

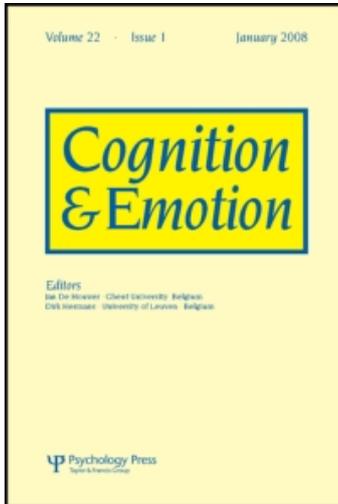
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### Retrieval-induced forgetting of negative stimuli: The role of emotional intensity

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## Retrieval-induced forgetting of negative stimuli: The role of emotional intensity

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Repeatedly retrieving a subset of previously studied items can cause forgetting of related non-retrieved material. We examined whether such retrieval-induced forgetting holds also for negative material. Participants studied neutral and negative stimuli and then repeatedly retrieved a subset of the neutral material. Later, a recall test was conducted in which participants were asked to recall all previously studied items. On average, retrieval practice on the neutral items caused the same amount of forgetting for neutral and negative items, indicating that the emotionality of material does not affect retrieval-induced forgetting. More detailed analysis, however, revealed that the forgetting of negative items decreased with both the emotional intensity of a negative item and the dispositional negative affectivity of a participant. The decreases in retrieval-induced forgetting may have been driven by item-specific processing of material, which is known to be enhanced for highly negative stimuli and participants high in dispositional negative affectivity and to reduce or even eliminate retrieval-induced forgetting.

**Keywords:** Episodic memory; Emotion; Retrieval-induced forgetting; Material; Dispositional affectivity.

A prominent factor shaping our memory of the past is the emotional content of an experience. There is abundant evidence that emotionally charged episodes are remembered better than neutral episodes. A particularly striking example is the memory advantage of so-called flashbulb memories, highly vivid images of extremely emotional events that are stored in autobiographic memory (Brown & Kulik, 1977). In the laboratory, the

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memory enhancement for emotional information has been shown across a wide range of stimuli, from words to pictures and narrated slide shows (see Reisberg & Heuer, 2004, for a review).

In view of the special status of emotional episodes in our memory, the question arises to what extent emotional stimuli differ in their susceptibility to forgetting from neutral stimuli. Whereas research on flashbulb memories suggests that extremely emotional events may persist in memory, other research indicates that emotional memories can be forgotten, at least intentionally. In fact, cuing participants to intentionally forget previously learned negative items and learn new negative items instead has been reported to reduce later accessibility of the to-be-forgotten items and to reduce it to about the same extent as that of neutral material (Wessel & Merckelbach, 2006), a finding that generalises to autobiographical memories (Barnier et al., 2007).

In contrast, the empirical evidence for unintentional forgetting of emotional material is scarce. One important factor leading to unintentional forgetting is our ability to selectively retrieve memories from the past. When we try to remember a specific past experience, related memories may compete for access to conscious awareness and be suppressed to successfully retrieve a target memory. Evidence for this proposal arises from the observation that the repeated retrieval of a subset of previously studied items can cause later forgetting of non-retrieved related items (Anderson, Bjork, & Bjork, 1994). Such retrieval-induced forgetting has been demonstrated in a variety of experimental settings and has been found to be retrieval specific (see Anderson, 2003; Bäuml, 2008, for reviews).

While there is abundant evidence for retrieval-induced forgetting of neutral stimuli, retrieval-induced forgetting of emotional stimuli is largely unexamined to date, and the few relevant studies that exist provide a mixed pattern of results. Extending the procedure to autobiographic memory, Barnier, Hung, and Conway (2004) examined the role of emotional significance in this type of forgetting and found forgetting of both neutral and emotional autobiographical memories. Also using autobiographical memories, Wessel and Hauer (2006) replicated the Barnier et al. (2004) finding for negative material, but did not observe forgetting for positive material. Finally, in a recent study by Hauer, Wessel, Merckelbach, Roefs, and Dalgleish (2007), no forgetting was found for details of previously presented emotional negative slides, after questioning participants about central or peripheral details of the pictures. However, because the authors also failed to find retrieval-induced forgetting for neutral slides, the result may also be taken as evidence that the emotional content of an item does not affect the consequences of selectively retrieving memories from the past.

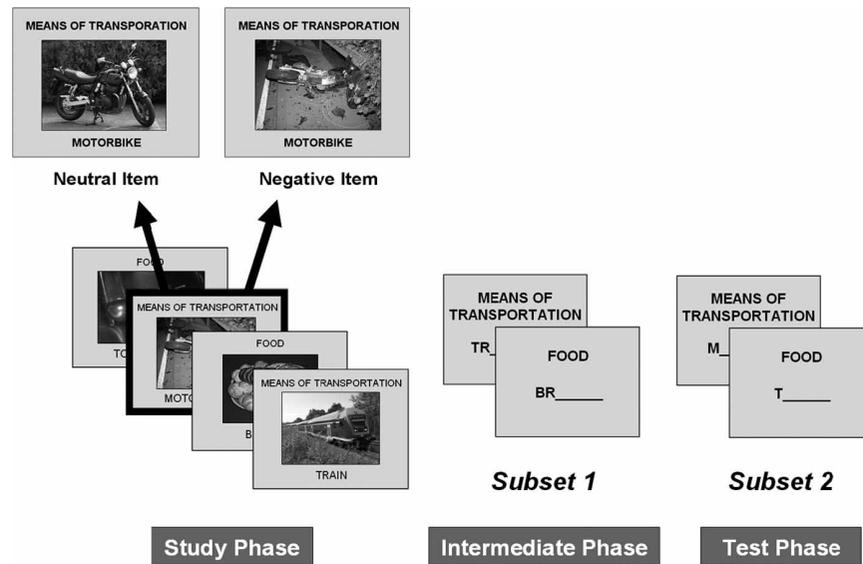
Concluding from these findings that emotionally negative material is equally susceptible to retrieval-induced forgetting as neutral material might

be premature, however. Besides the fact that, to date, the original retrieval-induced forgetting procedure, as introduced by Anderson et al. (1994), has not been applied to emotional stimuli, there are two further limitations in the prior work. A first limitation is that, in all three previous studies, practiced and unpractised items shared the same emotional valence. Participants thus repeatedly retrieved emotional items during retrieval practice, which may have influenced the participants' affective state (e.g., Ekman, Levenson, & Friesen, 1983). Because the affective state experienced during retrieval can influence retrieval-induced forgetting (Bäuml & Kuhbandner, 2007), this feature of the previous studies may have affected the results.

Another limitation in the prior work is that the role of emotional intensity of the items was not addressed. The results from numerous studies suggest that emotional items are processed differently depending on emotional intensity (see Kensinger, 2004, for a review). Highly negative items attract attention and are prioritised for processing, resulting in an enhanced, but item-specific storing of the item. The *weapon-focus* effect, for instance, describes the observation that witnesses often remember the weapon but no surrounding details (e.g., Loftus, Loftus, & Messo, 1987). In contrast, if items are only moderately negative, participants may think more about the items' meaning and their relation to other items, as suggested by the fact that the memory advantage for moderately negative items diminishes both when attention is divided during encoding (Kensinger & Corkin, 2003) and when neutral items have similarly strong inter-item associations (Talmi & Moscovitch, 2004). Differences in encoding, however, can affect retrieval-induced forgetting, as demonstrated by the finding that encoding items in terms of differences between the single items (item-specific processing) can eliminate retrieval-induced forgetting (Smith & Hunt, 2000).

The aim of the present study was to re-examine retrieval-induced forgetting of negative stimuli and to determine the role of emotional intensity in this type of forgetting. Participants studied neutral and negative stimuli and then repeatedly retrieved a subset of the neutral material in an intermediate phase. Subsequently, a recall test was conducted in which participants were asked to recall all previously studied items. In contrast to previous work, retrieval in the intermediate phase was restricted to neutral material to prevent the induction of negative moods. To minimise differences between neutral and negative items unrelated to emotion, category exemplars were used and the same exemplar names were paired with both neutral and negative pictures depicting the exemplar (see Figure 1). Several studies demonstrated that a memory advantage for negative information can be found with such material (e.g., Hurlmann et al., 2005).

On the basis of the prior work (Barnier et al., 2004; Wessel & Hauer, 2006), we expected to find a similar mean amount of retrieval-induced forgetting for neutral and negative items. Going beyond the prior work, we



**Figure 1.** Experimental timeline and material. Participants were instructed to study several exemplars from different categories and to repeatedly retrieve a subset of the exemplars of a category in an intermediate phase. In the final test phase, all studied items had to be recalled. Across participants, two exemplar names of a category were paired with either a neutral or a negative picture depicting the exemplar.

expected to find an additional effect of emotional intensity. To assess the emotional intensity of a negative item, participants also rated the affective experience evoked by each single item. If items high in emotional intensity are processed in an item-specific way, then mainly moderately negative items should show forgetting, whereas highly negative items should not. We also examined the influence of trait affect. A questionnaire was administered to measure participants' dispositional affective state. Because participants with a more negative affective style experience emotional stimuli more intensely (e.g., Davidson, 1998), the forgetting of negative stimuli may also depend on the dispositional affectivity of a participant, and high negative affectivity individuals may show reduced and low negative affectivity individuals enhanced forgetting.

## METHOD

### Participants

Sixty students (56 females; average age = 21.88) at the University of Regensburg participated in the experiment. They were tested individually.

### Materials

Four item lists were constructed, each consisting of three semantic categories, which contained eleven exemplars each. The exemplars and categories were selected from published norms (Mannhaupt, 1983). The chosen categories were *clothing*, *country*, *food*, *four-legged animal*, *liquid*, *means of transportation*, *occupation*, *part of the body*, *science*, *sports*, *traffic*, and *tool*. An item consisted of a picture of the exemplar and the exemplar name as a verbal descriptor to standardise stimulus verbalisation at retrieval. Within a category, no exemplar name began with the same letter to ensure that the initial letter could be used as a unique retrieval cue at test. Each category featured two different kinds of items, which differed only in the type of picture that was presented. Eight items of a category were non-critical items and two items served as critical items; the remaining eleventh item was used as a filler item. While for non-critical items the exemplar name was always paired with an emotionally neutral black-and-white picture of the exemplar, for each critical item three different types of pictures (neutral, distinctive, negative) were used.<sup>1</sup>

<sup>1</sup> One critical item had to be excluded from the study because recall for the negative version of this item was more than two standard deviations below recall for the neutral or distinctive version, revealing a poor fit between the negative picture and the denoted exemplar.

Figure 1 illustrates the material. The neutral and distinctive pictures showed the same illustration of the exemplar and were both perceptually neutral. The only difference was that the neutral version was presented in black-and-white while the distinctive version was presented in colour. The negative pictures showed a perceptually negative image of the exemplar and were also presented in colour. The pictures were mainly drawn from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999). The IAPS pictures were supplemented with pictures from other sources, because for some exemplars no adequate pictures were found in the IAPS. From the three categories of a list, one contained the critical items in the neutral version, one contained the critical items in the distinctive version, and one contained the critical items in the negative version. Distinctive items were included in the study to assess the emotional specificity of a possible effect of negative material, and to control for differences in recall levels between neutral and negative items.

To assess the emotionality of the neutral, distinctive, and negative critical items, participants were presented with the same stimuli again immediately after the experiment. A Likert-type rating scale was used ranging from 1 (*extremely negative*) to 9 (*extremely positive*) and participants were asked to indicate the emotional intensity of each single item. To examine the extent to which the prior study and test of the items affected participants' emotionality ratings, the pictures were additionally presented to an independent sample of 60 individuals who also rated the pictures. To measure the dispositional affectivity of a participant, the trait version of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was applied. The PANAS represents the dispositional positive and negative affect of a person on two scales ranging from 1 (*very slightly*) to 5 (*extremely*).

## Design

A  $3 \times 2$  design was used with the within-participants factors of Item Type (neutral, distinctive, negative) and Retrieval Practice Status (practice, no practice). Both the practice and the no-practice condition consisted of three main phases: a study phase, an intermediate phase, and a test phase; the two conditions differed only in the intermediate phase. In the initial study phase, participants were always presented with one list for study, which they had to recall in the final test phase. In the intermediate phase, there was either a retrieval-practice task in which participants were asked to recall to-be-practiced items, or a distractor task of equal duration. For each participant, two lists were assigned to the practice condition and two lists were assigned to the no-practice condition. The order of the two conditions was counter-balanced across participants. The assignment of the single lists to the two

conditions and the assignment of the neutral, distinctive, and negative pictures to the critical items were balanced across participants, so that each list and each version of a critical item served equally often in each condition. Participants were presented all four item lists within one experimental session.

## Procedure

Figure 1 provides an overview of the general procedure.

*Study phase.* The items of a list were displayed on a computer screen for 5 s together with their category name. The picture of an exemplar was presented in the middle of the screen, the name of the category was displayed above the picture, and the name of the exemplar was displayed below the picture. The participants were instructed to memorise the exemplars for a later memory test. The order of presentation within a list was determined by blocked randomisation. A random sequence of ten blocks each consisting of one randomly selected exemplar from each of the three categories was presented to the participants with the restriction that a critical item was followed by at least three non-critical items. The study list started always with the presentation of the three filler items. After presentation of a list's last item, the participants fulfilled a distractor task for 30 s in which they were asked to count backward from a three-digit number.

*Intermediate phase.* In the practice condition, the participants were told that some of the previously presented items would be tested orally several times by a word stem cued recall test. For each participant, four non-critical items from each of the three categories were selected and were retrieval practiced in three consecutive trials. To ensure that only non-critical items were practiced, the two initial letters of the name of the to-be-practiced exemplars were presented together with their category name. Participants were asked to remember the exemplars and to name the corresponding verbal descriptor. Each of the word stems was presented for 4 s. The selection of the non-critical items was balanced across participants, so that each non-critical item served equally often as a to-be-practiced item. The order of the stems was determined by blocked randomisation. For each of the three practice trials, one block was composed that contained all to-be-practiced items. The order within a block followed a random sequence of four sub-blocks, which each consisted of one randomly selected non-critical item from each of the three categories. In the no-practice condition, the retrieval-practice task was replaced by a distractor task of equal duration in which the participants were asked to solve simple arithmetic problems. In both the practice and the no-practice condition, another 2 min distraction task followed, which consisted of a simple reaction-time task.

*Test phase.* In the final test phase, the participants were presented with the first letter of the name of each studied exemplar together with its category name and were instructed to recall the corresponding item. The participants were again tested orally and were asked to name the verbal descriptor of a remembered exemplar. Each letter was provided for 4 s. The order of presentation was blocked by category. To control for output interference, the unpractised items of practised categories were always tested first within a category. Additionally it was ensured that after the testing of a critical item at least two non-critical items were tested to control for possible carry-over effects of emotions induced by the recall of a negative critical item. Apart from these restrictions, the presentation of the initial letters was randomised. After completion of the test phase and a 1 min break, the next list was presented.

## RESULTS

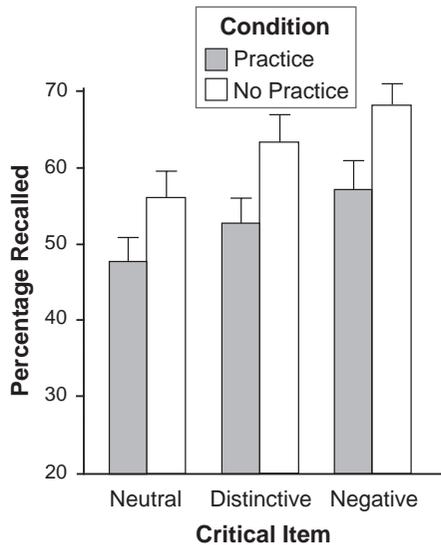
### Affective ratings

The three types of critical items (neutral, distinctive, negative) varied reliably in their emotional ratings, as indicated by the ratings of the participants and the independent participant sample. A 3 (Item Type: neutral, distinctive, negative)  $\times$  2 (Rating Group: experimental sample, independent sample) analysis of variance (ANOVA) revealed a significant effect of Item Type,  $F(2, 44) = 403.5$ ,  $MSE = 0.490$ ,  $p < .001$ ,  $\eta^2 = .29$ , no main effect of Rating Group, and no interaction between the two factors,  $F_s < 1$ . Additional pairwise comparisons showed that distinctive items were experienced as slightly more positive than neutral items (neutral:  $M = 5.3$ , distinctive:  $M = 5.6$ ),  $F(1, 22) = 9.7$ ,  $MSE = 0.116$ ,  $p < .01$ ,  $\eta^2 = .31$ , and negative items ( $M = 1.9$ ) were rated as much more negative than neutral items,  $F(1, 22) = 386.0$ ,  $MSE = 0.349$ ,  $p < .001$ ,  $\eta^2 = .95$ , and distinctive items,  $F(1, 22) = 595.9$ ,  $MSE = 0.270$ ,  $p < .001$ ,  $\eta^2 = .96$ .

### Recall rates for critical and non-critical items

For non-critical items, the two typical effects of retrieval practice arose. Recall of practised non-critical items increased from 53.0% in the no-practice condition to 79.0% in the practice condition, whereas recall of unpractised non-critical items declined to 45.0% in the practice condition. Both the facilitation and the impairment were significant,  $F(1, 59) = 218.3$ ,  $MSE = 0.009$ ,  $p < .001$ ,  $\eta^2 = .79$ , and  $F(1, 59) = 18.0$ ,  $MSE = 0.010$ ,  $p < .001$ ,  $\eta^2 = .23$ .

Figure 2 depicts recall rates for the three types of (unpractised) critical items, in the practice and the no-practice condition. A 3 (Item Type: neutral, distinctive, negative)  $\times$  2 (Retrieval Practice Status: practice, no practice)



**Figure 2.** Mean item recall and standard errors of critical items in the final test as a function of Item Type (neutral, distinctive, negative) and Retrieval Practice Status (practice, no practice).

ANOVA revealed a significant main effect of Item Type,  $F(2, 118) = 5.5$ ,  $MSE = 0.061$ ,  $p < .005$ ,  $\eta^2 = .09$ , indicating that negative items were remembered better than neutral items,  $F(1, 59) = 11.1$ ,  $MSE = 0.030$ ,  $p < .005$ ,  $\eta^2 = .16$ , and a significant main effect of Retrieval Practice Status,  $F(1, 59) = 11.7$ ,  $MSE = 0.077$ ,  $p < .001$ ,  $\eta^2 = .17$ , indicating that recall was worse in the presence than absence of retrieval practice. There was no interaction between the two factors,  $F(2, 118) < 1$ . Additional pairwise comparisons revealed that overall recall rates for negative and distinctive critical items did not differ significantly,  $F(1, 59) = 1.9$ ,  $MSE = 0.061$ ; the difference in overall recall between neutral and distinctive items was marginally significant,  $F(1, 59) = 3.7$ ,  $MSE = 0.062$ ,  $p = .06$ ,  $\eta^2 = .06$ .

### Role of emotional intensity

To analyse the effect of the emotional intensity of a negative critical item, the mean emotionality rating of a negative item was determined across all participants. Mean emotional intensity ranged from 1.10 to 2.70. Participants' ratings of the stimuli correlated well with the ratings obtained from the sample of independent raters,  $r = .86$ ,  $p < .001$ , indicating that the participants' ratings were not substantially affected by the previous study and recall of the stimuli. To determine the amount of retrieval-induced forgetting of each single item, the mean recall rates for a critical item in the

practice and the no-practice condition were calculated across all participants and the recall score in the practice condition was subtracted from the recall score in the no-practice condition. Correlating the mean intensity ratings for the negative items with the amount of forgetting observed for the items revealed a positive relationship,  $r = .44$ ,  $p < .05$ , indicating that the forgetting decreased with an increase in emotional intensity (note that high emotional intensity is reflected in low rating values; see method section). Intensity, however, was not correlated with the amount of forgetting observed for the same exemplars in the neutral and distinctive versions,  $ps > .35$ , suggesting that the effect was emotion specific and not the result of other differences between the exemplars.<sup>2</sup>

### Role of dispositional affectivity

As indicated by the negative affect scale of the PANAS, the participants varied substantially in dispositional negative affect. The ratings ranged from 1.40 to 3.60 with a mean of 2.53 and a standard deviation of 0.43. To analyse the effect of trait affect on amount of forgetting of negative items, for each participant, we determined the amount of forgetting of the negative critical items. To take into account that participants had seen different negative pictures under practice and no-practice conditions, for each participant, recall of the critical items in the practice condition was subtracted from mean recall of the same critical items in the no-practice condition, as averaged from recall performance of those participants to whom these items were presented in the no-practice condition. Correlating the ratings on the negative affect scale of the PANAS with the individual forgetting rate revealed a negative relationship,  $r = -.28$ ,  $p < .05$ , indicating that individuals with higher dispositional negative affectivity showed less forgetting for negative items. The ratings of the negative affect scale of the PANAS were uncorrelated with the amount of forgetting observed for both the neutral and the distinctive version of the critical items,  $ps > .15$ , indicating that the dispositional mood state did not affect the ability to forget neutral items.

### Interactions between emotional intensity and dispositional affectivity

To examine possible interactions between emotional intensity and dispositional affectivity, we regressed the amount of forgetting observed for a single

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<sup>2</sup> The same relationships between emotional intensity and forgetting arose when using the ratings obtained from the independent sample. Again, intensity was positively correlated with the amount of forgetting observed for negative critical items,  $r = .43$ ,  $p < .05$ , and uncorrelated with the amount of forgetting observed for both the neutral and the distinctive versions of the items,  $ps > .50$ .

negative item onto the mean intensity rating for the item, the dispositional affectivity of a participant, and their cross product. The analyses revealed significant effects for mean intensity rating ( $\beta = .16$ ,  $t = 2.50$ ,  $p < .01$ ) and dispositional affective state ( $\beta = -.17$ ,  $t = -2.59$ ,  $p < .01$ ), but no significant interaction ( $\beta = -.06$ ,  $t = -0.99$ ,  $p = .33$ ), indicating that the two factors affected the forgetting independently.

The finding that trait affect influences the amount of forgetting of negative items may be related to stronger reactions of participants with a more negative affective style to negative items. To examine whether the degree of dispositional negative affectivity affected how intensely the negative items were experienced, the ratings on the negative affect scale of the PANAS were correlated with a participant's mean intensity rating of the negative critical items. The resulting marginal significance of the correlation,  $r = -.23$ ,  $p = .08$ , indicates that participants high in dispositional negativity tended to experience the negative items more intensely.

## DISCUSSION

Prior work reported evidence that the repeated retrieval of a subset of negative stimuli impairs later recall of related negative stimuli to the same degree as is typically found for neutral material (Barnier et al., 2004; Wessel & Hauer, 2006). In contrast to this prior work, in the present study participants retrieved only neutral items during retrieval practice. This was done to prevent negative mood states due to repeated retrieval of negative material and thus prevent resulting possible influences of mood on the amount of forgetting. The present finding that, on average, the forgetting of negative items does not differ from the forgetting of neutral items therefore demonstrates more clearly than prior work that, on average, the emotionality of material does not affect retrieval-induced forgetting.

While, on average, negative and neutral items do not seem to differ in their susceptibility to retrieval-induced forgetting, the present results suggest that there are exceptions to this rule. The one exception has to do with the emotional intensity of the negative material. The correlational analyses showed that the amount of forgetting observed for negative items decreased with increased emotional intensity. The second exception has to do with the dispositional mood state of a participant. On the basis of the results from the PANAS questionnaire, the correlational analyses showed that the amount of forgetting observed for negative items decreased for participants with high dispositional negative affectivity.

In recent work, Bäuml and Kuhbandner (2007) reported evidence that mood experienced during retrieval practice can affect retrieval-induced forgetting. Using IAPS pictures to induce positive and negative moods, they

reported retrieval-induced forgetting when positive moods were experienced and no retrieval-induced forgetting when negative moods were experienced. These findings on the role of mood in retrieval-induced forgetting contrast with previous results on the role of the emotionality of material (Barnier et al., 2004; Wessel & Hauer, 2006): While negative mood can eliminate the forgetting, negative material did not affect the forgetting (see also Figure 2). The present results for very negative material and participants with high dispositional negative affectivity indicate that this contrast is a simplification and that both material and dispositional negative affectivity may influence the forgetting as well.

Concerning the effects of mood on retrieval-induced forgetting, it has been argued that the experience of negative moods during a retrieval attempt may induce item-specific processing of the material, thus reducing interference from related events and eliminating the later forgetting (Bäuml & Kuhbandner, 2007). The reduction of retrieval-induced forgetting for very negative items may be mediated by similar processes. Highly emotional items attract attention and are prioritised for processing, leading to an item-specific processing of such items (Kensinger, 2004). As a result, highly negative stimuli may have only weak relations to other episodes stored in memory, which should minimise their interference potential during the selective retrieval of other stored episodes and thus protect them from inhibition and later forgetting. Thus, item-specific processing may mediate the detrimental effects of both negative material and negative mood on retrieval-induced forgetting.

In the present study, we did not include items with a positive emotional content. Thus, we can draw no conclusions on whether the reduction of retrieval-induced forgetting observed for items experienced as very negative occurs for intense emotional material in general. Because several studies indicate that a strong memory advantage is found for both negative and positive episodes (e.g., Reisberg & Heuer, 2004), one might like to speculate that also items experienced as very positive may fail to show retrieval-induced forgetting (cf. Wessel & Hauer, 2006). However, there is evidence that positive and negative items differ in the awareness accompanying remembering (e.g., Ochsner, 2000), which suggests that they may be encoded differentially. Future work should examine whether the present effect of negative emotional content on retrieval-induced forgetting generalises to positive material.

Another limitation of the present study is that our sample did not include participants with extremely strong dispositional negative affect, as may be found in clinical samples. Depressive participants and individuals with general social phobia have been reported to show deficits in the forgetting of negative contents (Amir, Coles, Brigidi, & Foa, 2001; Moulds & Kandris, 2006). In view of the present findings, one might speculate that the inability

to forget is caused by the enhanced sensibility of those clinical populations for negative materials. However, a number of alternative explanations arise, like the suggestion that clinical and non-clinical samples may differ in their ability to inhibit negative material. Further work is needed to address the issue in more detail.

In sum, while negative moods can eliminate retrieval-induced forgetting (Bäuml & Kuhbandner, 2007), negative material often does not differ in forgetting from neutral material. Exceptions from this rule seem to occur when very negative material is encoded or when participants show a strong dispositional negative affectivity. In these cases, item-specific processing of the material may be enhanced and retrieval-induced forgetting be reduced. These results complement findings from prior work, in which it was shown that emotions can influence memory facilitation (e.g., Reisberg & Heuer, 2004), and demonstrate that emotions can also influence the forgetting of material.

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