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Depression-related differences in learning and forgetting responses to unrelated cues

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Abstract

Using the think/no-think paradigm, we examined the effect of a meaningful connection between emotionally neutral cues and targets on initial learning and later recall by students in dysphoric or nondysphoric mood states. Compared to meaningfully connected cue-target pairs, unrelated pairs were less easily learned and more easily forgotten, even when initial learning was controlled. Depressive deficits were obtained in initial learning (only marginally) and final recall. When examined separately within each cuing condition, the recall deficit associated with depressed mood was restricted to the unrelated condition, but when initial learning differences were controlled this deficit was only marginally significant. Results are discussed in relation to other recent findings concerning depression-related performance in this paradigm and to findings of depression and memory more generally.

PsycINFO classification: 2343

Keywords: Learning; Memory; Forgetting; Depression; Dysphoria

In most common uses of the term, forgetting is a passive act in that it occurs regardless of intention due to neglect, the poverty of initial learning, or interference from other mental acts (see the reviews by Anderson & Neely, 1996; MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). In contrast, recent research in cognitive psychology has investigated processes responsible for active forgetting—forgetting facilitated by the intention to suppress thoughts (see Levy & Anderson, 2008; Levy & Anderson, 2002). Laboratory approaches to the study of active forgetting include the think/no-think (TNT) paradigm developed by Anderson and Green (2001).[1] Participants first learn cue-target pairs (e.g., *ordeal-roach*) to a certain criterion, then practice cued recall of some targets and cued suppression of others, and ultimately try to remember all targets on a final test of cued recall. The TNT paradigm is designed to investigate forgetting as a function of the number of attempts at suppression, but as in any other paradigm passive forgetting also occurs. This distinction between passive and active forgetting has interesting implications for research on depression and memory. People who are depressed experience memory impairments (i.e., passive forgetting) that seem largely due to deficient cognitive control. Because the active disregard of targets requires such control, are depressed people likely to forget less well in this more active sense? The answer is not yet clear.

Considerable research supports the conclusion that deliberate remembering is impaired in depressed states (see the review by Burt, Zembar, & Niederehe, 1995). The impairment has been conceptualized as a resource deficit, because it occurs following more effortful learning tasks (see Ellis & Ashbrook, 1988; Weingartner, Cohen,

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[1] Recently, Anderson (2005) has argued that the TNT paradigm represents only intermediate levels of intention to forget, because participants are not instructed to forget the targets. Some might interpret suppression instructions as a "momentary" intention. Nevertheless, the paradigm comes closest to encouraging active forgetting of individual thoughts.

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Murphy, Martello, & Gerdt, 1981). Because it has been observed more frequently under conditions of loose external control, Hertel and colleagues have framed the impairment in terms of deficient cognitive control or initiative (see Hertel, 2000). Depressed individuals remember well when their attention has been focused by task demands on the use of beneficial and even effortful procedures; they remember poorly when the structure of the task permits but does not guide the use of such procedures. A similar truth might characterize active forgetting in depression; deficits in forgetting should be found only when the task does not guide the use of procedures important to later forgetting. Moreover, thought suppression is a good example of a cognitive act that is poorly guided by the environment or the task; one tries to not think a thought in the presence of thought-inducing cues (see Wenzlaff & Wegner, 2000). Thus, under various conditions that benefit from self-control, depression should enable passive forgetting and impair active, suppression-induced forgetting.

The rationale for the present experiment emerged from disparate findings concerning suppression-induced forgetting in depressed states, obtained in the think/no-think (TNT) paradigm. Hertel and Gerstle (2003) reported depression-related deficits in forgetting, anticipated on the basis of deficient cognitive control, whereas Joormann, Hertel, Brozovich, and Gotlib (2005) found a very strong depression-related advantage in forgetting emotionally negative targets. Beyond their reliance on the general features of the TNT paradigm, the research designs differed in several ways (e.g., the type of depressed sample, the number of trials during the TNT phase), and the present experiment was designed to bring some of these differences under experimental control. In particular, we considered the nature of the learning task and the cue-target relation, due to their relevance to cognitive control.

Like Anderson and Green (2001) and Joormann et al. (2005) used ostensibly unrelated nouns as cue-target pairings, and the targets to be suppressed were either emotionally negative or positive (e.g., *ketchup slum* or *ketchup sunrise*). In contrast, Hertel and Gerstle (2003) used related adjective–noun pairs (e.g., *gloomy cottage* or *romantic cottage*). Compared to Joormann et al.'s task of memorizing unrelated words, Hertel and Gerstle's (2003) orienting task more likely controlled the focus of attention during the learning phase; participants were asked to involve themselves in images of integrated events (e.g., imagine themselves in a gloomy cottage). To keep them on task, the procedure requested ratings of meaningfulness. Therefore, the two procedures should produce differences in initial learning, with a depression-related deficit more likely in the experiment by Joormann et al. Moreover, when targets are learned less well initially they should be forgotten more readily (passively) at the time of the final test; such passive forgetting might confound the evidence of active forgetting.

The subsequent TNT phase in both experiments required self-control of attention away from the targets to be suppressed. Arguably, however, the control of attention away from self-related images or thoughts well integrated with the cues (e.g., *gloomy*...) is more difficult than is the control of attention away from targets ostensibly unrelated to the cues (*ketchup*...). Active forgetting should be facilitated in the latter case. In short, we would expect greater passive and active forgetting of materials used by Joormann et al., compared to materials used by Hertel and Gerstle, on the basis of the degree of control required during the learning and TNT phases. Among all groups in both experiments, Hertel and Gerstle's depressed participants should recall the greatest number of suppressed targets on the final test. In fact, they did.

We now report an initial investigation of these hypotheses concerning passive and active forgetting, adjusted to a situation that involves only neutral materials. In this experiment, neutral materials were chosen to optimize learning deficits, which are often not found with emotionally negative materials (see Matt, Vazquez, & Campbell, 1992). Also, very practically, the conditions could not be directly compared if we used the original valenced materials, because the valence belonged to the pairs in one study and the targets alone in the other study.

The design of the experiment we report varied the relatedness between cues and targets, together with instructions for learning them. In the related condition, we used the adjective–noun pairs from Hertel and Calcaterra (2005, e.g., *stone cottage*) and instructions to construct and rate meaningful mental images. In the unrelated condition, we used the same targets, together with the neutral nouns that served as cues for Joormann et al. (2005), and instructions merely to learn the pairs. The unrelated condition, therefore, constituted a poorly controlled learning task, performance on which should rely on self-controlled attention. In contrast, the related condition provided better guidance about what should be done on each trial. We predicted poorer performance on initial learning tests in the unrelated condition and a depression-related impairment only in that condition.

The main question, however, concerned the extent to which those learning differences would masquerade as evidence for active forgetting on the final test. In the related condition, we did not expect to find a depression-related impairment in forgetting neutral materials. Hertel and Calcaterra (2005) found that dysphoria was not associated with differential difficulty in the control of attention away from neutral related targets during the TNT phase; both mood groups recalled quite well (or forgot poorly). In the unrelated condition, however, we predicted that a dysphoria-related deficit in initial learning would carry over to final test performance and confound evidence typically interpreted as active forgetting.

1. Method

1.1. Materials

1.1.1. Target nouns

The 36 targets used in both cuing conditions (related and unrelated) were taken from Hertel and Calcaterra (2005). As shown in the Appendix, all targets were 4–7 letters long. Concreteness and imageability ratings were greater than 5.0 (on 7-point scales from Paivio, Yuille, & Madigan, 1968). Emotionality ratings were less than 4.0, and goodness (valence) ratings between 3.0 and 5.0 (on 7-point scales from Rubin & Friendly, 1986). Average frequency of occurrence was 68.2 (Kucera & Francis, 1967).

1.1.2. Cues

In the related condition, the targets were cued with the accompanying related adjectives used by Hertel and Calcaterra (2005). Ratings of the emotional valence of the cue/target pairs fell between 3.5 and 5.0 (on a 9-point rating scale ranging from extremely positive to extremely negative; Hertel & Parks, 2002). In the unrelated condition, nouns used as cues by Joormann et al. (2005) were paired nonmeaningfully with the targets. The emotionality ratings of those nouns ranged from 4.8 to 6.1 (on the 9-point scale used by Bradley & Lang, 1999).

1.1.3. Lists

The 36 triplets (related-cue/unrelated-cue/target) comprised six sets of 6 triplets each. The sets were balanced on length, concreteness, imageability, emotionality, valence, and the frequency of the targets, and the valence ratings for the related pairs and the unrelated nouns. The six sets rotated across the six cells of the within-subjects design: instruction (suppress vs. respond) by the number of cue presentations (0, 2, or 12). Seven filler triplets were constructed similarly.

1.2. Participants

Participants were selected from students enrolled in an introductory psychology course at Trinity University who had completed the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996) in class. Students with a BDI score less than seven were considered nondysphoric, and students with a BDI score greater than 11 were considered dysphoric. Without their knowledge of the connection between the BDI and the selection for the study, they were randomly assigned to a combination of cue type (related vs. unrelated) with a materials factor (the rotation of sets across within-subjects conditions), subject to the constraint of equal cell size.

Of the 102 students recruited for the experiment, the data from 18 were not included in the analysis due to disqualifying end-of-session BDI scores (6 from the related condition and 12 from the unrelated). An additional 12 participants assigned to the unrelated condition did not complete the experiment, because they were unable to reach the criterion of 50% correct by the end of the fourth learning test (as in Anderson & Green, 2001). Half of those were dysphoric. The final sample consisted of 18 dysphoric and 18 nondysphoric students in each cuing condition; within that combination, 3 students received each of the six materials assignments. Independently, 10 students in each cell were female and 8 male. The mean BDI-II score at the end of the experimental session was 3 in the nondysphoric group and 18 in the dysphoric group. The means did not differ significantly according to participants' assignment to cue type.

1.3. Procedure

All phases of the experimental session were implemented with Superlab Pro software (Version 2.04, Cedrus Corp.). Decisions about ordering of materials and timing of displays were based on those used by Hertel and Calcaterra (2005).

1.3.1. Learning phase

Cue/target pairs were ordered by randomized block design (six blocks each containing one pair from each of the six sets); three filler pairs were placed at the beginning of the list, three at the end, and one filler pair in the middle between the third and fourth blocks. Each pair was presented in black font on a light background for 5 s each. Participants in the related condition were instructed to form a mental image involving themselves and the words in each pair. Following each pair display, "How personally meaningful was the image you created?" appeared on the screen, and participants reported aloud a rating from 1 to 5 (not at all meaningful to very meaningful). The rating was keyed by the experimenter. Participants in the unrelated condition were simply told to try to learn the word pairs, so that they could later recall the target when given the cue.

Next, initial learning levels were assessed by presenting the cues and requesting target recall. Each cue was presented in black for 5200 ms, and participants were instructed to say the corresponding target aloud as quickly as possible. Then the target was presented in blue font for 2 s, regardless of the participant's response. Participants who recalled at least 50% of the targets correctly moved on to the next phase. Those who recalled fewer than 50% were retested with a new order until the criterion of 50% correct was reached or until they failed the fourth test. In the latter case, participants were told that a computer error had occurred, and they were dismissed.

1.3.2. TNT phase

For 18 practice trials and 240 actual trials, participants were presented with 3-s cues that were either red or green. When the cue was green, they were instructed to say the corresponding target aloud as quickly as possible. Errors were followed by the presentation of the target in blue font for 500 ms; correct responses led immediately to the next trial. When the cue was red, participants were instructed to avoid saying or thinking about the target, although it was very important to attend to the cue itself. If they responded to a red cue, a series of very large red X's was briefly presented on the screen. Trials began with a 200-ms display of small plus signs and were separated by a 400-ms blank screen.

In the practice phase, six filler cues appeared in green two times each and one filler cue appeared in red six times. Trials were randomly ordered. A short questionnaire about the practice set provided the context for questions and corrections. In the actual TNT task, two 6-cue sets were not presented; these cues provided baseline data on the final test. The cues from two other sets were presented twice each (one set in green and the other in red), and the cues from the remaining two sets were presented 12 times each. Six filler cues were also presented 12 times each, all in green. These cues were randomly ordered, with the constraint that all cues in any set were presented before the next iteration could begin.

1.3.3. Final test phase

On the final test of cued recall, all cues were presented in black font, and the participants were instructed to recall each target aloud. The constant order consisted of four filler cues, followed by six randomized blocks of one cue from each of the six sets. Following a 200-ms display of plus signs, the cue was displayed for 4 s, and it was followed by a 400-ms blank screen. No feedback was given. Participants were told that it was now important to recall all targets from the first part of the experiment, regardless of prior instructions. Following the test, participants filled out another BDI, which was subsequently used to determine whether they remained in the same mood category in which they were recruited.

2. Results and discussion

2.1. Initial learning

The percentages of the 36 targets produced on the first learning test were submitted to an analysis of variance (ANOVA), with between-subjects factors for mood group (nondysphoric vs. dysphoric) and cue type (related vs. unrelated) and a within-subjects factor for the status of the item during the TNT phase (baseline, respond, or suppress). To reduce error variance in this and subsequent analyses, we also included a between-subjects factor for the materials assignment and do not report associated differences. The significance level was set at 0.05 for all analyses.

Targets were produced more often in response to related than to unrelated cues ($M = 66$ vs. 47), $F(1,48) = 15.40$, $\text{MSE} = 1242.98$, $p < 0.001$, $\eta_p^2 = 0.24$. There was also a marginally significant tendency for the dysphoric students to learn less well ($M = 52$ vs. 61), $F(1,48) = 3.48$, $p = 0.068$, $\eta_p^2 = 0.07$. The difference between the groups was more extreme in the unrelated condition, but not significantly so, as seen in Fig. 1. The only remaining significant effect was the main effect of item status, $F(2,48) = 3.54$, $\text{MSE} = 133.73$, $p = 0.033$, $\eta_p^2 = 0.07$. Items destined for baseline testing were initially learned less well ($M = 53$) than items to be responded or suppressed during the TNT phase ($M = 57$ and 58, respectively).

Subsequent tests with feedback were administered when participants did not score above 50% on the first test. When performance on the participants' qualifying test constituted the dependent variable in the same analysis, none of the effects was significant, although a trend for a main effect of cue type remained, $F(1,48) = 2.83$, $\text{MSE} = 355.69$, $p < 0.099$, $\eta_p^2 = 0.06$. Finally, more feedback tests were required in the unrelated condition, ($M = 1.8$ vs. 1.1 related), $F(1,68) = 17.30$, $\text{MSE} = 0.462$, $p < 0.001$, $\eta_p^2 = 0.20$. To qualify, dysphoric participants took about the same number of tests as nondysphoric participants, regardless of the cue type.

In summary, regarding our first prediction about a learning deficit in dysphoria, there was a marginally significant trend for dysphoric participants to perform less well on the first test, although not on the qualifying test, and not to a greater degree in the unrelated condition.

Second, as a verification of the main manipulation, the related pairs were easier to learn, judging by the performance on the first test and a tendency for the same difference on the qualifying test, and by the number of tests required to reach criterion. And even further, the number of errors made in response to green (think) cues presented 12 times during the TNT phase also provide evidence of learning differences; they were more frequent in the unrelated condition than in the related condition ($M = 4.3$ vs. 1.1), $F(1,48) = 20.43$, $\text{MSE} = 9.306$, $p < 0.001$, $\eta_p^2 = 0.30$. In that regard, however, it is also important to realize that any errors made in response to green cues during the TNT phase were followed by another exposure of the target, which possibly compensated. Finally, the learning of baseline items was oddly more difficult than other items—a fact that should be taken into account in interpreting final recall.

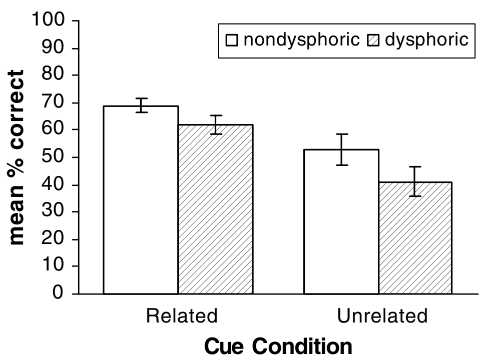

Fig. 1. Mean percentage correct on the first learning test. Bars represent one standard error from the mean.

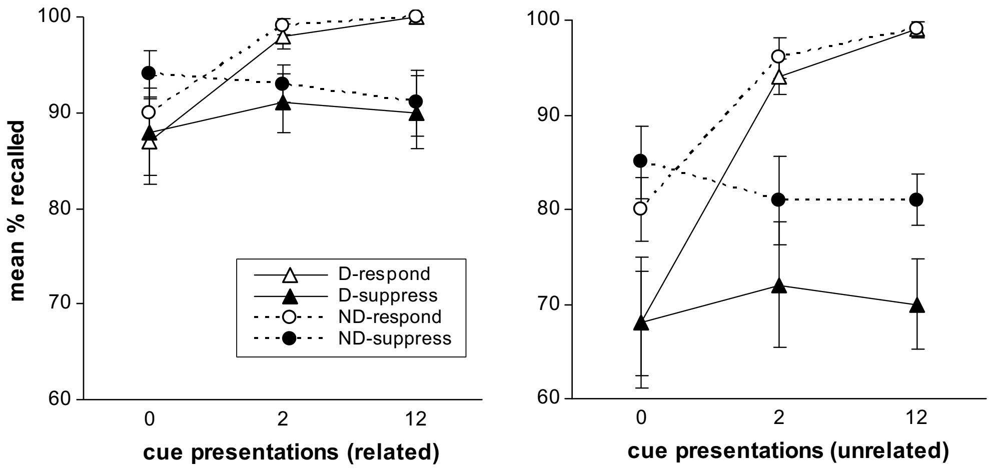

Fig. 2. Mean percentage of targets recalled on the final test by nondysphoric (dashed-line, circle) and dysphoric (solid-line, triangle) participants in the related (left panel) and unrelated (right panel) cue-target conditions. Unfilled points represent targets that were practiced during the TNT phase, whereas filled points represent targets that were suppressed. Bars represent standard errors.

2.2. Final recall: overall analysis

The percentages of the 36 targets recalled on the final test were submitted to a mixed-design ANOVA, with between-subjects factors for mood group (nondysphoric vs. dysphoric) and cue type (related vs. unrelated) and within-subjects factors for TNT instruction (respond or suppress) and the linear trend across the number of cue presentations during the TNT phase (0, 2, or 12). Evidence of suppression-induced forgetting in TNT experiments is typically assessed in two ways: through the interaction of instruction with the linear trend across the number of cue presentations and through separate tests of the linear trend across the number of cue presentations for suppressed targets only. Means are depicted in Fig. 2.

The main effect of mood group indicated that dysphoric participants recalled fewer targets on the final test ($M = 85$ vs. 91 by nondysphoric), $F(1,48) = 6.96$, $\text{MSE} = 414.72$, $p = 0.011$, $\eta_p^2 = 0.13$. Also, the three-way interaction of cue type, instruction, and the linear trend across cue presentations was significant, $F(1,48) = 6.57$, $\text{MSE} = 123.45$, $p = 0.014$, $\eta_p^2 = 0.12$. To follow up on that interaction, as well as to test specific predictions, we analyzed recall within the related and unrelated conditions separately.

2.3. Final recall: related pairs

In the related condition, as in results from Hertel and Calcaterra (2005), dysphoria was not a significant factor in recall ($M = 92$ vs. 94 for dysphoric and nondysphoric, respectively), $p = 0.358$. In this case, however, the lack of difference might have been constrained by ceiling-level recall. Regardless of group, TNT instruction (respond vs. suppress) significantly interacted with the linear trend across the number of cue presentations, $F(1,24) = 13.00$, $\text{MSE} = 100.31$, $p = 0.001$, $\eta_p^2 = 0.35$. The left panel of Fig. 2 shows that below-baseline recall was not obtained following practice in suppression; this outcome is not surprising, given the relation between cues and targets. Hertel and Calcaterra found below-baseline forgetting only when thought substitutes were provided during the TNT phase.[2] Nevertheless, the flat function across a number of presentations indicates that participants attempted to suppress targets; recall did not increase as a function of cue exposure as it did for the respond cues.

2.4. Final recall: unrelated pairs

In the unrelated condition, dysphoric participants recalled fewer targets ($M = 76$ vs. 87 for nondysphorics), $F(1,24) = 6.44$, $\text{MSE} = 582.53$, $p = 0.018$, $\eta_p^2 = 0.21$. This group difference was greater for suppressed targets than for responded targets, however, the interaction was only marginally significant, $F(1,24) = 3.73$, $\text{MSE} = 232.76$, $p = 0.065$, $\eta_p^2 = 0.14$. Again, regardless of group, TNT instruction significantly interacted with the linear trend across cue presentations, $F(1,24) = 39.81$, $\text{MSE} = 146.59$, $p < 0.001$, $\eta_p^2 = 0.62$. The right panel of Fig. 2 shows that this interaction is more extreme than the one obtained for related pairs (as evidenced by the significant three-way interaction). It also shows a slight tendency for below-baseline forgetting by the nondysphoric students, but one that did not approach significance. In this case, the failure to find below-baseline forgetting was unexpected, given that the materials and instructions were of the same type used by Anderson and Green (2001), who first demonstrated the effect.

[2] Hertel and Calcaterra (2005) also found below baseline forgetting by participants who were not given substitutes, if on a final questionnaire they reported complying particularly well with suppression instructions or (independently) using a strategy of thinking about something else. These correlations were not significant in the present experiment, possibly due to the constraints of near-ceiling levels of performance in final recall.

The pattern of means in the dysphoric group suggests that the failure to find below-baseline forgetting was associated with low levels of baseline recall—recall in response to cues that were not exposed during the TNT phase. And the low levels of baseline recall in dysphoria indicate that differences in learning might be responsible for the significant depressive deficit in final recall found in the unrelated condition.

2.5. Recall differences with learning differences controlled

To control for the relation between performance on tests of final recall and initial learning, we performed two regression analyses, the first across all participants in order to examine the effect of cue type, the second within the unrelated condition in order to examine dysphoria-related differences in that condition. The outcome variable in each analysis was the percentage of to-be-suppressed targets recalled on the final test.

In the first analysis, the percentage correct on the qualifying learning test (to-be-suppressed targets only) was entered first in the equation, a code for cue type second (1 = related, 2 = unrelated), and a code for mood group third (1 = nondysphoric, 2 = dysphoric). The percentage correct on the learning test was significantly correlated with final recall, $R^2 = 0.26$, $p < 0.001$. The increase in R^2 of 0.20 with the addition of the code for cue type was also significant, $F(1,69) = 24.96$, $p < 0.001$. And in the third step, the addition of the code for mood group produced a nonsignificant increase in R^2 of 0.02, $F(1,68) = 2.76$, $p = 0.101$. The full equation:

$$\% \text{ recalled} = 79.50 + 0.46(\% \text{ correct on learning test}) - 13.44(\text{cue code}) - 4.40(\text{group code}).$$

Forgetting on the final test was exaggerated in the dysphoric group, beyond differences in original learning and detriments from unrelated cues, but not significantly so.

In the second analysis, restricted to data in the unrelated condition, the percentage correct on the qualifying test was entered first and a code for mood group was entered second. Again, the percentage correct on the learning test was significantly correlated with final recall, $R^2 = 0.28$, $p = 0.002$. The 0.07 increase in R^2 with the addition of the mood code was marginally significant, $F(1,33) = 3.35$, $p = 0.076$. Dysphoric participants tended to recall fewer targets on the final test, beyond what would be expected on the basis of initial level of learning. The full regression equation:

$$\% \text{ recalled} = 50.38 + 0.57(\% \text{ correct on learning test}) - 8.12(\text{group code}).$$

Finally, we examined correlations between the percentage correct on the qualifying learning test and percentage correct on the final recall test within each mood group in the unrelated condition (suppressed targets only). Final recall and initial learning should be positively correlated to the extent that final recall is uninfluenced by processes operating beyond initial learning, namely attempts to avoid thoughts of targets during suppression trials. In other words, if equally well-learned items receive differential suppression practice, the correlation should be low. Indeed, final recall correlated with initial learning nonsignificantly in the nondysphoric group ($R^2 = 0.09$, $p = 0.233$), but significantly in the dysphoric group ($R^2 = 0.42$, $p = 0.003$). These correlations suggest differential cognitive control by the two mood groups during the TNT phase.

3. General discussion

3.1. Present results

The primary purpose of this experiment was to discover if depression-related differences in initial learning would masquerade as successful active forgetting. Our prediction regarding a depression-related learning deficit in the unrelated condition was minimally supported. Dysphoric participants tended to perform less well on the first learning test, but not significantly more so in the unrelated condition. This trend for a learning difference disappeared as participants were given more chances to learn with feedback. Although deficits have been found when BDI scores are even lower on average than in the present experiment, clearer evidence would likely be obtained from a clinical sample (see Burt et al., 1995).

Dsyphoric participants in the unrelated condition recalled significantly fewer words on the final test. In that condition, a trend toward lower recall in dysphoria remained after controlling for the association of final recall with performance on the qualifying learning test, and this trend might be seen as superior active forgetting. Alternatively, this trend might have resulted from learning differences that were not reflected in performance on the qualifying learning test, due to its possible lack of sensitivity, or to a steeper passive forgetting function for items less well learned. The low level of performance on baseline trials is consistent with the latter possibilities. Thus, the more conservative interpretation of our results favors passive over active forgetting by dysphoric participants in the unrelated condition.

A conclusion in favor of passive forgetting is also supported by the correlations between qualifying performance and final recall within the unrelated condition. Initial learning did not significantly predict final recall by nondysphoric students, presumably because thought suppression occurred differentially across similarly well-learned (or similarly poorly-learned) pairs. That initial levels of learning did significantly predict final recall by the dysphoric students suggests that they suppressed less successfully.

Other factors might also have influenced recall by dysphoric participants in the unrelated condition without implicating superior cognitive control. In particular, if dysphoric participants were engaged in mind wandering or ruminative thought (Nolen-Hoeksema, 1991), they might not have attended completely to the red cues and could thereby sidestep the need to suppress targets. And if so, they would have trouble refocusing attention during the test of final recall, when such refocus was requested (for a related finding see Hertel, 1998). In the related condition, however, the cues on the final test would provide a sturdier bridge back to the originally well-learned targets. Based on these possible interpretations—initial-learning deficits or a mind-wandering set during TNT—we suggest that the evidence for successful forgetting by our dysphoric sample is compatible with a framework emphasizing reduced cognitive control in depressed states (Burt et al., 1995; Hertel, 2000) and incompatible with a claim of superior self-control of attention. Clearly warranted, further research on the issue of controlled forgetting should employ more sensitive measures of initial learning instead of those typically used in the TNT paradigm. Also, as Anderson (2005) suggested, future uses of the TNT paradigm might incorporate explicit instructions to forget.

Finally, from outcomes that ignore participants' mood states we learned that the manipulation of meaningful relation between the cues and their targets produced clear effects on performance in the first learning test, the qualifying learning test (a trend), respond trials during the TNT phase, final recall of suppressed targets, and final recall in general after allowing for the relation between learning and recall. Obviously, suppression practice is more successful when the connection between the cue and the target is less meaningful and less well learned at the outset. Inversely speaking, a cue that is part of an image related to the self is more effective in reinstating the corresponding target, regardless of the degree of initial learning, and thoughts of the target are harder to avoid during attempts to suppress.

Active forgetting under real-world conditions analogous to our related condition is not as impossible as our results might imply. Hertel and Calcaterra (2005) found that below-baseline forgetting of related targets was successful when thought substitutes had been used during the TNT phase. Substitutes can be used effectively, particularly if they are closely related to the cues but not to the targets (see Anderson & McCulloch, 1999).

More generally, suppression practice in both conditions of our experiment produced forgetting only in the sense that targets associated with cues presented 12 times were not recalled more frequently than those not presented during the TNT phase. In other words, memory for these targets was not aided by the frequent presentation of reminders. At best, we have provided weak evidence of suppression effects. Stronger support comes in the form of below-baseline forgetting, which was not significant in any condition of our experiment, although nondysphoric participants produced differences in the appropriate direction. (For other failures to find below-baseline forgetting, see Bulevich, Roediger, Balota, & Butler, 2006.) Even more generally, we should avoid the temptation to believe that evidence produced in TNT experiments has direct relevance for the repression of memories for entire events (see Hayne, Garry, & Loftus, 2006). Application of findings in this paradigm is better suited to the management of brief thoughts associated with cues provided by the environment.

3.2. Relation to other research on suppression and forgetting in depressed states

The first published study on intentional forgetting in depression employed the directed-forgetting paradigm (Power, Dalgleish, Claudio, Tata, & Kentish, 2000). In this paradigm, a word list is presented, and midway through the list some participants are told to forget the preceding "practice" words and concentrate on learning the words to come; following a filler task, all participants are asked to recall all words. Power et al. found that participants diagnosed with major depressive disorder (MDD) recalled more negative than positive words that they had been instructed to forget. This outcome is compatible with the cognitive control framework, because it suggests that the depressed participants experienced difficulty in switching attention away from mood-congruent but task irrelevant material. However, compared to the TNT paradigm, the directed-forgetting paradigm places less emphasis on cognitive self-control. Forgetting happens passively, presumably because the participants no longer rehearse material that has been declared irrelevant, whereas in the TNT paradigm, turning attention away from explicit retrieval cues is practiced repeatedly as a more active, possibly inhibitory process (see Levy & Anderson, 2002).

In the first published TNT study concerning depressed states, Hertel and Gerstle (2003) also exposed participants to positive and negative material, but asked them to form self-involving images in the same kind of task that we used in the related condition of the current experiment. These dysphoric students had relatively greater difficulty in forgetting both negative and positive pairs. Thus, the results implicate a general deficit in attentional self-control during the TNT phase, at least in the suppression of emotional materials. Like the results from Hertel and Calcaterra (2005), the results from the related condition in the present study do not show this deficit, possibly because our materials were not emotional and therefore not harder for dysphoric participants to avoid. (Also notable is the generally high level of recall by all participants in our related condition, which might obfuscate possible deficits.)

In the only published TNT study with MDD participants, the target words used by Joormann et al. (2005) were either emotionally negative or positive. Otherwise, the method was similar to the present method in the unrelated condition. Following the suppression of negative targets, their results were also similar to our results, in that depressed participants' baseline recall was significantly lower than in other conditions. Joormann et al. reported no evidence of learning differences although, as was suggested regarding the current results, the measure of learning might have been insufficiently sensitive to detect such differences. Regardless of possible learning differences, however, Joormann et al. found below-baseline forgetting of unrelated negative targets by MDD participants (not the flat function found in the present report). These participants clearly did not divert attention from all red targets in a general pattern of rumination or mind-wandering, as we suggested as a possible account for the present results. If they had, below-baseline forgetting of targets—and just the negative targets—would not have ensued.

As speculation for the obtained differences in the forgetting of negative and positive targets, Joormann et al. suggested that depressed participants might be more inclined to use thought substitutes to suppress negative targets. Depressed people might more frequently distract themselves from unwanted negative thoughts by entertaining other negative thoughts that fluently come to mind (Wenzlaff, Wegner, & Roper, 1988). Clearly, these issues deserve investigation, particularly to determine whether cognitive control is important to the use of substitutes or instead whether suppression by association is a relatively automatic process when thoughts are negative in the long term (Joormann, Hertel, LeMoult, & Gotlib, submitted for publication).

Appendix. Materials

Related cue	Unrelated cue	Target
Wide	Hammer	River
Amateur	Bowl	Poet
Leather	Violin	Shoes
Brass	Wagon	Harp
Thin	Lawn	Book
Furniture	Writer	Factory
Porcelain	Skyscraper	Doll
Extra	Spray	Dollar
Carved	Month	Cane
Average	Jug	Person
Stone	Ketchup	Cottage
Appointed	Fork	Judge
Part-time	Trunk	Pianist
Capital	Elevator	City
Racing	Fabric	Hound
Cloth	Pencil	Banner
Sleeping	Mushroom	Mammal
Yellow	Ankle	Butter
Wooden	Umbrella	Chair
Office	Cork	Window
Underground	Chin	Cellar
Cotton	Kettle	Dress
Base	Foam	Camp
Humble	Clock	Monk
Captured	Cord	Leopard
Security	Tower	Officer
Brown	Curtains	Bird
Farm	Highway	Horse
Typed	Glacier	Letter

Appendix (*continued*)

Related cue	Unrelated cue	Target
Bus	Runner	Ticket
Laminated	Plant	Poster
Green	Vest	Frog
Log	Museum	Cabin
Teenage	Circle	Student
Clean	Lamp	Hotel
Unremarkable	Knot	Queen

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