting of both the unpracticed items from the retrieval-practiced categories and the unpracticed items from the restudied categories. Such expectation may arise from the view that the effect of reexposure can depend on the setting of the task (Bäuml & Aslan, 2004), and the suggestion that switching between retrieval and restudy trials may lead participants to engage in more retrieval during restudy trials, so that restudy trials may trigger similar processes than retrieval trials and, thus, induce forgetting of related, not restudied items.

5.1 Experiment 3A

Methods

Participants. Eighty-four undergraduates participated in the experiment (mean age = 22.87, range 19-33 years, 70 females), all of them speaking German as native language. They took part in the experiment on a voluntary basis, were tested individually, and received monetary reward for their participation.

Materials. Two study lists were constructed, each list consisting of words from nine semantic categories. Each category contained six exemplars, which were drawn from several published word norms (Battig & Montague, 1969; Mannhaupt, 1983; Scheithe & Bäuml, 1995). The two most frequent exemplars of each category were excluded. Because previous work showed that categories' high-frequency exemplars may be more susceptible to RIF than their low-frequency exemplars (e. g., M. C. Anderson et al., 1994; Bäuml, 1998), for each category, the three items with the lower word frequency, in the following referred to as low-frequency items, were practiced during the intermediate practice phase, whereas the three items with the higher word frequency, in the following referred to as high-frequency items, served as unpracticed items (see also Spitzer & Bäuml, 2007). Within each category each item had a unique initial letter. Additionally, two exemplars from six other categories were used as buffer items in the study phase.

Design. To replicate prior work with pure practice conditions, a mixed factorial design with the between-participants factor of PRACTICE TYPE (pure prior retrieval vs. pure prior restudy) and the within-participants factor of ITEM TYPE (practiced vs. unpracticed vs. control) was used. To investigate dynamic effects between retrieval and restudy trials, an additional mixed practice condition was implemented, in which retrieval-practice and restudy were manipulated within-participants. All participants went through three main phases: an initial study phase, an intermediate practice phase, and a final test phase. Experimental conditions differed in the intermediate practice phase only. In the pure prior retrieval condition (n=24), participants were asked to repeatedly retrieve the low-frequency items of six of the nine categories; in the pure prior restudy condition (n=24), participants repeatedly restudied the low-frequency items of six of the nine categories; in the mixed practice condition (n=36), participants repeatedly retrieved the low-frequency items of three of the nine categories and repeatedly restudied the low-frequency items of three further categories. The order of the retrieval and restudy trials in the mixed practice condition was random, so that participants did not know if the next exemplar was to be restudied or to be retrieved. In each of the three conditions, the items of the three remaining categories served as control items; the categories' low-frequency items were used as control items for the practiced items and the categories' high-frequency items served as baseline for the unpracticed items. Consequently, six different item types were created: practiced items from retrieval-practiced categories (rp+ items), practiced items from restudied categories (rs+ items), unpracticed items from retrieval-practiced categories (rp- items), unpracticed items from restudied categories (rs- items), control items for the practiced items (c+ items), and control items for the unpracticed items (c- items). Across participants, it was counterbalanced which of the studied categories was retrieval-practiced, restudied, or served as control condition. For each participant, the experiment consisted of two parts, which differed only in which of the two study lists was used. That is, after participants had completed a study-practice-test cycle, they had a 10-minute break before they were asked to complete another cycle with new word material. The assignment of the two study lists to the two parts of the experiment was counterbalanced. The second cycle was run with the only goal to increase statistical power of the data.

Procedure. In the study phase, each item was presented together with its category cue (e. g., TREE-*maple*, INSECT-*beetle*) at a rate of 4 seconds per item. The serial order of the items was blocked randomized, that is, six blocks were created, which were composed of one randomly selected item from each of the nine categories, with the restriction that no two items from the same category were presented in succession. Additionally, three buffer items were shown at the beginning and the end of the study list. After half of the participants had been tested, the order of the study sequence was reversed. After the study phase, participants were asked to count backward from 500 in steps of three for 60 seconds as a recency control.

In the intermediate practice phase, participants were asked to practice the low-frequency items of six of the nine categories. For items of categories which should be retrieval-practiced (rp+ items), the item's initial letter was presented together with its category cue (e. g., TREE-*m*____) and participants were given 5 seconds to recall the corresponding word. Items which should be restudied in the practice phase (rs+ items) were presented together with their category cue (e. g., INSECT-*beetle*) for 5 seconds. The order of the items was again blocked randomized. Within each block, items were presented randomly and the succession of the blocks was randomly drawn for each participant. After the first practice cycle, a second practice cycle was conducted following the same procedure as in the first practice cycle. After the intermediate practice phase, the participants completed a distractor task, in which they rated the attractiveness of international celebrities for 3 minutes.

In the final test phase, participants were provided with the first letter of each studied word together with its category cue (e. g., INSECT-*b*____) and were asked to write down the appropriate word in a test booklet within 7 seconds. The order of presentation was blocked by category. Because all of a category's items had unique initial letters, output order could be controlled. For each category, the (unpracticed) high-frequency items were tested first and the (practiced) low-frequency items second. Presentation order of the cues was random. The order of the categories was counterbalanced across participants

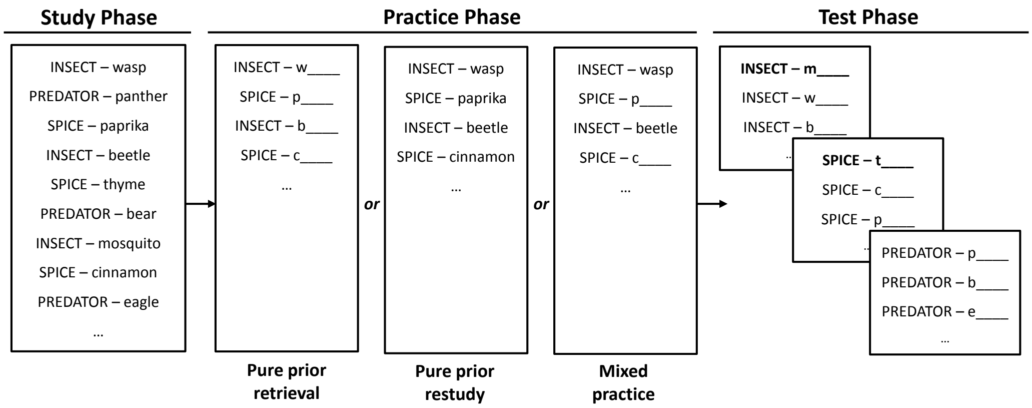

Figure 7. Procedure and conditions employed in Experiment 3A. In the study phase, participants studied a categorized list of items. In the practice phase, participants were asked to repeatedly retrieve half of the items of six of the nine categories (pure prior retrieval), to repeatedly restudy half of the items of six of the nine categories (pure prior restudy), or to repeatedly retrieve half of the items of three of the nine categories and to repeatedly restudy half of the items of three further categories (mixed practice). In the test phase, recall for all items was tested with a cued recall test. Unpracticed items from practiced categories are depicted in bold letters.

(see Figure 7 for an illustration of the experimental procedure and conditions).

Results

Practice Phase. Mean success rates in the intermediate practice phase were high and did not vary with practice condition (pure prior retrieval: 81.73%, mixed practice: 80.73%), $t(58) < 1$.

Test Phase - Detrimental effects of practice. Figure 8A depicts percentage of recalled unpracticed items and their corresponding control items on the final test. For the two pure practice conditions, an ANOVA with the between-participants factor of PRACTICE TYPE (pure prior retrieval vs. pure prior restudy) and the within-participants factor of ITEM TYPE (unpracticed vs. control) revealed no main effects of PRACTICE TYPE, $F(1, 46) < 1$, and ITEM TYPE, $F(1, 46) = 2.407$, $MSE = .007$, $p = .128$, but a significant interaction of the two factors, $F(1, 46) = 6.346$, $MSE = .007$, $p = .016$, partial $\eta^2 = .121$. Post-hoc tests showed that pure prior retrieval-practice impaired recall of unpracticed items (rp- items) relative to the c- items, thus showing standard RIF, $t(23) = 2.324$, $p = .029$, $d = .579$, whereas pure prior restudy did not affect recall of unpracticed items (rs- items) relative to the c- items, $t(23) = 0.831$, $p = .415$. In the mixed practice condition, an ANOVA with the within-participants factor of ITEM TYPE revealed a significant main effect of ITEM TYPE, $F(2, 70) = 4.584$, $MSE = 0.012$, $p = .013$, partial $\eta^2 = .116$. Planned comparisons showed that, compared to recall of the c- items, prior retrieval-practice led to forgetting of rp- items, $t(35) = 2.043$, $p = .049$, $d = .324$, and prior restudy led to forgetting of rs- items, $t(35) = 2.935$, $p = .006$, $d = .406$; rp- and rs- items did not differ in recall level, $t(35) < 1$.

The results of Figure 8A suggest that the effect of prior retrieval-practice on recall of the related unpracticed items did not vary between pure and mixed practice. Consistently, a 2 x 2 ANOVA with the within-participants factor of ITEM TYPE (rp- items vs. c- items) and the between-participants factor of PRACTICE MODE (pure prior retrieval vs. mixed practice) showed no significant interaction, $F(1,58) < 1$. In contrast, the results of Figure 8A suggest that the effect of prior restudy on recall of the related unpracticed items varied with practice mode. Consistently, a 2 x 2 ANOVA with the within-participants factor of ITEM TYPE (rs- items vs. c- items) and the between-participants factor of PRACTICE MODE (pure prior restudy vs. mixed practice) revealed a significant interaction, $F(1,58) = 6.701$, $MSE = .009$, $p = .012$, partial $\eta^2 = .104$.

Test Phase - Beneficial effects of practice. Figure 8B shows percentage of recalled practiced items and their corresponding control items on the final test. For the two pure practice conditions, an ANOVA with the between-participants factor of PRACTICE TYPE (pure prior retrieval vs. pure prior restudy) and the within-participants factor of ITEM TYPE (practiced vs. control) revealed a significant main effect of ITEM TYPE, $F(1,46) = 67.373$, $MSE = .007$, $p < .001$, partial $\eta^2 = .594$; no main effect of PRACTICE TYPE, $F(1,46) = 1.749$, $MSE = .014$, $p = .192$, and no interaction effect, $F(1,46) < 1$, arose. Post-hoc tests showed that pure retrieval-practice improved later recall of practiced items (rp+ items) compared to c+ items, $t(23) = 6.545$, $p < .001$, $d = 1.349$, and pure prior restudy improved later recall of practiced items (rs+ items) compared to c+ items, $t(23) = 5.485$, $p < .001$, $d = 1.137$. Regarding the mixed practice condition, an ANOVA with the within-participants factor of ITEM TYPE revealed a significant main effect of ITEM TYPE, $F(2,70) = 30.488$, $MSE = 0.009$, $p < .001$, partial $\eta^2 = .466$. Planned comparisons showed that all three item types differed significantly in recall level from each other: prior practice improved recall of rp+ items, $t(35) = 5.012$, $p < .001$, $d = .941$, as well as recall of rs+ items, $t(35) = 7.789$, $p < .001$, $d = 1.597$, compared to c+ items, and recall of rs+ items was higher than recall of rp+ items, $t(35) = 2.536$, $p = .016$, $d = .474$. Both the beneficial effect of restudy and the beneficial effect of retrieval did not vary between pure and mixed practice (restudy: $F(1,58) < 1$, retrieval: $F(1,58) < 1$).

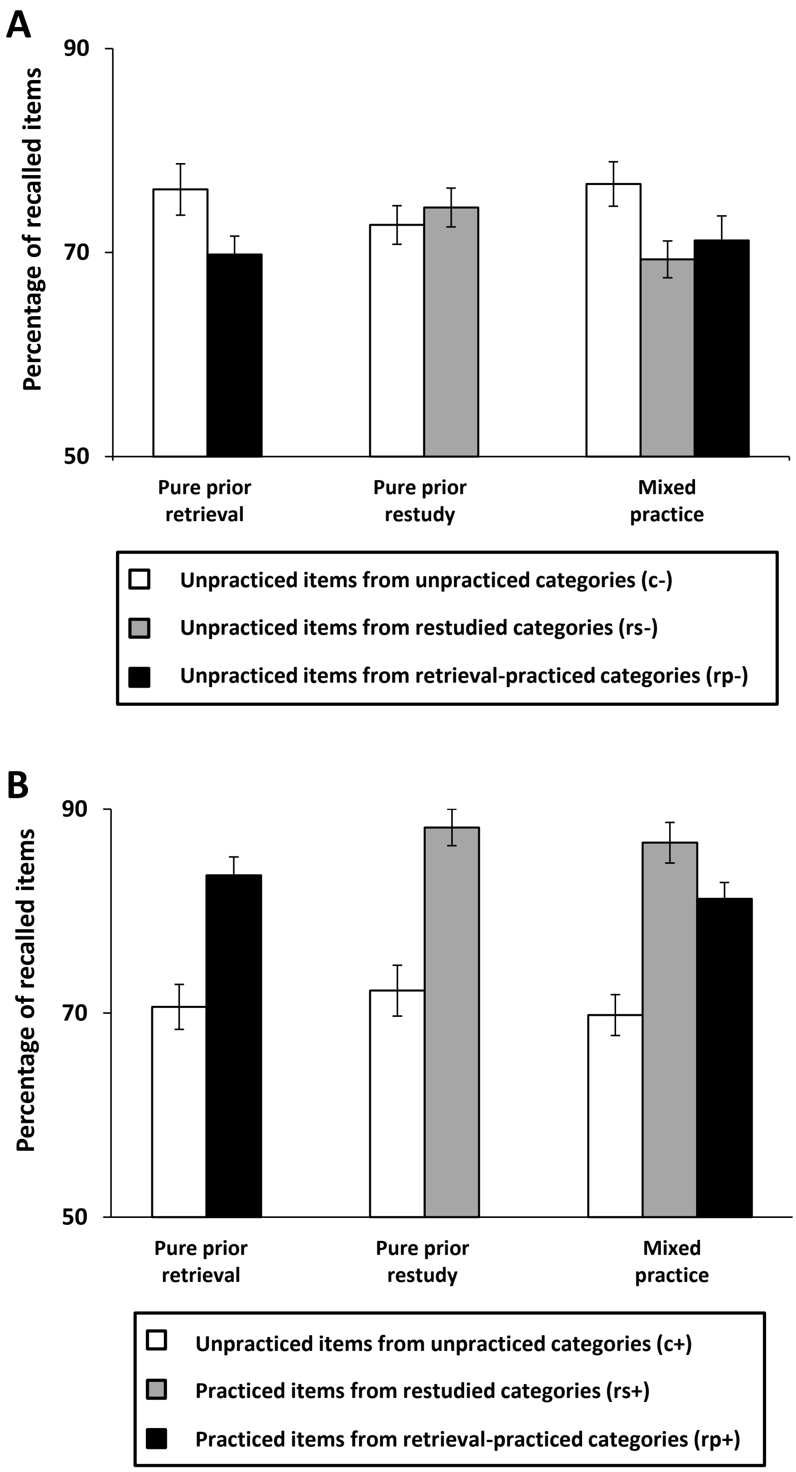

Figure 8. Results of Experiment 3A. Mean recall rates are shown for unpracticed, practiced, and control items after pure retrieval-practice, pure restudy, and mixed practice. Error bars represent standard errors. (A) Results for the unpracticed and control items. (B) Results for the practiced and control items.

Discussion

The results of Experiment 3A replicate prior work examining the beneficial and detrimental effects of (pure) retrieval-practice and (pure) restudy. In the pure retrieval condition, prior retrieval-practice of a subset of the previously studied items led to improved recall of the retrieval-practiced items and induced forgetting of related unpracticed items relative to the control items. In the pure restudy condition, prior restudy of a subset of previously studied items facilitated recall of the restudied items but did not affect recall of related unpracticed items. Numerous previous studies reported the same pattern, pointing to retrieval-induced forgetting as a recall specific effect (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999).

Going beyond the prior work, the present results show that, with mixed practice, retrieval-practice of some items still causes beneficial effects on the practiced material and detrimental effects on related unpracticed material. With such practice, however, the effects of restudy mimic the effects of retrieval-practice, improving recall of the restudied items but inducing forgetting of the related, not restudied material. The finding that restudy induces detrimental effects on related items with mixed practice but not with pure practice, provides the first demonstration of dynamic effects between retrieval and restudy conditions when practice is mixed.

5.2 Experiment 3B

The goal of Experiment 3B was to replicate this pattern of results using item recognition rather than cued recall as the memory task. Again, participants studied a categorized item list before completing a practice phase. In the blocked practice condition, participants first repeatedly retrieved some of the previously studied items from some of the categories, and then repeatedly restudied other items from other categories of the list, or vice versa. In the mixed practice condition, participants again retrieval-practiced some of the previously studied items from some of the categories and restudied other items from other categories, but this time retrieval and restudy trials were interleaved in random order. After completing a distractor task, an item recognition test based on confidence ratings was applied. Old and new items were presented and participants were asked to indicate on a six-point rating scale for each single item whether it was previously studied or not. Following prior work that shows recall specificity of RIF (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999), like in Experiment 3A it was expected that pure prior retrieval but not pure prior restudy causes forgetting of the unpracticed items from the practiced categories. On the contrary, following results that the effect of restudy can depend on the setting of the task (Bäuml & Aslan, 2004) and based on findings of asymmetric switching costs (e. g. Allport et al., 1994; Campbell, 2005; Meuter & Allport, 1999), it was expected that both prior retrieval and prior restudy induce forgetting of related unpracticed items in the mixed practice condition.

Methods

Participants. Forty-eight new participants were tested in this experiment (mean age = 22.31, range 18-30 years, 42 females). All participants spoke German as native language, took part on a voluntary basis, and received monetary reward or course credits for their participation. All of them were tested individually.

Material. Twelve exemplars from each of nine semantic categories were drawn from published word norms (Mannhaupt, 1983). The two most frequent exemplars of each category were excluded. Within each of the categories, six of the chosen exemplars were studied, whereas the remaining six items were used as lures in the later recognition test. According to their rank in the norms, the exemplars of each category were alternately assigned to the study list and the lure list. Like in Experiment 3A, for each category, the three study list items with the lower word frequency (low-frequency items) were practiced during the intermediate practice phase, whereas the three study list items with the higher word frequency (high-frequency items) served as unpracticed items. Within each category, each study item had a unique first letter. Additionally, two exemplars from three further categories were used as buffer items in the study and recognition test phase.

Design. The experiment had a mixed factorial design with the between-participants factor of PRACTICE MODE (blocked practice vs. mixed practice), the within-participants factor of PRACTICE TYPE (prior retrieval vs. prior restudy), and the within-participants factor of ITEM TYPE (practiced vs. unpracticed vs. control). Like in Experiment 3A, all participants went through three main phases: an initial study phase, an intermediate practice phase, and a final recognition test phase. Again, experimental conditions differed in the intermediate practice phase only. In the blocked practice mode, participants first repeatedly retrieved the low-frequency items of three of the nine categories, before repeatedly restudying the low-frequency items of three further categories, or vice versa. In the mixed practice mode, participants also retrieval-practiced the low-frequency items of three of the nine categories and restudied the low-frequency items of three further categories; this time, however, retrieval-practice and restudy trials were not blocked but had a random order. The blocked practice mode mimics the two pure practice conditions employed in Experiment 3A, whereas the mixed practice mode is identical to the one employed in Experiment 3A. In each of the two practice modes, the items of the three remaining categories served as control items. Consequently, the same two practiced item types (rp+ and rs+ items), the same two unpracticed item types (rp- and rs- items), and the same two control item types (c+ and c- items) as in Experiment 3A were created. Additionally, because of the final recognition test, the design created three types of new items: lures from retrieval-practiced categories (rp lures), lures from restudied categories (rs lures), and lures from unpracticed control categories (c lures).

Across participants, it was counterbalanced which of the studied categories was retrieval-practiced, restudied, or served as control condition.

Procedure. The study phase and the intermediate practice phase were identical to the study and the intermediate practice phase of Experiment 3A, with the only exception that participants in Experiment 3B completed a blocked practice phase, including a block of to-be-retrieved and a block of to-be-restudied items, rather than two pure practice conditions as employed in Experiment 3A. After the intermediate practice phase, the participants completed a distractor task, in which they worked on Raven's Progressive Matrices for 8 minutes.

In the final test phase, participants completed an old-new recognition test, in which they rated their confidence of a presented exemplar being old or new on a six-point rating scale (1: definitely old, 6: definitely new). The responses were entered via the digits on the PC keyboard and were recorded automatically in a log file. The participants were asked to use the whole range of the rating scale. Each exemplar was presented together with a schematically depicted rating scale in the lower part of the screen. As soon as the participant had entered any allowed digit, the next exemplar was presented on the screen. The order of the items was blocked randomized with two constraints: neither old material nor lures appeared more than three times in a row, and the unpracticed material and its corresponding control items mixed with lures were presented in the first half of the test phase, whereas the practiced material and its corresponding control items mixed with lures in the second. At the beginning of the test phase, three practice trials with old and new buffer items occurred (see Figure 9 for an illustration of the experimental procedure and conditions).

Statistical Analysis. A signal-detection approach was used to analyze the recognition data (e. g., Macmillan & Creelman, 2005). For this, hit and false alarm rates were cumulated over the different criterion points, starting with the most confident criterion point (i. e., 1 = definitely old). To account for the characteristic shape of recognition ROCs (*receiver operating characteristics*), which are usually asymmetrical along the diagonal, it is often assumed that the variance of the strength distribution for studied items exceeds the variance of the distribution for unstudied items, and the unequal-variance signal-detection model is applied to describe the data (e. g., Dunn, 2004; Wixted, 2007). According to this model, recognition in the present experiment was based on a single source of memorial information (i. e., [general] memory strength),[6] and participants responded with a given level of confidence whenever their assessment of the memory strength of a presented item exceeded the response criterion, c_i, associated with that confidence level. Studied items' memory strength is then given by the distance between the means of the underlying strength distributions for those studied items and the lures (d'). When applied to 5-point ROC data, this model has seven free parameters (memory strength of studied items d', variance of the strength distribution for studied items σ, and five response criteria c_1-c_5) and, thus, three degrees of freedom for statistically testing its goodness of fit. The model parameters were estimated using maximum likelihood techniques, which also allow for statistical testing (for further technical details, see Appendix of Spitzer & Bäuml, 2007).

Concretely, it was tested in the first step, whether the unequal-variance signal-detection model was able to describe the data for the single item types and practice conditions. If the model fitted the single data sets, it was analyzed in the second step, whether parameter d' varied significantly across item types and practice conditions; differences in d' across conditions suggest differences in memory strength and thus allow conclusions about possible beneficial and detrimental effects of practice. Specifically, for each practice condition, it was examined whether d' was higher for practiced than for control items, and was lower for unpracticed than for control items. If reliable differences between item types arose, it was further tested whether the differences varied significantly

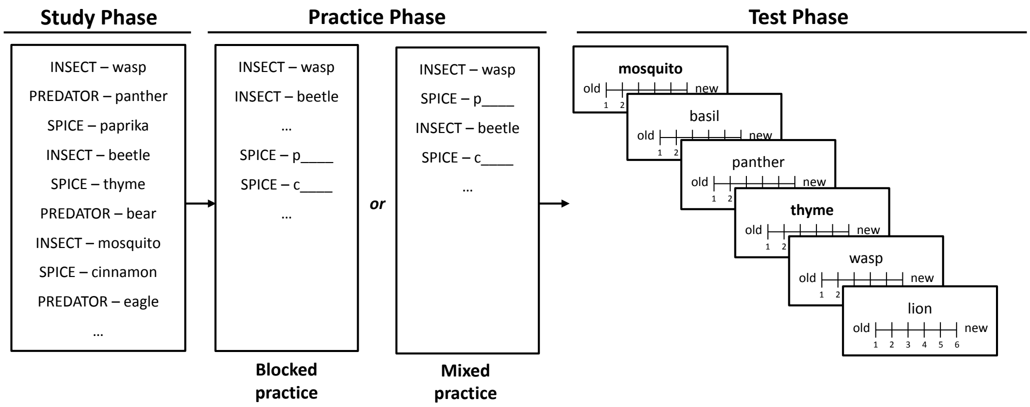

Figure 9. Procedure and conditions employed in Experiment 3B. In the study phase, participants studied a categorized list of items. In the practice phase, participants were either asked to first repeatedly retrieve half of the items of three of the nine categories, before repeatedly restudying half of the items of three further categories, or vice versa (blocked practice), or they were asked to practice retrieval of half of the items of three of the nine categories and to restudy half of the items of three further categories in a random order, i. e., this time, retrieval and restudy trials were randomly alternated (mixed practice). In the test phase, an item recognition test based on confidence ratings was applied. Old and new items were presented and participants were asked to indicate on a six-point rating scale whether the item was previously studied or not. Unpracticed items from practiced categories are depicted in bold letters.

across practice conditions.

Results

Practice Phase. Mean success rates in the intermediate practice phase were high and did not vary with practice mode (blocked practice: 71.8%, mixed practice: 75.9%), $t(46) < 1$.

Recognition Test - Detrimental effects of practice. Figures 10A and 10B depict the ROCs obtained by plotting the cumulative false alarm rates against the hit rates for each of the unpracticed item types and the corresponding control items, separately for the blocked (A) and mixed (B) practice mode. In addition, the figure shows the fit of the unequal-variance signal-detection model to each single data set. Table 2 shows the goodness-of-fit statistics and maximum-likelihood parameter estimates for the unpracticed items and their corresponding control items.

The unequal-variance signal-detection model described the data of the two unpracticed item types (rp- and rs- items) and the control items (c-) in both practice modes (blocked practice, mixed practice) well, all $\chi^2 s(3) < 5.88$, all $ps > .12$.[7] Analysis of whether the model parameters varied with item type revealed standard RIF in both practice modes; in fact, d' was significantly lower for rp- than c- items, both in the mixed practice mode, $\chi^2(1) = 9.51$, $p = .002$, and the blocked practice mode, $\chi^2(1) = 5.02$, $p = .025$; the detrimental effect did not vary with practice mode, $\chi^2(1) = 1.22$, $p = .269$. A different pattern

[6]The suggestion of a general memory strength dimension does not imply a single underlying memory process, but, for instance, may reflect the additive combination of familiarity and recollection codes (e. g., Kelley & Wixted, 2001; Wixted & Stretch, 2004).

[7]The equal-variance signal-detection model was also fitted to the data. This model is identical to the unequal-variance model with the constraint that the variance of the strength distribution for studied items is assumed to equal the variance of the distribution for unstudied items. The equal-variance model did not describe the ROCs as well as the unequal-variance model. The equal-variance model described the data of two item types (rp+ and rs+ items) in the blocked practice condition, but not as well as the unequal variance model did, all $\chi^2 s(4) < 8.58$, all $ps > .073$. For all other item types, the equal-variance signal-detection model had to be rejected, all $\chi^2 s(4) > 12.64$, all $ps < .013$.

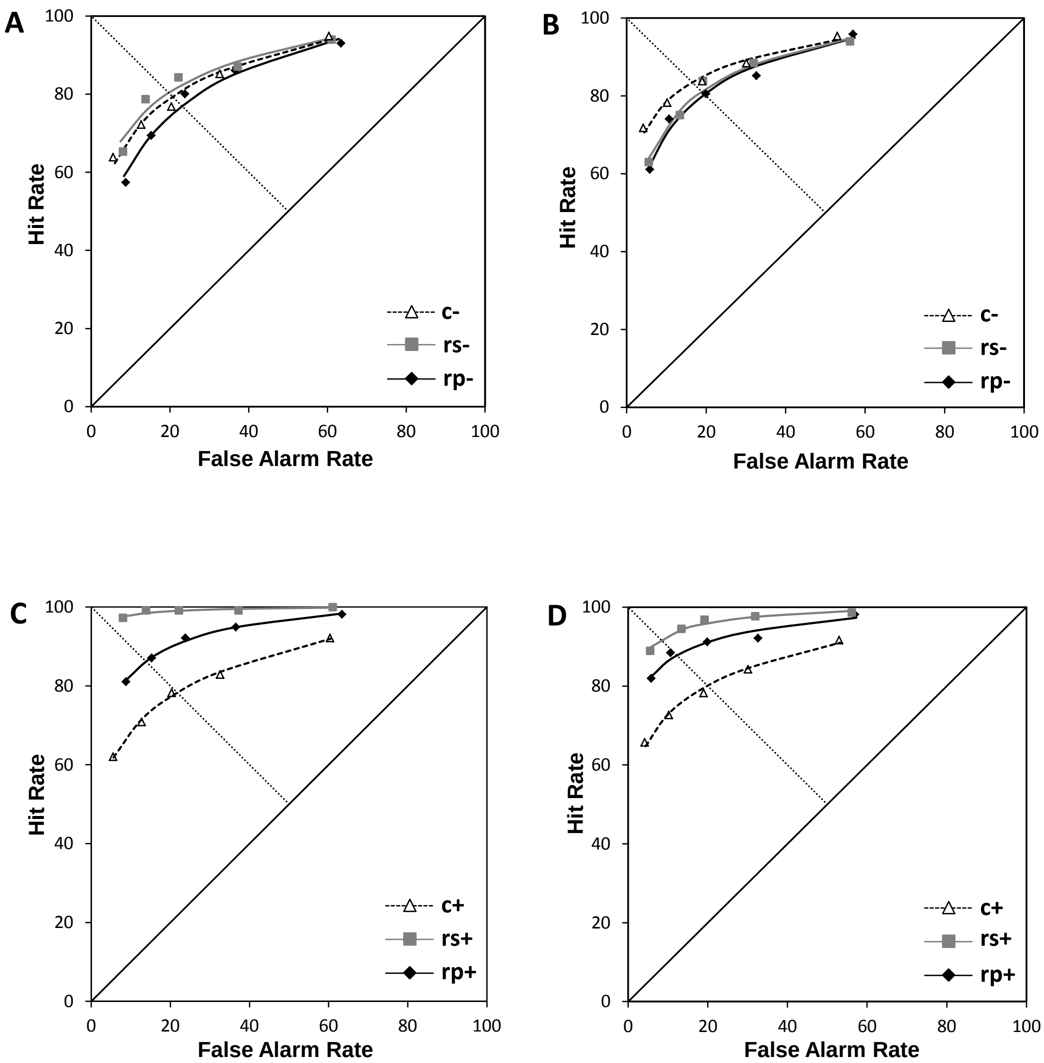

Figure 10. Item recognition receiver operating characteristics (ROCs) depicting the cumulative hit and false alarm rates for the different item types in the two practice modes (blocked practice, mixed practice) of Experiment 3 B. Solid lines indicate theoretical ROCs predicted by the unequal-variance signal-detection model. (A) ROCs for the two unpracticed item types (rp-, rs-) and the control items (c-) in the blocked practice mode. (B) ROCs for the two unpracticed item types (rp-, rs-) and the control items (c-) in the mixed practice mode. (C) ROCs for the two practiced item types (rp+, rs+) and the control items (c+) in the blocked practice mode. (D) ROCs for the two practiced item types (rp+, rs+) and the control items (c+) in the mixed practice mode.

Table 2. Unequal-variance signal-detection model for Experiment 3B.

blocked practice					
	parameter estimates		goodness of fit		
item type	*d'*	*σ*	X^2	*df*	*p*
rp-	1.68*	1.28	3.38	3	0.336
rs-	2.16	1.53	5.88	3	0.118
c-	2.02	1.47	2.46	3	0.483
rp+	2.59*	1.37	0.44	3	0.932
rs+	4.79*	1.72	4.27	3	0.234
c+	2.09	1.68	0.48	3	0.944

mixed practice					
	parameter estimates		goodness of fit		
item type	*d'*	*σ*	X^2	*df*	*p*
rp-	1.98*	1.32	4.17	3	0.244
rs-	2.09*	1.38	2.63	3	0.452
c-	2.62	1.69	1.73	3	0,631
rp+	3.21*	1.76	5.02	3	0.170
rs+	3.67*	1.63	2.39	3	0.495
c+	2.41	1.86	0.94	3	0.816

Note. rp- = unpracticed items from retrieval-practiced categories; rs- = unpracticed items from restudied categories; c- = unpracticed items from unpracticed categories; rp+ = practiced items from retrieval-practiced categories; rs+ = practiced items from restudied categories; c+ = unpracticed items from unpracticed categories; d' = general memory strength; σ = variance of the distribution for studied items. * Significant deviations from control performance ($p < .05$).

arose for the rs- items: After mixed practice, d' was lower for rs- compared to c- items, $\chi^2(1) = 5.69$, $p = .017$, and no difference between rs- and rp- items was found, $\chi^2(1) = 0.48$, $p = .503$, suggesting that prior restudy induced forgetting in the mixed practice mode. In contrast, after blocked practice, no difference in d' between rs- and c- items was observed, $\chi^2(1) = 0.55$, $p = .460$, and d' was significantly higher for rs- than rp- items, $\chi^2(1) = 8.31$, $p = .004$, indicating that no forgetting of rs- items took place after blocked practice. The effect of prior restudy on related unpracticed items varied reliably with practice mode, $\chi^2(1) = 5.18$, $p = .023$.[8]

Beneficial effects of practice. Figures 10C and 10D depict the ROCs obtained by plotting the cumulative false alarm rates against the hit rates for each of the practiced item types and the corresponding control items, separately for the blocked (C) and mixed (D) practice mode. In addition, the figure shows the fit of the unequal-variance signal-detection model to each single data set. Table 2 shows the goodness-of-fit statistics and the maximum-likelihood parameter estimates for the practiced items and their corresponding control items.

Again, the unequal-variance signal-detection model described the data of the two practiced item types (rp+ and rs+ items) and the control items (c+ items) in both practice modes (blocked practice, mixed practice) well, all $\chi^2 s(3) < 5.02$, all $ps > .17$. Statistical testing revealed improved memory for practiced items. Indeed, d' was significantly higher for rp+ than c+ items, in both the mixed practice mode, $\chi^2(1) = 5.82$, $p = .016$, and the blocked practice mode, $\chi^2(1) = 3.99$, $p = .046$; this beneficial effect did not vary with practice mode, $\chi^2(1) = .492$, $p = .483$. Similarly, d' was significantly higher for rs+ compared to c+ items, in both the mixed practice mode, $\chi^2(1) = 10.59$, $p = .001$, and the blocked practice mode, $\chi^2(1) = 21.08$, $p < .001$; this

[8]In the blocked practice condition, half of the participants did retrieval first and restudy second, whereas the other half did restudy first and retrieval second, which raises the question of whether block order might have affected results for unpracticed items. Corresponding analysis showed that there were no significant effects of block order, all $\chi^2 s(1) < 2.66$, all $ps > .10$.

beneficial effect did also not vary with practice mode, $\chi^2(1) = 1.935$, $p = .164$. d' was higher for rs+ than rp+ items after blocked practice, $\chi^2(1) = 8.78$, $p < .001$, whereas, despite an analogous numerical trend, no reliable difference in d' between rs+ and rp+ items was found after mixed practice, $\chi^2(1) = .80$, $p = .372$.

Discussion

The results of Experiment 3B replicate the main findings of Experiment 3A. With blocked practice, retrieval-practice improved recognition of the practiced items but induced forgetting of related unpracticed items; in contrast, restudy of a subset of previously studied items improved recognition of the restudied material, but did not affect memory for related but not restudied items. With mixed practice, again both retrieval-practice and restudy improved memory for the practiced items; however, this time both practice types induced forgetting of the related unpracticed material. This pattern mimics the results of Experiment 3A and generalizes them from recall to item recognition. The results indicate that retrieval-practice causes forgetting regardless of practice mode, whereas restudy causes forgetting with mixed practice but not with pure/blocked practice. The findings of Experiment 3B thus provide another demonstration of the possible dynamic effects between restudy and retrieval-practice.

The Experiments 3A and 3B examined the effects of retrieval-practice and restudy on related unpracticed material, using both recall and recognition testing. The results replicate prior work on retrieval-induced forgetting by showing beneficial effects of retrieval-practice on practiced material and detrimental effects of retrieval-practice on related unpracticed material relative to control items, both in recall and item recognition tasks (e. g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995; Hicks & Starns, 2004; Spitzer & Bäuml, 2007). Like in the prior work, these effects were found with pure retrieval-practice, i. e., when retrieval-practice occurred in a seperate experimental block, but equivalent effects arose also with mixed practice, i. e., when participants retrieval-practiced some items on some of the practice trials and restudied other items on other trials of the experimental block. The results thus provide a further demonstration of the very robust beneficial and detrimental effects of retrieval-practice.

The results of Experiments 3A and 3B also replicate prior work on the effects of restudy in the modified retrieval-practice paradigm, showing that restudy of some previously studied items is beneficial for the restudied items but can leave memory for related unpracticed material unaffected, both in recall and item recognition tasks (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml, 2002; Ciranni & Shimamura, 1999). Importantly, this pattern was present only with pure practice, i. e., when restudy of some of the previously studied items occurred in a seperate experimental block. In contrast, with mixed practice, i. e., when retrieval and restudy trials were randomly interleaved, a different picture arose, and restudy induced detrimental effects on related but not reexposed material. Obviously, the effect of restudy on related material can vary with the setting of the task, and be absent with pure practice but be present with mixed practice. This finding is in line with prior work on task switching, which showed asymmetric dynamic effects when switching between tasks varying in difficulty (e. g., Allport et al., 1994; Campbell, 2005). Switching back and forth between (more effortful) retrieval trials and (less effortful) restudy trials may have caused the asymmetric dynamic effects in Experiments 3A and 3B, and participants may have engaged in more retrieval during restudy trials when the trials were mixed than when restudy trials occurred in the absence of intermittent retrieval trials.

The results of Experiments 3A and 3B are also consistent with Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval, which attributes the detrimental effect of selective retrieval to inhibtion or blocking of related (target) information. If, with mixed practice, participants engage in retrieval during restudy trials, restudy might also trigger inhibitory processes and, thus, cause forgetting of the related unpracticed items very similar to how retrieval does. The finding is also in accordance with noninhibitory blocking accounts: If, with mixed practice, participants engage in retrieval during restudy trials, then the restudied items in this condition may be strengthened to a similar degree as the retrieval-practiced items, thus inducing increased interference and forgetting of the related not restudied items at test.

Chapter 6

General Discussion

Bäuml and Samenieh (2010, 2012a, 2012b) showed that selective retrieval of some memories can be detrimental for the recall of related information when access to the original encoding context is (largely) maintained. On the contrary, they found prior selective retrieval to improve related item material, when access to the original encoding context is impaired. To account for this finding, Bäuml and Samenieh (2012b) suggested, that quite different processes underlie the two opposing effects: inhibition or blocking is assumed to cause the detrimental effect (e. g., M. C. Anderson, 2003; Roediger & Neely, 1982), whereas reactivation of the original study context is thought to induce the beneficial effect of selective memory retrieval (e. g., Howard & Kahana, 1999, 2002). Crucially, which of these processes dominates in an experimental situation depends on whether the to-be-retrieved memories are subject to impaired context access, or not. If access to the original context is (largely) maintained - as it should be the case in the remember condition and in the short retention interval condition of the present experiments - inhibitory or blocking processes should dominate and not much room should be left for context reactivation processes; in contrast, if access to the original context is impaired - as it should be the case in the forget condition and the long retention interval condition of the present experiments - context reactivation processes should dominate and not much room should be left for interference and inhibition/blocking. Based on this hypothesis that the two faces of selective memory retrieval are mediated by different underlying mechanisms, the detrimental effect should be dissociable from the beneficial effect of selective memory retrieval. One major goal of the present thesis was to identify possible dissociating factors of the two faces of selective memory retrieval. Experiment 1 addressed the issue by showing that the delay between preceding nontarget and subsequent target recall influenced the detrimental and the beneficial effect of selective memory retrieval differently, whereas Experiments 2A and 2B were designed to demonstrate that the two opposing effects differ in recall specificity.

6.1 Dissociating the two faces of selective memory retrieval

Delay between nontarget and target recall as a dissociating factor and relation to prior work

Both the inhibition and the blocking account suggest that the detrimental effect of selective retrieval should be lasting. According to the inhibition account (e. g., M. C. Anderson, 2003) retrieval-practice can reduce the strength of the nonretrieved items' memory representation, thus creating an effect that lasts for quite a while (e. g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995). Lasting detrimental effects of selective memory retrieval are also in line with blocking accounts, which attribute RIF to relatively impaired recall chances for unpracticed items. According to these noninhibitory accounts, items which are strengthened through retrieval-practice block unpracticed items in a later recall test (e. g., Roediger & Neely, 1982). Because strengthening through retrieval or relearning still causes higher recall rates for practiced items after days and weeks (e. g., Karpicke, 2012; Roediger & Karpicke, 2006), practiced items should also be able to block relatively weaker (unpracticed) items after a delay between retrieval-practice of nontarget items and later target retrieval. Indeed, numerous studies found robust RIF when retrieval-practice and test were separated by a delay of 5 to 20 minutes (e. g., M. C. Anderson et al., 1994; MacLeod & Macrae, 2001). In contrast, on the basis of the view that the beneficial effect of selective memory retrieval is caused by a reactivation of the retrieved items' original encoding context, the expectation may arise that beneficial effects will not occur when target recall is delayed (Howard & Kahana, 1999; Polyn et al., 2009). Such reactivation can make the context a potentially powerful retrieval cue for target recall, but the cue should be effective primarily if the retrieval process was not interrupted, for instance, by means of an interpolated distractor task. A disruption between nontarget and target retrieval may reduce the context's activation level and thus reduce the cue's effectiveness in reactivating the target items. Thus, beneficial effects of selective retrieval should be present mainly when target recall is undelayed. Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval combines the two hypothesis suggesting that the delay between nontarget and target recall should dissociate the two faces of selective memory retrieval. While the detrimental effect should still be present after a delay between nontarget and target recall, the beneficial effect should be present primarily when target recall follows nontarget recall immediately, and be reduced, or even eliminated, when target recall is delayed.

Experiment 1 exactly showed this expected pattern of results. Detrimental effects of selective memory retrieval arose regardless of the delay between preceding nontarget retrieval and subsequent target recall, thus replicating prior work on RIF (e. g., M. C. Anderson et al., 1994; MacLeod & Macrae, 2001). Going beyond the prior work, the results of Experiment 1 provide first evidence that the beneficial effect of selective retrieval is limited to situations in which target recall is undelayed and does not generalize to conditions in which there is a delay of at least 1 minute between retrieval of some (nontarget) items and later recall of related (target) items. Hence, Experiment 1 is the first study to dissociate the beneficial and detrimental effects of selective memory retrieval.

Altogether, by showing the pattern of beneficial and detrimental effects of selective retrieval in the forget and remember conditions of the present experiment when target recall was undelayed, and by showing persisting detrimental effects in the remember condition but transient beneficial effects in the forget condition, the results of Experiment 1 support the suggested two-factor account according to which the detrimental effect is caused by inhibition or blocking and the beneficial effect is due to context reactivation processes. Specifically, the results of Experiment 1 concerning the beneficial effect of selective memory retrieval are consistent with a particular version of context retrieval theory, the *context maintenance and retrieval model* (Polyn et al., 2009), according to which accessibility of previously studied items can be disrupted if during recall the task is shifted to another task and the temporal context that is associated with the studied items is pushed out in favor of novel information.

Research on the detrimental effects of selective memory retrieval has demonstrated that RIF is a very general phenomenon and occurs for a wide range of materials and experimental situations (for reviews, see M. C. Anderson, 2003; Bäuml et al., 2010). However, this research has also identified a number of boundary conditions of RIF. For instance, detrimental effects of selective retrieval have been shown to be absent when retrieved nontargets and not-yet-retrieved targets show a high degree of interitem similarity (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml & Hartinger, 2002), and when participants are in negative mood (Bäuml & Kuhbandner, 2007), under stress (Koessler et al., 2009), or perform a divided-attention task during retrieval of the nontarget items (Román et al., 2009). Boundary conditions of the beneficial effects of memory retrieval have not yet been shown. By demonstrating that the beneficial effects on target recall are restricted to undelayed target recall, the present study suggests a first boundary condition of the beneficial effects of selective memory retrieval.

Using the listwise directed-forgetting task, Storm et al. (2007) recently found that semantic generation of related, but not previously presented items reduces later recall of previously studied to-be-remembered items but leaves recall of to-be-forgotten items unaffected. This finding mimics the present results in the 1-minute and the 10-minute delay conditions. Because in the Storm et al. study target recall was delayed as well, the parallel in results between the two studies is consistent with the present suggestion that delay can serve as a boundary condition for the beneficial effects of selective memory retrieval. However, using a semantic generation task for preceding recall of the nontarget items, the Storm et al. results may also point to a second boundary condition of the beneficial effects of selective retrieval. Indeed, whereas the generation of related but not previously presented items can cause forgetting of previously studied material when access to the original encoding context is maintained (see Bäuml, 2002), such generation may not be sufficient to induce enhancement of previously studied items if access to the encoding context is impaired. Rather, intralist but not extralist retrieval may be necessary to reactivate the original list context of the to-be-retrieved target items and thus cause target recall improvement (e. g., Howard & Kahana, 1999, 2002). Future work is needed to examine whether, like delay between preceding nontarget and subsequent target recall, usage of a semantic generation task for nontarget recall creates a boundary condition for the beneficial effects of selective memory retrieval. Recently, Bäuml and Schlichting (2014, Experiment 3) provided first evidence that semantic generation of unrelated (unstudied) nontarget items after a long retention interval did not cause beneficial effects on target material indicating that the beneficial effect of selective memory retrieval is not caused by simply priming retrieval processes, and prior episodic retrieval of nontarget items is necessary to induce the effect. This study, however, remains silent on the influence of semantic generation of related nontarget items on later recall of target items.

Chan et al. (2006) and Chan (2009) reported beneficial effects of selective memory retrieval when there was a longer delay between nontarget and target recall. In contrast to the present study (and most other work in RIF), these studies used integrated study material which typically eliminates RIF if target and nontarget recall are separated by short delay (e. g., Bäuml & Hartinger, 2002). Chan (2009) replicated this finding and additionally found recall of the control items to be reduced and recall of the unpracticed items to be unaffected by longer delay, which created the facilitation effect for the unpracticed items in their study. The results from this prior work and the results from the present study thus seem to be mediated by quite different mechanisms.[9]

[9]Recently, there has been a debate in the literature whether the delay between preceding (nontarget) retrieval and subsequent (target) recall is a further boundary condition for the RIF effect. RIF has been shown frequently after (comparatively short) delays up to 20 minutes (e. g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995; Bäuml & Aslan, 2004). Though, studies investigating RIF after delays of 24 hours or longer, have provided inconsistent results. While some studies found RIF to be eliminated after 24 hours (e. g., Chan, 2009; MacLeod & Macrae, 2001), other studies showed intact RIF after a delay of a week (e. g., Garcia-Bajos et al., 2009; Tandoh & Naka, 2007). More recently, however,

Recall specificity as a dissociating factor and relation to prior work

Bäuml and Samenieh's (2012b) two-factor account of the two effects of selective memory retrieval assumes that the detrimental effect is caused by inhibition or blocking of the target items and arises if access to the study context is still maintained. Inhibition is generally assumed to be recall specific (e. g., M. C. Anderson, 2003), and even blocking may be recall specific, at least if retrieval strengthened the nontargets to a much higher degree than restudy does (e.g., Raaijmakers & Jakab, 2012). In addition, the two-factor account assumes that the beneficial effect of selective memory retrieval is caused by reactivation of the targets' study context and arises if access to the study context is impaired. Following context retrieval theory (e.g., Greene, 1989; Howard & Kahana, 2002; Thios & D'Agostino, 1976), such reactivation should not be recall specific and arise both after retrieval and restudy of nontarget items. In sum, predicting that the detrimental but not the beneficial effect is recall specific, the two-factor account of selective memory retrieval suggests that recall specificity should be another factor dissociating the two faces of selective memory retrieval.

By showing this expected pattern of results, the findings of the Experiments 2A and 2B thus support Bäuml and Samenieh's (2012b) two-factor account. The present results replicate prior work by demonstrating that the detrimental effect of selective memory retrieval is recall specific, i. e., RIF occurs after active selective retrieval but not after restudy trials (e. g., M. C. Anderson, Bjork, et al., 2000; Bäuml, 2002; Ciranni & Shimamura, 1999). Going beyond the prior work, the results of Experiment 2A and 2B provide first evidence that the beneficial effect is not recall specific and also occurs after selective restudy of (nontarget) items. Moreover, the results of

Abel and Bäuml (2012) provided an explanation for these divergent results by suggesting that whether RIF is present or absent after a longer delay can depend on whether sleep or being awake follows the retrieval-practice phase. This assumption is based on their finding that RIF is present after nocturnal sleep but absent when the delay between prior retrieval-practice and later (target) recall was filled with diurnal wakefulness (see Racsmány, Conway, & Demeter, 2010, for similar results).

Experiments 2A and 2B extend prior work on the two faces of selective memory retrieval by showing that the two opposing effects of selective memory retrieval are also present when retention interval is varied; selective memory retrieval can be detrimental for other items when the retention interval is short, and be beneficial when the retention interval is prolonged.

Strict versions of context retrieval theory may assume constant retrieval for items regardless of lag between original presentation and repetition, and regardless of type of repetition. Such versions of the theory may be too strict. Indeed, there is evidence from prior work that amount of context retrieved for a repeated item can decrease as a function of its lag (e. g., Pavlik & Anderson, 2005), and there is evidence from the present work that type of repetition may affect context retrieval. By showing equivalent beneficial effects of retrieval and restudy, the results of Experiment 2A indicate that retrieval and restudy may in fact induce the same amount of context retrieval, whereas the results of Experiment 2B suggest that, under certain circumstances, retrieval can induce a higher amount of context retrieval than restudy does. Thus, depending on how exactly contextual change is induced, repetition by virtue of restudy may differ in context retrieval from repetition by virtue of retrieval. These findings impose restrictions on context retrieval theory and the two-factor account of memory retrieval.

There is recent debate in the literature about whether the detrimental effect of selective memory retrieval is really recall specific. This debate is motivated by findings which show that some restudy formats - e. g., asking participants to rate how they feel about a reexposed item, or asking participants to decide whether an exposed category is the first category to choose for a simultaneously reexposed item - can induce recall impairment for other items, very similar to how retrieval does (Verde, 2013; see also Raaijmakers & Jakab, 2012). These findings are of direct relevance for the question of whether the detrimental effect of selective memory retrieval is mediated by inhibition or blocking. In particular, they indicate that some restudy formats may induce a different pattern of recall specificity than the standard restudy format does. Future work is required to investigate these restudy formats in more detail, examine exactly which mechanisms are involved in creating the detrimental effects, and examine whether these formats also affect the amount of context reactivation and thus the beneficial effects of memory retrieval.

6.2 Dynamic effects between restudy and retrieval trials: when restudy causes forgetting

Another major goal of the present thesis was to identify possible dynamic effects between selective memory retrieval and selective restudy trials. Numerous prior studies adressing the detrimental effect of selective retrieval showed forgetting of related (target) material after selective retrieval of (nontarget) items but not after selective restudy of these (nontarget) items (e. g. Bäuml & Aslan, 2004; Ciranni & Shimamura, 1999; Johansson et al., 2007). In these studies, however, practice effects through restudy and retrieval have invariably been examined using pure practice conditions. Hence, the question arose whether dynamic effects between selective retrieval and selective restudy exist under certain prerequisites. Studies investigating task switching suggest that this might be the case: with mixed practice, in which participants have to switch back and forth between (more effortful) retrieval trials and (less effortful) restudy trials, dynamic effects might arise that influence the processing of items after switching, particularly after switching from retrieval to restudy trials (e. g., Campbell, 2005; Meuter & Allport, 1999). In such cases, participants may engage in more retrieval during restudy trials, causing the reexposure of the single items to impair memory for related unpracticed material, very similar to how retrieval-practice does. Moreover, prior work also showed detrimental effects of reexposure in a retrieval context but not in a restudy context (Bäuml & Aslan, 2004). Experiments 3A and 3B addressed the issue by examining whether the effects from pure retrieval-practice and pure restudy generalize to mixed practice situations in which retrieval-practice and restudy trials were randomly interleaved within a single experimental block.

The present results of Experiment 3A and 3B provide first evidence for possible dynamic effects between retrieval and restudy trials. While the effects of retrieval seem to be robust and to not depend on practice mode, the effects of restudy appear less robust and to vary with the setting of the task. Indeed, the results show clear differences in the effects of restudy and retrieval-practice with pure practice, but no such differences with mixed practice. In particular, with pure practice, selective retrieval but not selective restudy induced forgetting of the related unpracticed item material. In mixed practice conditions, however, both practice types impaired recall for unpracticed items in a later memory test.

In principle, different detrimental effects of restudy with pure and mixed practice might arise if the two practice modes led to different degrees of beneficial effects for the restudied items (e. g., Mensink & Raaijmakers, 1988; Rundus, 1973). Indeed, if the beneficial effect of restudy was higher with mixed than with pure practice, one could argue that the detrimental effect with mixed practice arose because of enhanced competition from the restudied items at test. However, neither in Experiment 3A nor in Experiment 3B did mixed practice induce larger beneficial effects for restudied items than pure practice did, indicating that the present finding was not caused by differences in competition at test. Moreover, in Experiment 3A unpracticed items were tested first within their category, and in Experiment 3B participants rated the unpracticed items mixed with lures in the first half of the recognition test and the practiced items mixed with lures in the second. Thus, in both experiments output order was controlled, preventing that the detrimental effects were induced by tested-first practiced items causing forgetting of tested-last unpracticed items.

The results of Experiment 3A and 3B are in line with Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval, which puts the detrimental effect down to inhibition or blocking of related (target) material. According to the inhibitory account of RIF, during retrieval-practice, a category's not-to-be-practiced items interfere and, as a consequence, are inhibited to reduce interference and make selection of the target information easier (e. g., M. C. Anderson & Spellman, 1995). The results of Experiment 3A and 3B are consistent with this account. If, with mixed practice, participants engage in retrieval during restudy trials, restudy might also trigger inhibitory processes and thus cause forgetting of the related unpracticed items very similar to how retrieval does. Such restudy-induced inhibition, however, should be restricted to mixed practice and be absent with pure practice (e. g., M. C. Anderson, Bjork et al., 2000; Ciranni & Shimamura, 1999), which is what the present results suggest.

The findings of Experiment 3A and 3B are also in accordance with noninhibitory accounts of retrieval-induced forgetting. According to the competition account (Camp et al., 2007; Jakab & Raaijmakers, 2009), for instance, retrieval-practice strengthens the practiced items to a larger extent than restudy does, thus creating more interference at test for related unpracticed items after retrieval than after restudy trials. However, if, with mixed practice, participants engage in retrieval during restudy trials, then the restudied items in this condition may be strengthened to a similar degree as the retrieval-practiced items, thus inducing increased interference and forgetting of the related not restudied items at test. Finally, according to the context-change account (Perfect et al., 2004), participants create distinct learning contexts during study and retrieval-practice, so that at test for practiced categories - but not for unpracticed categories - participants focus their search on the practice context, which would improve recall of the practiced items but relatively impair recall of the unpracticed items. However, if participants in the mixed condition engage in retrieval during restudy trials, then a new, distinct practice context may be created not only for retrieval-practiced but also for reexposed categories, which would induce the observed forgetting of the unpracticed items at test. The inhibitory and noninhibitory accounts of retrieval-induced forgetting have sometimes been difficult to tease apart (see Storm & Levy, 2012), and this study was not designed to resolve this issue.

6.3 Theoretical and practical implications

Bäuml and Samenieh's (2012b) two-factor account of selective memory retrieval assumes that whether selective retrieval is detrimental or beneficial for related material depends on the accessibility of the original encoding context. According to this account, selective retrieval reduces recall of related memories via inhibition or blocking when access to the original study context is (largely) maintained, and it facilitates recall of related memories via context reactivation when access to the original study context is impaired. All present experiments support this account by showing RIF when access to the original encoding context was (largely) maintained after the presentation of a remember cue (Experiments 1 and 2A) or after a short retention interval (Experiments 2B, 3A and 3B), and by showing a beneficial effect of selective retrieval when access to the original encoding context was impaired after a forget cue (Experiments 1 and 2A) or after a long retention interval (Experiment 2B). There is still an ongoing debate in the literature about whether the detrimental effect of selective memory retrieval is mediated by inhibition or blocking (e. g., M. C. Anderson, 2003; Raaijmakers & Jakab, 2012; Verde, 2013). In this thesis, both accounts are mentioned and discussed as possible mechanisms for the detrimental effect because the present experiments were not designed to distinguish between inhibition and blocking. Further research is needed to examine exactly which mechanisms induce the detrimental effect of selective memory retrieval.

The present results are consistent with the most simple form of the two-factor account, which assumes that one type of processes is active when context access is maintained, and the other type of processes is active when context access is impaired. In general, a more realistic view may be that both types of processes are active in both conditions, and it is only that the one type of processes is more influential in the one condition and the other type is more influential in the other condition. The present experiments were not designed to distinguish between different versions of the two-factor account, thus, future work is required to address the issue.

One major goal of the present thesis was to identify dissociating factors of the detrimental and the beneficial effect of selective memory retrieval. Experiment 1 provided first evidence that the delay between nontarget and target recall influences the two faces of selective memory retrieval differently. While the detrimental effect occurs regardless of the length of the delay, the beneficial effect does not generalize to situations in which target recall is delayed. Future work is necessary to identify further boundary conditions for the beneficial effect of selective memory retrieval. Bäuml and Schlichting (2014) already showed that semantic generation of unrelated (unstudied) nontarget items does not induce higher recall rates for target items. According to the two-factor account (Bäuml & Samenieh, 2012b) semantic generation of related (unstudied) nontarget items might reactivate the original encoding context via spreading activation and induce beneficial effects on target material. It remains to be investigated whether this prediction holds true. Similarly, the two-factor account assumes that the beneficial effect should no longer be present, if nontarget items and target items are from different study contexts. In this case, episodic nontarget retrieval should not reactivate target items, and, consequently, not cause beneficial effects.

Experiments 2A and 2B identified recall specificity as another dissociating factor of selective memory retrieval. While the detrimental effect proved to be recall specific and only occurred after selective retrieval but not after selective restudy of nontarget items, the beneficial effect was present regardless of practice type. Particulary, in Experiment 2A, selective retrieval and selective restudy induced beneficial effects that were equivalent in amount. In Experiment 2B, beneficial effects after selective retrieval were larger than after selective restudy trials, indicating that the setting of the task may influence the effects of selective retrieval and restudy. The present results do not provide an answer on why the beneficial effects of retrieval and restudy may be equivalent under some circumstances but differ in size under others. However, two speculations arise. The one speculation is that retrieval may be generally better able than restudy to reactive the study context, but the difference may manifest itself mainly after major contextual change. The view is consistent with the present results, because the prolonged retention interval condition of Experiment 2B created much larger forgetting than the presentation of the forget cue in Experiment 2A (44% vs. 17%), which may indicate that the longer retention interval created a higher degree of contextual change than the forget cue did. The other speculation is that the contextual effects in the two experiments may have differed qualitatively. For instance, longer retention intervals may create larger contextual drift than shorter retention intervals (Estes, 1955; McGeoch, 1932), whereas a forget cue may create context inhibition (Geiselman et al., 1983; Kimball & Bjork, 2002). If retrieval and restudy were differently responsive to different forms of context change effects, then retrieval and restudy may be equivalent under some circumstances (e. g., contextual inhibition) but differ in size under others (e. g., contextual drift). It is a high priority for future research to examine in more detail, when exactly the beneficial effects of retrieval and restudy are equivalent and when they are not. Such findings would impose restrictions on context retrieval theory and the two-factor account of memory retrieval.

Experiments 3A and 3B replicated recall specificity of the detrimental effect in pure practice conditions. Examining also mixed practice conditions, both experiments extend the results from previous studies by reporting an exception to this "rule" and showing that restudy can also induce forgetting of related items, although only in the presence of intermittent retrieval. This finding is the first demonstration of dynamic effects between retrieval and restudy trials. Moreover, Experiments 3A and 3B have implications for future research concerning the beneficial effect of retrieval or restudy for the practiced items. In the mixed practice conditions of Experiment 3A and 3B, restudy was equivalent to retrieval-practice with regard to the unpracticed items, whereas the same equivalence did not arise with regard to the practiced items. Indeed, in Experiment 3A, the beneficial effect of practice was statistically larger after restudy than after retrieval-practice, and in Experiment 3B, at least a similar numerical trend arose. Although such difference between restudy and retrieval-practice is not unusual (e. g., Roediger & Karpicke, 2006) and may be the result of the intact reexposure of the to-be-restudied items during practice in comparison to the only partly successful retrieval-practice of the to-be-retrieved items, an interesting question for future research might be whether restudied items in the mixed condition reveal parallels to retrieved items, for instance, by showing reduced forgetting after a delay. Indeed, several studies on the so-called testing effect observed that retrieval of previously studied material, in comparison to (pure) restudy of the material, largely reduces such delay-induced forgetting (e. g., Karpicke & Roediger, 2008; Roediger & Karpicke, 2006). Thus, if, with mixed practice, the effects of reexposure mimicked the effects of retrieval, reexposure with mixed practice might not only reduce memory for the related unpracticed material but might reduce delay-induced forgetting for the restudied material as well.

Finally, the present thesis also has practical implications and sheds light on the ongoing discussion why selective retrieval is detrimental in many experimental situations, whereas everyday experiences suggest that selective retrieval of some memories can aid recall of related information. According to the present results, selective retrieval is disadvantageous for related material if the access to the original study context is (largely) maintained - a situation which should happen only rarely in everyday life. When pupils study, for instance, some facts about the ice age in their geography class, this new material usually is not tested during the same lesson. Normally, some days or weeks pass until the facts are to be recalled. Similarly, if we are asked to testify as an eyewitness, usually some time elapses between the crime and the interrogation. The present findings suggest that when access to the original encoding context is impaired, for example through a longer retention interval between study and selective retrieval, selective retrieval is beneficial for the remaining material. Thus, in most everyday situations, in which some time passes between encoding and recall, selective retrieval should reactivate the original encoding situation and, thus, help us remember related information. Fittingly, using more integrated prose material, Bäuml and Schlichting (2014) recently showed beneficial effects of selective retrieval after a prolonged retention interval with different spacial and social context between encoding and test - conditions that mimic people's everyday experiences to a much larger extent than usual laboratory conditions do. The present findings are also in line with studies applying the so-called cognitive interview as an alternative technique to interrogate eyewitnesses (e. g., Geiselman et al., 1985; Fisher & Geiselman, 1988). Participants interviewed with this technique are, for instance, asked to recount the previoulsy observed crime in different orders (e. g., forwards, backwards) or to recall every detail (even if it may seem irrelevant to the participants) in order to reactivate the eyewitness's original internal and external context during the observation of the incident. Geiselman and colleagues showed enhanced recall rates for the relevant details of previously observed incidents when participants were questioned with the cognitive interview technique compared to a standard police interview technique, pointing to beneficial effects of selective memory retrieval.

Considering the findings of the Experiments 3A and 3B, practical implications may arise for educational settings, where retrieval and restudy naturally play an important role. Mixed practice, i. e., when retrieval-practice and restudy alternate, seems more close to instructional methodology in the classroom and to how pupils normally rehearse material than pure practice does. Using pure practice conditions, previous studies showed beneficial effects for related material after selective restudy but detrimental effects after selective retrieval (e. g., M. C. Anderson, Bjork, et al., 2000; Ciranni & Shimamura, 1999). Experiments 3A and 3B replicated these findings. Going beyond prior work, however, the present findings point to dynamic effects between selective retrieval and selective restudy by showing that - like retrieval - restudy can cause forgetting of related information when practice is mixed. To what extent this laboratory finding generalizes to more applied settings needs yet to be investigated - especially, if one takes into account the preceding thoughts that, in everyday life, retrieval may be rather a self-propagating than a self-limiting process.

6.4 Conclusions

The present thesis supports Bäuml and Samenieh's (2012b) recent finding that selective retrieval is detrimental under some circumstances but beneficial under others. Which of the two faces of selective memory retrieval appears is assumed to depend on the accessibility of the original encoding context. When access to the original encoding context is (largely) maintained - as should be the case after a remember cue, a short distractor task or, generally, a short retention interval - selective retrieval of some previously studied information is supposed to trigger inhibition or blocking of the remaining material, thus, leading to a detrimental effect of selective retrieval. In contrast, when access to the original encoding context is impaired - as should be the case after a forget cue, a shift in the participant's internal state of context or a prolonged retention interval - selective retrieval of some previously studied items is assumed to reactivate the retrieved items' original encoding context and this reactivated context may then serve as a retrieval cue for the remaining information. Thus, under these circumstances, selective retrieval is beneficial for related memories. In sum, depending on whether access to the original study context is impaired or (largely) maintained, two completely different processes are supposed to operate and cause the effects of selective retrieval. Being mediated by different underlying mechanisms, the detrimental and the beneficial effect should be differently susceptible to alterations of the experimental procedure, and, hence, the two faces of selective retrieval should be dissociable.

The present thesis deepens the knowledge concerning the two faces of memory retrieval by identifying two dissociating factors. Firstly, the delay between prior (nontarget) retrieval and later recall of the remaining (target) items affected the two faces of selective retrieval differently. While the detrimental effect of selective memory retrieval occurred regardless of the delay between nontarget and subsequent target recall, beneficial effects arose only if target recall was undelayed. Secondly, this thesis provides first evidence that the detrimental effect of selective memory retrieval is recall specific, whereas the beneficial effect is not and also generalizes to restudy trials.

Moreover, the present thesis extends prior work on the recall specific detrimental effect of selective retrieval by showing that selective restudy can also induce forgetting of related items, although only in the presence of intermittent retrieval. This finding is the first demonstration of dynamic effects between retrieval and restudy trials, and opens the window into the more detailed study of the interplay between retrieval and restudy practice.

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