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PII: S0165-1781(15)30137-2  
DOI: <http://dx.doi.org/10.1016/j.psychres.2016.04.086>  
Reference: PSY9650

To appear in: *Psychiatry Research*

Received date: 10 August 2015  
Revised date: 23 February 2016  
Accepted date: 25 April 2016

Cite this article as: Saima Noreen and Nathan Ridout, Examining the impact of  
thought substitution on intentional forgetting in induced and naturally occurring  
d y s p h o r i a , *Psychiatry Research*  
<http://dx.doi.org/10.1016/j.psychres.2016.04.086>

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DYSPHORIA

Examining the impact of thought substitution on intentional forgetting in  
induced and naturally occurring dysphoria

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Word Count: 7544

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## Abstract

Two experiments were conducted to determine if natural and induced dysphoria is associated with impaired forgetting and, whether a thought-substitution strategy would ameliorate any observed deficits. Study 1: 36 dysphoric & 36 non-dysphoric participants learnt a series of emotional word pairs. Participants were subsequently presented with some of the cues and were asked to recall the targets or prevent the targets from coming to mind. Half of the participants were provided with substitute words to recall instead of the original targets (aided suppression). At final memory testing, participants were asked to recall the targets to all cues. Dysphoric participants exhibited impaired forgetting, even when using a thought substitution strategy. Non-dysphoric participants, however, were able to use substitutes to suppress words. Study 2: 50 healthy participants initially completed the aided condition of the forgetting task. Participants were then given a positive or negative mood-induction, followed by another version of the forgetting task. Although all participants showed a forgetting effect prior to the mood-induction, only the positive group was successful at forgetting after the mood induction. Taken together, these findings do not support the utility of thought-substitution as an aid to forgetting in individuals in a naturally or induced dysphoric mood.

Word Count: 199

Keywords: Intentional forgetting; Think/no-think; dysphoria; thought substitution; induced mood

## 1. Introduction

Impaired emotion regulation is a hallmark feature of depression (Joormann and Gotlib, 2010; Kovacs, Joormann, and Gotlib, 2008) with difficulties in self-reported emotion regulation being related to current and past levels of depressive symptomology (Garnefski and Kraaij, 2006; Ehring et al., 2008). Recently, research has found that intentional forgetting may play an important role in emotion regulation (Joormann, Hertel, LeMoult and Gotlib, 2009; Joormann, Hertel, Brozovich and Gotlib, 2005) and may be an effective strategy to counteract ruminative tendencies and maintain psychological well-being.

Intentional forgetting involves deliberately attempting to suppress unwanted memories from consciousness and has been studied using the think/no-think (TNT) paradigm (Anderson and Green, 2001). The TNT paradigm mirrors the type of deliberate forgetting that, arguably, occurs when we are confronted with a reminder of a memory we wish to forget. In the paradigm, participants learn a series of cue-target word pairs and are then presented with some of the cue words. In some cases, participants are asked to recall the target word associated with the cue (i.e., ‘respond’ condition), and, for others, to prevent the associated target word from coming to mind (i.e., ‘suppress’ condition). At final test, participants are asked to recall the target words for all of the cues. Recall of the targets from the respond and suppress conditions is compared to memory for words that were presented only at initial learning (baseline words). Anderson and Green (2001) found that whilst memory for items in the respond condition was facilitated, recall of targets from the suppress condition was significantly poorer in comparison to baseline words. This finding is referred to as the below-baseline forgetting effect (see Anderson 2003; Anderson and Levy, 2009; Bergstrom, de Fockert, and Richardson-Klavehn, 2009). According to Anderson(2003) forgetting of suppress items may be due, in part, to an active inhibitory control mechanism

that disrupts the availability of the representation of the unwanted memory and renders it inaccessible to subsequent retrieval.

Evidence that participants can be trained to suppress unwanted memories from coming to mind has led some researchers to explore intentional forgetting effects in clinical populations, most notably patients with major depressive disorder (MDD). This is important as individuals with depression tend to experience recurrent unintentional negative thoughts (Matt, Vazquez and Campbell, 1992; see Mathews and MacLeod, 2005 for a review). However, research investigating intentional forgetting in depression has produced inconsistent results. Earlier work provided evidence that individuals with depression exhibit deficits in forgetting. For example, Hertel and Gerstle (2003) used the TNT to examine forgetting in subclinical depression (dysphoria) and found that dysphoric participants exhibited impaired forgetting of both positive and negative words. Other studies, however, have reported intact forgetting in participants with depression. For example, Joormann, Hertel, Brozovich and Gotlib (2005) explored forgetting in clinically depressed patients on a variant of the TNT task, and found that depressed individuals exhibited below-baseline forgetting of negative, but not positive words. Joormann et al (2009) also showed successful forgetting of negative words in patients with depression, but only when the patients were provided with positive or negative substitute words to think about during the suppression trials.

One potential explanation for the discrepancy in the findings concerns the word pairs used in the different studies. Joormann et al. (2005), for example, used unrelated cue-target word pairs (e.g. mushroom-hostage), which may have been harder to learn and easier to forget, and, as a consequence may have masked deficits in the depressed patients. In line with this notion, Hertel and Mahan (2008) demonstrated that unrelated word pairs were more difficult to learn and more easily forgotten than related word pairs. Further

evidence that the word pairs used in Joormann et al. (2005) were harder to learn than those in the study conducted by Hertel and Gerstle (2003) comes from the exclusion rates from the two studies. Joormann et al. (2005) excluded 20% of their sample for failing to meet the 50% learning criterion after four attempts, whereas none of the participants in Hertel and Gerstle's (2003) study were excluded following three attempts.

As noted above Joormann et al. (2009) demonstrated that providing emotional substitutes enabled clinically depressed patients to demonstrate successful forgetting on the TNT task. This is an interesting and important finding as it suggests that training depressed patients to use substitute thoughts might help them to forget unwanted thoughts. It is worth considering the proposed mechanisms by which thought substitution might lead to enhanced forgetting. It has been suggested that thought substitution may aid forgetting due to associative interference (Bergstrom et al., 2009), that is, the new associations between the substitute word and the cue interfere with the initial association between cue and target. However, evidence is stronger for an inhibitory explanation, whereby inhibitory processes are recruited in order to resolve the competition between the target word and the substitute item in memory (Del Prete, Hanczakowski, Bajo and Mazzoni, 2015; Benoit and Anderson, 2012).

Given that automatic negative thoughts are also observed in dysphoric participants (Wenze, Gunthert and Forand, 2007) and these thoughts are assumed to play a role in the development of clinically relevant depression (Van der Does, 2002), it is important to establish if thought substitution could aid forgetting in dysphoria. There is some evidence to suggest that this strategy would be effective, as Hertel and Calcaterra (2005) demonstrated that thought substitution aided forgetting of neutral targets and that this forgetting effect was also evident in participants with mild depression. Nevertheless, as the authors noted themselves, the depression levels were very low, which might have masked depression-related deficits. Furthermore, it would be of more utility to be able to forget emotional

material rather than neutral, particularly depression-relevant words (e.g. worthless, miserable). With this in mind, we conducted a study to determine if thought substitution could aid forgetting of emotional (positive and depression-relevant) words in a subclinical sample with moderate levels of depression.

### 1.1. Overview and predictions

Dysphoric and non-dysphoric participants learned a set of word pairs (neutral nouns paired with positive or depression-relevant adjectives) before practicing recalling the targets (adjectives) to some cues (nouns) and suppressing their responses to others. In line with the approach of Hertel and Gerstle (2003), half of the participants suppressed depression-relevant words and half suppressed positive, which ensured that suppression trials would not be contaminated by valence. Further, in line with Joormann et al., (2009), half of the participants in each group were provided with substitutes to help them to ‘not think’ about the targets during the suppression trials. During the final memory test, participants were asked to recall the target words to all cues.

In line with Hertel and Gerstle (2003) we predicted that both dysphoric and non-dysphoric participants in the unaided condition would exhibit impaired forgetting of emotional words which would become progressively worse with practice. We also predicted that dysphoric participants would show a greater deficit for depression-relevant words. Finally, we predicted that in line with Joormann et al. (2009) both dysphoric and non-dysphoric participants would show successful forgetting in the aided condition which would increase with practice.

## 2. Method

### 2.1 Participants

102 students (39M, 63F; mean age= 23.41, SD= 5.98) with no reported history of depression, were recruited from the undergraduate population at Aston University, UK. At initial screening, participants completed the Beck Depression Inventory-II (BDI-II; Beck et

al., 1996) and the trait scale of the state trait anxiety inventory (STAI-T, Spielberger, 1983). Based upon their BDI scores 72 participants were invited to take part in the main study, which took place 7 to 14 days (median =10) after the screening. In line with Kao, Dritschel and Astell (2006) those with a BDI score of 5 or below on both occasions were categorised as non-dysphoric and participants with a BDI score of 15 and above on both occasions were classified as dysphoric. Following this procedure, 18 dysphoric (6M, 12F; mean age = 19.11; SD=.76) and 18 non-dysphoric participants (2M, 16F; mean age = 22.28; SD=8.25) were allocated to the aided (thought substitution) condition and 18 dysphoric (5M, 13F; mean age = 20.06; SD=3.44) and 18 non-dysphoric participants (4M, 14F; mean age = 22.39; SD=6.41) were allocated to the unaided condition.

## 2.2. Measures

The Beck Depression Inventory-II (Beck et al., 1996) was used to assess the presence and severity of depression, and to allocate participants to groups. The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was used to assess levels of dispositional and situational anxiety. The Strategies Questionnaire (Hertel and Calcaterra, 2005) was included to establish the extent to which participants used a strategy during the suppression phase and/or attempted to circumvent instructions to suppress. The National Adult Reading Test (NART; Nelson and Willison, 1991) was used as a proxy measure of intelligence to ensure that all groups were matched in terms of general intellectual ability.

## 2.3. Materials

Thirty-six nouns (e.g., baby, dog, antique) were paired with a positive (e.g., smiling, content, charming, good), a depression-relevant (e.g., crying, abandoned, worthless) and a neutral adjective (e.g., big, brown, household) to create three sets of 36 adjective-noun pairs (e.g. 'smiling baby', 'crying baby' and 'big baby'). These words were taken from John (1988) and drawn from a larger set of word pairs compiled during a pilot study. The words

differed in emotionality (positive,  $M=3.71$ ,  $SD=0.37$ ; depression-relevant,  $M=2.20$ ,  $SD=0.35$ ; neutral,  $M=3.05$ ,  $SD=0.43$ ), but not word length (positive,  $M=7.94$ ,  $SD=2.11$ ; depression-relevant,  $M=7.78$ ,  $SD=1.99$ ; Neutral,  $M=6.92$ ,  $SD=1.74$ ). We considered it important to ensure the negative words were depression-relevant, as previous research (e.g. Bellew & Hill, 1990; Mathews & Bradley, 1983; Watkins et al., 1992) has shown that depression-related changes in memory are usually only observed under conditions involving depression-relevant words (e.g. useless, hopeless, miserable, lonely) and not all negative words (e.g. poison, hostage, assault).

Ten additional word pairs (neutral noun-neutral adjective) were included in the current study as practice stimuli and as buffer items to minimise primacy and recency effects. For each participant, half of the nouns were presented with the associated depression-relevant adjective and half with the positive adjective. These pairings were fully counterbalanced across all participants so that all the word pairs appeared in the respond, suppress and baseline conditions during the study. The 36 word pairs were divided into six sets of six nouns, three sets paired with positive adjectives and three paired with depression-relevant adjectives.

## 2.4. Procedure

In the first session participants completed the BDI-II and the trait scale of STAI (STAI-T). In the main session, participants completed the TNT task, the strategies questionnaire, NART, BDI-II, and the state scale of STAI.

### Learning phase

Participants were presented with each word pair for 6000ms and were asked to create a self-referential mental image related to each pair, which they rated for personal meaningfulness on a 5-point scale (with 1= not meaningful, and, 5= very personally meaningful). Each trial was separated by an inter-trial interval (ITI) of 600ms.

## Recall phase

Participants were presented with each cue word (noun) for up to 5200ms and were asked to recall aloud the associated target (adjective). All trials ended with the correct target being displayed for 2000ms, followed by an ITI of 300ms. Participants were given a maximum of 3 attempts to achieve a minimum of 50% recall accuracy in order to continue with the study<sup>1</sup>.

Prior to the TNT phase, participants in the aided condition were presented with a random sequence of 12 new adjective-noun pairs (the original nouns paired with novel adjectives, e.g., 'big' baby, instead of 'crying' or 'smiling'). Each pair was presented for 3000ms and participants were asked to learn these new word-pairs.

## TNT phase

All trials began with a focus cross (presented for 200ms) followed by a cue word (for 3000ms) in red or green ink. On respond trials (green cues) participants were required to recall the associated target word. Incorrect or absent responses on respond trials resulted in a display of the correct target word (in blue ink) for 500ms. On suppression trials (red cues) participants were required to avoid responding with or thinking about the associated target word. In the aided condition participants were requested to think about the substitute word instead of the original target, whereas in the unaided condition instructions were simply to avoid thinking about the target word. Suppression trials in the aided condition ended with the relevant substitute word being presented (in blue ink) for 500ms, whereas a blank screen was presented for 500ms in the unaided condition. All suppression trials were preceded by three large red Xs (displayed in font size 36 for 500ms) as stronger forgetting effects have been observed when suppression trials are primed (Hanslmayr, Leipold and Bauml, 2010).

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<sup>1</sup> One participant failed to achieve the learning criterion and their data were completely excluded from the study.

Prior to the main set of TNT trials, participants completed a random sequence of 26 practice trials. The cues from the 10 filler word pairs were presented one at a time in red or green and participants were asked to respond or suppress accordingly. Nine of the cues appeared twice throughout the sequence of practice trials (always in green font) and the remaining cue word appeared eight times (always in red). Participants in the aided condition were given a substitute word to recall on suppress trials. Following the practice, participants were presented with a random sequence of 184 trials. The cues from 24 of the 36 word pairs presented during the initial learning phase were presented in red or green ink and participants asked to respond or suppress accordingly. Twelve cues were presented in each colour and half of the words in each colour appeared twice in the sequence and half were repeated eight times. Half of the participants in each group recalled depression-relevant targets and suppressed positive targets and half recalled positive targets and suppressed depression-relevant targets.

#### Final test phase

Participants were presented with all 36 cues (in a random order) and were asked to recall the associated target, ignoring previous recall instructions. Each cue remained on screen for 4000ms and was preceded by a focus cross (presented for 200ms) and followed by an ITI of 400ms. Participants in the aided condition were told that they must try to recall the original targets, but could also recall the substitutes. Participants were then asked to complete the strategies questionnaire, NART, BDI and state scale of the STAI.

### 3. Results

#### 3.1. Participant Characteristics

Differences in age, intelligence (NART errors), depression and anxiety were analysed using a series of 2 (group; dysphoric vs. non-dysphoric) x 2 (condition; aided vs. unaided suppression) univariate ANOVA. See Table 1. All participant groups were matched for

general intellectual ability (NART error score), all tests  $F < 1$ . Importantly, depression scores of the participants in the aided and unaided conditions did not differ significantly;  $F < 1$ . Similarly, these groups were matched on state and trait anxiety, both tests  $F < 1$ . Dysphoric participants rated themselves as more state and trait anxious than did the non-dysphoric participants;  $F(1, 68) = 16.33, p < 0.001, \eta^2_p = 0.19$ ;  $F(1, 68) = 31.69, p < 0.001, \eta^2_p = 0.32$ , respectively.

### 3.2. Memory for target words

The percentage of target words correctly recalled on the final cued recall test were initially analysed using a 2 (group; dysphoric vs. non-dysphoric) x 2 (condition; aided vs. unaided suppression) x 2 (instruction: respond vs. suppress) x 2 (valence for suppression; positive vs. depression-relevant) x 3 (number of repetitions; 0 vs. 2 vs. 8) mixed factorial ANOVA.

Our analysis revealed significant main effects of instruction,  $F(1, 64) = 5.67, p = .02, \eta^2_p = .08$ , condition,  $F(1, 64) = 5.11, p = .03, \eta^2_p = .07$ , and repetition,  $F(1, 64) = 51.91, p < .001, \eta^2_p = .45$ . However, although we failed to find a significant group by condition by repetition by instruction interaction,  $F(2, 64) = 1.0, p = .37, \eta^2_p = .02$ , given that we had predicted group differences in suppression ability in the aided and unaided conditions, we conducted pairwise analysis which revealed that dysphoric and non-dysphoric participants in the unaided condition exhibited impaired forgetting, with both groups of participants recalling more of the targets that has been suppressed twice or eight times than baseline; dysphoric,  $t(35) = 4.70, p < .001$  and  $t(35) = 4.51, p < .001$ , respectively, and non-dysphoric,  $t(35) = 1.86, p = .08$  and  $t(35) = 2.10, p = .051$ , respectively. Furthermore, dysphoric participants in the aided condition, also recalled significantly more of the of the targets that had been suppressed twice or eight times than baseline,  $t(35) = 2.96, p = .009$ ;  $t(35) = 3.72, p = .002$ , respectively. However, as seen in Figure 1, non-dysphoric participants in the aided condition were

successful at demonstrating a below-baseline forgetting effect as they recalled fewer of the targets that had been suppressed twice or eight times than baseline,  $t(35)=1.54$ ,  $p=.07$ ;  $t(35)=1.64$ ,  $p=.06$  (one tailed), respectively.

Furthermore, although our analysis also revealed a significant group by valence interaction;  $F(2, 142)=24.59$ ,  $p=.001$ ;  $\eta^2_p=.28$ , we failed to find a significant instruction by group by valence interaction,  $F<1$ . However, as we had an apriori prediction that the dysphoric participants would show a greater deficit in suppressing depression-relevant words, we conducted pairwise analysis which revealed that overall, dysphoric participants recalled a greater percentage of the depression-relevant targets (Mean=70.06, SD=11.5) than did the non-dysphoric participants ( $M=49.85$ ,  $SD=20.1$ );  $t(34)=3.9$ ,  $p<0.001$ . They also recalled significantly fewer positive targets ( $M=49.5$ ,  $SD=8.6$ ) than did the non-dysphoric participants ( $M=62.35$ ,  $SD=18.8$ );  $t(34)=2.6$ ,  $p=0.013$ . In order to establish if the dysphoric participants demonstrated poorer forgetting of the negative targets in comparison to positive targets, we compared the magnitude of the forgetting effect (% recall of baseline words minus % recall of suppressed targets) for the positive and depression-relevant targets separately. Results revealed that the size of the forgetting effect in dysphoric participants did not differ for positive and negative targets,  $t(34)=.83$ ,  $p=.41$ , which does not support the prediction that forgetting effects in the dysphoric group would be more evident for depression-relevant targets.

### 3.3. Mood, compliance and forgetting

In line with Hertel and Calcaterra (2005), we created an index of the extent to which participants complied with suppression instructions by summing the first three items on the strategies questionnaire, with low scores indicating greater compliance. We then examined the significance of the relationships between depressed mood, compliance to suppression instructions, and the size of the forgetting effect (% recall of baseline words minus % recall

of suppressed targets). In the unaided condition, forgetting was not associated with depression or anxiety scores, all tests  $p > 0.05$ . However, it was negatively related to compliance score;  $r(36) = -0.30$ ,  $p = 0.04$ , suggesting that compliant individuals tended to be associated with positive scores (good forgetting) and less compliant individuals tended to be associated with greater recall of suppressed targets (poor forgetting). In the aided condition, forgetting was negatively related to depression scores and compliance;  $r(36) = -0.51$ ,  $p < 0.001$  and  $r(36) = -0.35$ ,  $p = 0.039$ . It was also negatively associated with state and trait anxiety;  $r(36) = -0.45$ ,  $p = 0.006$  and  $r(36) = -0.45$ ,  $p = 0.006$ . A partial correlation revealed that, after controlling for compliance and anxiety, forgetting was still significantly negatively correlated with depression;  $r(32) = -0.36$ ,  $p = 0.038$ .

#### 4. Discussion

In line with our predictions, dysphoric participants in the unaided condition failed to show below-baseline forgetting and instead demonstrated enhanced recall of targets that had been suppressed twice or eight times. Furthermore, the size of the forgetting effect (% recall of baseline words minus % recall of suppressed targets) was negatively correlated with depression scores, which is also consistent with this prediction, although it is notable that this relationship was only observed in the aided condition. Contrary to our expectations, providing dysphoric participants with substitute words did not improve their ability to suppress targets relative to the unaided condition. Non-dysphoric participants did show below-baseline forgetting in the aided condition, but this was only a non-significant trend. Nevertheless, the size of the observed forgetting effects (12% and 15%, for 2 and 8 presentations, respectively) are comparable to previous studies using thought substitution in the TNT task (for example, 13% and 15% for 2 and 12 presentations in Hertel and Calcaterra, 2005). Thus, our findings for non-dysphoric individuals in the aided condition are consistent with previous studies (Bergstrom et al., 2009; Hertel and Calcaterra, 2005; Hotta and

Kawaguchi, 2009) and suggest that thought-substitution did help these individuals to successfully forget the suppressed targets.

The finding of impaired forgetting by the dysphoric participants in the aided condition is inconsistent with the results of Joormann et al. (2009). One possible reason for this discrepancy concerns the substitute words used in the two studies. Joormann et al. (2009) provided participants with emotional words, whereas the current study used neutral substitutes, which may not have been as effective as emotional in enabling participants to inhibit recall of suppressed targets. Nevertheless, it is notable that the non-dysphoric participants in the current study were able to use the neutral substitutes to intentionally forget emotional words. Another possible explanation for these contrary findings concerns the cue-target pairs used in the different studies. In Joormann et al. (2009) participants learned unrelated word pairs that were not encoded self referentially, whereas, in line with Hertel and Gerstle (2003), we used highly relatable word pairs and a self-referent encoding strategy, which will have been made the targets in our study harder to forget (Hertel and Mahan, 2008).

It is important to mention that non-dysphoric participants also failed to show a forgetting effect in the unaided suppression condition. This is contrary to previous research which has demonstrated a successful suppression-induced forgetting effect (Anderson and Green, 2001; Joormann et al., 2009; Noreen and MacLeod, 2015). Our findings are, however, consistent with a growing body of research that has failed to demonstrate below-baseline forgetting using the TNT task (Bulevich, Roediger, Balota and Butler, 2006; Nørby, Lange and Larsen, 2010; Hertel and Gerstle, 2003). The lack of forgetting by both groups in the unaided condition was most likely due to non-compliance with suppression instructions. Evidence for this explanation comes from the significant relationship between the size of forgetting effect and the noncompliance score (calculated from the strategies

questionnaire), as participants who complied with instructions exhibited below-baseline recall of targets in suppression trials, whereas participants who failed to comply demonstrated above baseline recall of these words.

Although it has been suggested that thought substitution may aid forgetting due to associative interference (Bergstrom et al., 2009), evidence is stronger for an inhibitory explanation, whereby inhibitory processes are recruited in order to resolve the competition between the target word and the substitute item in memory (Del Prete, Hanczakowski, Bajo and Mazzoni, 2015; Benoit and Anderson, 2012). Given that impaired inhibition is a central characteristic of depression and dysphoria (Joormann, Yoon and Zetsche; 2007; Owens, Koster and Derkashan, 2012) it is plausible that observed depression-related deficit in forgetting in the aided condition was a consequence of impaired inhibition of targets. In line with this notion, depressed individuals have been shown to have reduced activation in the prefrontal regions (Siegle et al., 2002) which play a key role in the selection and maintenance of relevant information and the inhibition of irrelevant material in memory (Blasi et al., 2006; Johansson, Aslan, Bäuml, Gabel and Mecklinger, 2007) and has also been linked to successful intentional forgetting (Anderson et al., 2004; Benoit and Anderson, 2012).

We predicted that forgetting deficits in the dysphoric participants would be more evident for negative than positive targets. Although the dysphoric participants did show greater recall of the depression-relevant targets than did the non-dysphoric participants, they did not show greater deficits in forgetting (indexed by the size of the forgetting effect) for depression-relevant targets. This finding is consistent with Hertel and Gerstle (2003), as they only found a general deficit in forgetting for emotional words in dysphoric individuals, which was not greater for negative words. However, it is possible that our study did not have the required statistical power to effectively test this prediction and thus subsequent work should examine this question using a larger cohort.

In conclusion, the evidence from Study One indicates that, whilst thought substitution enabled non-dysphoric participants to suppress recall of suppressed emotional targets, this strategy did not aid forgetting in the dysphoric group. These findings question the usefulness of thought-substitution, at least using neutral substitutes, as a method of helping depressed individuals to forget unwanted memories. As higher depression scores were associated with poorer forgetting, this suggests that the observed deficit is likely to be even more pronounced in a clinical sample with more severe depression. In Study Two we further examine the influence of negative affect and thought substitution on forgetting on the TNT task.

## Study Two

### 5. Introduction

In the aided condition of Study One, the size of forgetting effect was negatively related to depression score, suggesting that participants with more severe depression experienced greater disruption in their ability to suppress recall of emotional targets than did those with low depression scores. This is consistent with previous research reporting that greater negative affect was associated with an increased number of intrusions during thought suppression (Freeston, Ladouceur, Thibodeau and Gagnon, 1992; Purdon and Clark, 1993). Furthermore, Minnema and Knowlton (2008) reported that both naturally occurring negative affect and induced negative mood impaired forgetting of negative words on the directed forgetting task. Taken together these findings suggest that negative mood is sufficient to impair forgetting. However, the effect of induced negative mood on forgetting as measured by the TNT task has yet to be established. This is important, as, given that individuals may exhibit elevated scores on depression inventories for a number of different reasons (Vrendenberg, Flett and Krames, 1993), observed deficits in forgetting might not be attributable to the mood of the individual per se, but to some other factor, for example,

differences in cognitive style (e.g. tendency to ruminate) or personality (e.g. neuroticism).

Using a mood induction procedure will provide us with greater experimental control of the influence of mood on forgetting using thought-substitution.

### 5.1. Overview and predictions

50 never-depressed participants completed two parallel versions of the TNT task before and after undergoing a mood induction (MI) procedure (either positive or negative). We predicted that participants in the negative MI group would exhibit impaired forgetting of the suppressed targets in comparison to the positive MI group. However, this difference would only be evident on the post MI TNT task. In line Minnema and Knowlton (2008), we expected that the deficit in forgetting in the negative MI group would be more evident for depression-relevant words. Finally, it was expected that the size of the forgetting effect on the post MI TNT task would be correlated with self-rated negative mood (post MI and with the change in negative mood from pre- to post-MI).

## 6. Method

### 6.1. Participants

Seventy-one participants (24M, 47F; mean age = 25.36, SD=2.98) from Aston University completed the Beck depression Inventory (BDI-II) and a general screening questionnaire concerning their mental health. Participants who reported no history of depression and who scored five or below on the BDI were invited to take part in the main study. During the main experiment session, participants completed a second BDI-II to confirm the stability of their mood. Thirteen participants were excluded because they scored above five on the BDI-II and eight because their mood scores suggested that the mood induction did not work. This resulted in a final sample of 50 participants, who were then pseudo-randomly allocated to either positive or negative mood-induction conditions. Thus 25 participants (9M, 16F; mean age = 21.56; SD=3.07) were allocated to the positive MI

condition and 25 participants (10M, 15F; mean age = 20.48; SD=2.35) to the negative MI condition. Within each group, participants were pseudo-randomly assigned to either suppress positive targets and recall depression-relevant words or suppress depression-relevant targets and recall positive words.

## 6.2. Think-No Think (TNT) Task

The 36 noun-adjective pairs from Study One were augmented with an additional 24 cue-target pairs, which resulted in a set of 60 nouns (each paired with a positive, depression-relevant and neutral adjective). An additional twenty neutral noun-adjective pairs (ten from Study One plus a new set) were included as practice trials and as buffer stimuli to minimize primacy and recency effects. Overall, the target adjectives differed in their emotionality (positive,  $M=3.78$ ,  $SD=.36$ ; depression-relevant,  $M=2.08$ ,  $SD=.37$ ; neutral,  $M=3.09$ ,  $SD=.43$ ), but not word length (positive,  $M=7.92$ ,  $SD=1.94$ ; depression-relevant,  $M=7.73$ ,  $SD=2.07$ ; Neutral,  $M=7.06$ ,  $SD=1.67$ ). The 80 word pairs were randomly assigned to one of two sets (A and B), each featuring 30 emotional adjective-noun pairs plus ten neutral pairs. Within each set, half of the emotional pairs featured a positive adjective and half a depression-relevant adjective; these pairings were randomly assigned each time the set was presented. The order in which the participants completed the two sets (prior to and post MI) was fully counterbalanced. It is notable that fewer emotional pairs ( $n=30$ ) were used in Study Two in comparison to Study One ( $n=36$ ). However, as previous studies (e.g. Noreen and MacLeod, 2013; 2014; Noreen, Bierman and MacLeod, 2014) have demonstrated significant below-baseline forgetting using a similar number of trials we did not expect this to affect our results. A second change from Study One is that all participants were provided with substitutes during suppression trials (i.e. there was no unaided condition). Both versions of the TNT in Study Two followed the identical procedure and timings as the aided TNT described in Study One. In each TNT task, ten of the 30 word pairs were presented only at initial learning (baseline

words), whereas the cues for 20 pairs were presented during suppression practice, with 10 cues being repeated twice (5 in green ink and 5 in red ink) and 10 repeated eight times (5 in green and 5 in red). Participants were requested to provide the correct target in response to green cues and to suppress the target in response to red cues. In order to aid their suppression of targets, all participants were provided with the appropriate neutral substitutes to think about on suppression trials instead of the original target. At final memory testing participants were required to recall the targets to all 30 cues.

### 6.3. Mood Induction Procedure

Depressed and happy moods were induced using autobiographical memory focus augmented with mood congruent music (Ridout, Noreen and Johal, 2009). Prokofiev's 'Russia under the Mongolian Yoke' recorded at half-speed was used to induce a negative mood (Au Yeung, Dalglish, Golden and Schartau, 2006) and an excerpt of Beethoven's Moonlight Sonata no. 2 was used to induce a positive mood (Ridout et al., 2009). Prior to attending the lab, participants were asked to think of an event from their past when they were very sad and another time when they were very happy. During the mood induction procedure participants were given four minutes to think about the appropriate memory (depending on condition), whilst they listened to the music, and were asked to focus on how they felt at the time of the event.

### 6.4. Assessment of Mood

Six visual analogue scales (VAS) were used at several points throughout the experimental session in order to assess changes in participants' mood state (happiness, sadness, anxiety, relaxation, energy and fatigue) in response to the MI procedures. Each scale consisted of a single 100mm line, anchored at one end with the words 'not at all...' and at the other end with the words 'extremely...' and participants were asked mark the point on each line that best represented their mood at that point in time. The VAS were scored by

measuring the mark on the line with the range of scores from 0-100. As were primarily interested in the influence of negative affect on forgetting, the scores for happiness, relaxation and energy scales were reverse scored and averaged with the scores for sadness, anxiety and fatigue. Higher scores on these scales equate to more intense negative affect.

## 6.5. Procedure

At initial screening, participants completed the BDI-II, the mental health screening questionnaire, and the trait scale of the STAI. During the main session, participants initially completed the NART, BDI-II, state scale of the STAI, and the first VAS. They then completed the following sequence of tasks and measures: first TNT task, mood induction (MI) procedure, second VAS, second TNT task, third VAS, positive MI (negative MI group only) and final VAS.

## 7. Results

### 7.1. Participant Characteristics

Analysis of the participant' characteristics (presented in Table 2) revealed that the positive and negative MI groups did not differ significantly in age, sex or general intellectual ability (NART error score),  $t(48) = 1.40$ ,  $p = 0.17$ ;  $\chi^2(1) = 0.89$ ,  $p = .76$  and  $t(48) = 0.33$ ,  $p = 0.74$ , respectively. The two groups were also matched on their levels of depression and anxiety (state and trait);  $t(48) = 0.85$ ,  $p = 0.9$ ;  $t(48) = 0.33$ ,  $p = 0.40$  and  $t(48) = 1.49$ ,  $p = 0.14$ , respectively.

### 7.2. Effectiveness of Mood Induction

The effectiveness of the mood induction procedure was determined by analysing self-reported mood (indexed by the VAS for sadness, anxiety and fatigue) at the three different time points using separate 2 (mood induction: positive vs. negative induction) x 3 (time of rating; pre MI vs. after MI vs. end of study) mixed factorial ANOVA. Analysis of sadness ratings revealed a significant time x mood induction interaction,  $F(1, 49) = 80.45$   $p < 0.001$ ,

$\eta^2_p = 0.63$ , with subsequent analyses revealing that the positive ( $M=22.70$ ,  $SD=12.01$ ) and negative MI groups ( $M=20.88$ ,  $SD=11.71$ ) did not differ in sad mood prior to the mood induction;  $t(24) = 0.54$   $p = 0.59$ . However, post MI, participants in the negative MI group reported significantly higher sadness ( $M=56.25$ ,  $SD=16.74$ ) than did participants in the positive MI group ( $M=9.86$ ,  $SD=8.28$ );  $t(24) = 12.42$   $p < 0.001$ . Furthermore, we also found that this difference was still evident after participants had completed the second TNT task ( $M=48.04$ ,  $SD=20.84$ ;  $M=11.84$ ,  $SD=12.56$ , respectively);  $t(24) = 7.44$ ,  $p < 0.001$ .

Analysis of anxiety ratings revealed a significant time x mood induction interaction,  $F(1, 49) = 20.33$ ,  $p < 0.001$ ,  $\eta^2_p = 0.30$ , with subsequent analysis revealing that two MI groups did not differ in anxiety prior to the mood induction ( $M=26.46$ ,  $SD=22.65$  vs.  $M=25.66$ ,  $SD=14.11$ );  $t(24) = 0.15$ ,  $p = 0.88$ . However, following the mood induction, participants in the negative MI condition reported significantly higher anxiety ( $M=46.98$ ,  $SD=18.85$ ) than did individuals in the positive MI group ( $M=17.28$ ,  $SD=13.66$ );  $t(24) = 6.38$ ,  $p < 0.001$ . Again, this difference was still evident after the second TNT task ( $M=49.42$ ,  $SD=18.72$  vs.  $M=19.77$ ,  $SD=13.90$ );  $t(24) = 6.43$ ,  $p < 0.001$ .

Analysis of fatigue ratings revealed no main effects of time,  $F(1, 49) = 1.44$   $p = 0.24$  or mood induction,  $F(1, 49) = .002$   $p = 0.96$ ,  $\eta^2_p = 0.03$  and no time x mood induction interaction,  $F(1, 49) = 1.44$   $p = 0.24$ ,  $\eta^2_p = 0.03$ .

### 7.3. Recall accuracy on TNT task

The percentage of targets recalled on the final memory test were analysed using a 2 (time: pre- mood induction vs. post- mood induction) x 2 (mood induction: positive vs. negative induction) x 2 (valence; positive vs. depression-relevant) x 2 (instruction; respond vs. suppress) x 3 (repetition; 0 vs. 2 vs. 8) mixed design ANOVA.

This analysis revealed a significant time x mood induction x valence x instruction x repetition interaction,  $F(1, 49) = 3.52$ ,  $p = 0.03$ ,  $\eta^2_p = 0.07$ . In order to explore this interaction

further, we examined recall of targets prior to and following the mood induction using separate 2 (mood induction: positive vs. negative induction) x 2 (valence; positive vs. depression-relevant) x 2 (instruction; respond vs. suppress) x 3 (repetition; 0 vs. 2 vs. 8) mixed design ANOVAs. Only significant effects and interactions are reported.

#### Prior to Mood Induction

Analysis revealed main effects of instruction,  $F(1, 49) = 68.21, p < 0.001, \eta^2_p = 0.60$ , repetition,  $F(1, 49) = 7.86, p = 0.001, \eta^2_p = 0.15$ , and a significant instruction x repetition interaction (See Figure 2),  $F(1, 49) = 49.95, p < 0.001, \eta^2_p = 0.52$ . Subsequent comparisons revealed that participants recalled more of the respond words presented twice ( $M = 71.20, SD = 27.75$ ) and eight times ( $M = 81.60, SD = 28.53$ ) than words presented only at baseline ( $M = 40.0, SD = 23.21$ );  $t(24) = 7.87, p < 0.001$  and  $t(24) = 8.42, p < 0.001$  respectively.

Importantly, participants demonstrated significant below-baseline forgetting, as they recalled fewer of the words presented twice (Mean = 29.20,  $SD = 25.94$ ) and eight times ( $M = 27.20, SD = 25.48$ ) during suppression trials than baseline words ( $M = 45.20, SD = 26.44$ );  $t(24) = 3.23, p = 0.002$  and  $t(24) = 3.81, p < 0.001$  respectively (see Figure 2).

#### After Mood Induction

Analyses revealed main effects of instruction,  $F(1, 49) = 54.61, p < 0.001, \eta^2_p = 0.54$ , mood induction,  $F(1, 49) = 14.31, p < 0.001, \eta^2_p = 0.24$ , repetition,  $F(1, 49) = 43.18, p < 0.001, \eta^2_p = 0.48$  and a mood induction x instruction x repetition interaction (See Figure 3),  $F(1, 49) = 9.87, p < 0.001, \eta^2_p = 0.18$ .

Subsequent analyses revealed that the positive MI group recalled significantly more of the respond words presented twice ( $M = 75.20, SD = 24.0$ ) and eight times ( $M = 91.20, SD = 14.24$ ) than words presented only at baseline ( $M = 43.20, SD = 16.0$ );  $t(24) = 6.93, p < 0.001$  and  $t(24) = 11.11, p < 0.001$  respectively. They also demonstrated significantly below-baseline forgetting, as they recalled fewer of the targets for cues presented twice ( $M = 39.20,$

SD=24.82) and eight times (M=32.80, SD=31.56) during suppression trials than baseline words (54.40, SD=21.23);  $t(24)= 2.19, p= 0.04$  and  $t(24)= 2.86, p=0.009$  respectively.

In line with the positive MI group, the negative MI group recalled significantly more of the respond words presented twice (M=80.0, SD=23.80) and eight times (M=92.80, SD=14.0) than words presented only at baseline (M=47.20, SD=22.27);  $t(24)= 6.07, p< 0.001$  and  $t(24)= 9.18, p< 0.001$  respectively. However, the negative MI group failed to show below-baseline forgetting, and instead recalled more of the words presented twice (M=56.0, SD=22.36) and eight times (M=70.40, SD=23.89) during suppression trials than baseline words (M=48.80, SD=16.41);  $t(24)= 1.25, p= 0.22$  and  $t(24)= 3.54, p= 0.002$ .

Our analyses also revealed a significant mood induction x valence interaction,  $F(1, 49)= 10.94, p= 0.002, \eta^2_p= 0.19$ . The positive MI group recalled significantly more positive (M=60.56, SD=9.30) than depression-relevant words (M=51.79, SD=9.58), whereas the negative MI group recalled significantly more depression-relevant (M=70.28, SD=8.34) than positive words (M=61.79, SD=9.49);  $t(24)= 2.37, p= 0.03$ . Given that we expected that impaired forgetting in the negative MI group would be more evident for depression-relevant words we decided to conduct a series of pairwise comparisons to establish if the group x valence interaction was driven by differences in recall of suppressed depression-relevant targets or simply a general mood congruent bias in the negative MI group. Results revealed that the two groups did not differ in their recall of depression-relevant words at baseline;  $t(23)=0.51, p=0.61$ . However, the negative MI group recalled a greater percentage (M=70.00, SD =16.5) of suppressed depression-relevant words (collapsed across two and eight repetitions) than did the positive MI group (M=21.45, SD=10.7);  $t(23)=5.29, p<0.001$ . We calculated the size of forgetting effect by subtracting the percentage recall of suppressed targets (collapsed across two and eight repetitions) from the recall of baseline words, with higher scores equating to more effective forgetting. The forgetting effect in the positive MI

group was similar for the positive and negative words,  $t(23) = 1.28$ ,  $p = 0.23$ , whereas the participants in the negative MI group exhibited a trend for poorer forgetting of negative than positive targets;  $t(23) = 1.6$ ,  $p = 0.06$  (one-tailed).

#### 7.4. The impact of sad and anxious mood on forgetting

The size of forgetting effect (recall of baseline words minus recall of suppressed targets) was negatively correlated with self-rated sadness and anxiety post MI;  $r(50) = -0.51$ ,  $p < 0.001$  and  $r(50) = -0.26$ ,  $p = 0.068$ . Interestingly, the size of forgetting effect was correlated with the change in sadness and anxiety from pre- to post- MI (post-MI score minus pre-MI score),  $r(50) = -0.49$ ,  $p < 0.001$  and  $r(50) = -0.27$ ,  $p = 0.058$ . Partial correlations controlling for anxiety scores revealed that sadness post MI and change in sadness pre- to post-MI remained significantly related to the size of the forgetting effect,  $r(47) = -0.43$ ,  $p = 0.002$  and  $r(47) = -0.44$ ,  $p = 0.001$ .

#### 8. Discussion

The aim of Study Two was to examine the effect of induced negative mood on intentional forgetting of emotional words in the TNT task; specifically we aimed to determine if participants induced into a negative mood would exhibit a deficit in forgetting suppressed targets, particularly when they were depression-relevant.

As expected, participants in the negative MI group exhibited impaired forgetting of suppressed targets in comparison to the positive MI group. However, also as expected, this difference was only evident on the TNT task post MI. Importantly, on the pre-MI TNT task all participants exhibited significantly below-baseline recall of suppressed targets, confirming the finding of Study One that using neutral substitutes can aid forgetting of emotional words in non-depressed participants. It is also notable that participants in the positive MI group also demonstrated successful forgetting of suppressed targets on the TNT task post MI. However, in line with the dysphoric sample reported in Study One, participants in the negative MI

group actually exhibited above baseline recall of suppressed targets on the post MI TNT task. This finding confirms that thought substitution, at least with neutral substitutes, is not an effective strategy in aiding participants in a negative mood to forget unwanted memories. Correlational analysis revealed that the deficit in forgetting was related to self-rated sadness post MI, with those reporting greater levels of sadness exhibiting poorer forgetting. Interestingly, forgetting was also related to the change in sadness from pre- to post MI, with those experiencing the greatest increase in sadness exhibiting the greatest impairment in forgetting. These data are consistent with the findings using the directed forgetting task (e.g. Minnema and Knowlton, 2008) and with research showing that negative affect is associated with deficits in suppression of unwanted thoughts (Freeston, Ladouceur, Thibodeau and Gagnon, 1992).

Our prediction that the forgetting deficit exhibited by the participants in the negative MI group would be greater for depression-relevant than positive words received only partial support, as there was only a non-significant trend for a difference in the magnitude of the forgetting effect for positive and depression-relevant words in the negative MI group. This finding is less clear than that observed in studies using the directed forgetting task (e.g. Minnema and Knowlton, 2008) and may be due to a lack of statistical power, as we only had 12 participants suppressing depression-relevant targets in the negative MI group compared to 28 participants in the relevant condition of Minnema and Knowlton's study (2008).

One possible explanation for the general deficit in forgetting exhibited by the negative MI group is that sad mood may have impaired executive functioning, notably inhibition (see Mitchell and Phillips, 2007 for a review), which in turn may have impacted on the participants' ability to inhibit recall of suppressed targets (Benoit and Anderson, 2012; Del Prete et al., 2015). Consistent with this notion, research has shown that healthy individuals experiencing negative affect show lower activity in the dorsolateral prefrontal cortex

(DLPFC; Aoki, et al., 2011), a region that has been implicated in successful inhibition (Blasi et al., 2006) and in the successful suppression of memories on the TNT task (Anderson et al., 2004; Benoit and Anderson, 2012).

Taken together, the findings of Study Two suggest that sad mood may be sufficient to impair forgetting and this deficit may be greater for depression-relevant words. Findings also confirm that, using neutral substitutes at least, thought substitution is not an effective method of aiding individuals in a negative mood to forget unwanted memories.

## 9. General Discussion

Overall our results revealed that both naturally occurring and induced dysphoria are associated impaired forgetting of emotional words. Furthermore, across both studies, greater intensity of negative mood was associated with more marked deficits in forgetting, which is plausibly due to the impact of negative mood on inhibitory control. In Study One, the deficit in forgetting was not greater for depression-relevant targets. However, there was some evidence in Study Two that deficits associated with negative mood were greater for depression-relevant targets. It is notable, that both studies were statistically underpowered in regards to this hypothesis and so replications with larger sample sizes would be required before conclusions can be drawn in regards to the mood congruent nature of forgetting in dysphoric mood. What was clear from both studies is that thought substitution, with neutral substitutes at least, is not an effective strategy in aiding participants in a dysphoric mood to forget unwanted memories. It remains to be determined if emotional substitutes, like those used in Joormann et al. (2009) would enable individuals in a dysphoric mood or with induced negative affect to successfully forget suppressed targets.

Our findings have a number of clinical implications. For example, given that dysphoric participants and clinically depressed patients are best considered part of the same continuum (e.g. Hankin et al., 2005) then it would be expected that, when material is self-

referentially encoded, similar or even more marked forgetting deficits would be observed in clinically depressed patients. In line with this notion, both of the present studies showed that intense negative affect was associated with poorer forgetting. Furthermore, although there is some evidence that thought substitution may be an effective method of training depressed patients to forget unwanted memories (e.g. Joormann et al., 2009), our findings suggest that this may be dependent upon the valence of the substitute memories. Moreover, given that depressed patients have been shown to have highly organised self-referential negative cognitive systems (Dozois and Dobson, 2001) there is a need to confirm the effectiveness of thought substitution as a method of forgetting unwanted memories that have been encoded self-referentially. Our finding that sad mood appears to be sufficient to impair forgetting is notable, as fluctuations in mood have been shown to exert greater influence on the cognitive function of individuals with a history of depression (Van der Does, 2002), and thus, may represent a risk factor for relapse in recovered patients. In line with this, it has been proposed that active suppression of unwanted thoughts during remission is a key factor in preventing relapse (Van der Does, 2005).

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Table 1. Study One: Mean indices of the demographic characteristics, as a function of participant group (standard deviations are presented in parentheses).

	Dysphoric		Non-Dysphoric	
	Aided	Unaided	Aided	Unaided
	(n=18)	(n=18)	(n=18)	(n=18)
Age	19.11 (1.0)	20.06 (3.4)	22.28 (8.2)	22.39 (6.4)
Sex	6M; 12F	5M; 13F	2M; 16F	4M; 16F
STAI-S	41.50 (7.5)	39.67 (8.2)	30.39 (5.8)	33.83 (11.6)
STAI-T	50.39 (7.2)	43.33 (8.7)	33.22 (6.3)	35.94 (8.1)
BDI	19.78 (6.1)	17.17 (2.4)	3.94 (1.8)	3.44 (1.8)
NART	21.39 (5.4)	22.11 (5.4)	20.89 (7.0)	19.89 (5.1)

M = Male F = Female; STAI-S = State anxiety subscale of the State Trait Anxiety Inventory; STAI-T = Trait anxiety subscale of the STAI; BDI = Mean Beck Depression Inventory score. NART= number of errors on the National Adult Reading Test

Table 2. Study Two: Mean indices of the demographic characteristics, as a function of participant group (standard deviations are presented in parentheses).

	Positive MI (n=25)	Negative MI (n=25)
Age	22.28 (8.2)	22.39 (6.4)
Sex (M/F)	9M; 16F	10M; 15F
STAI-S	30.39 (5.8)	33.83 (11.6)
STAI-T	33.22 (6.3)	35.94 (8.1)
BDI	3.94 (1.8)	3.44 (1.8)
NART	20.89 (7.0)	19.89 (5.1)

M = Male F = Female; STAI-S = State anxiety subscale of the State Trait Anxiety Inventory; STAI-T = Trait anxiety subscale of the STAI; BDI = Mean Beck Depression Inventory score. NART= number of errors on the National Adult Reading Test

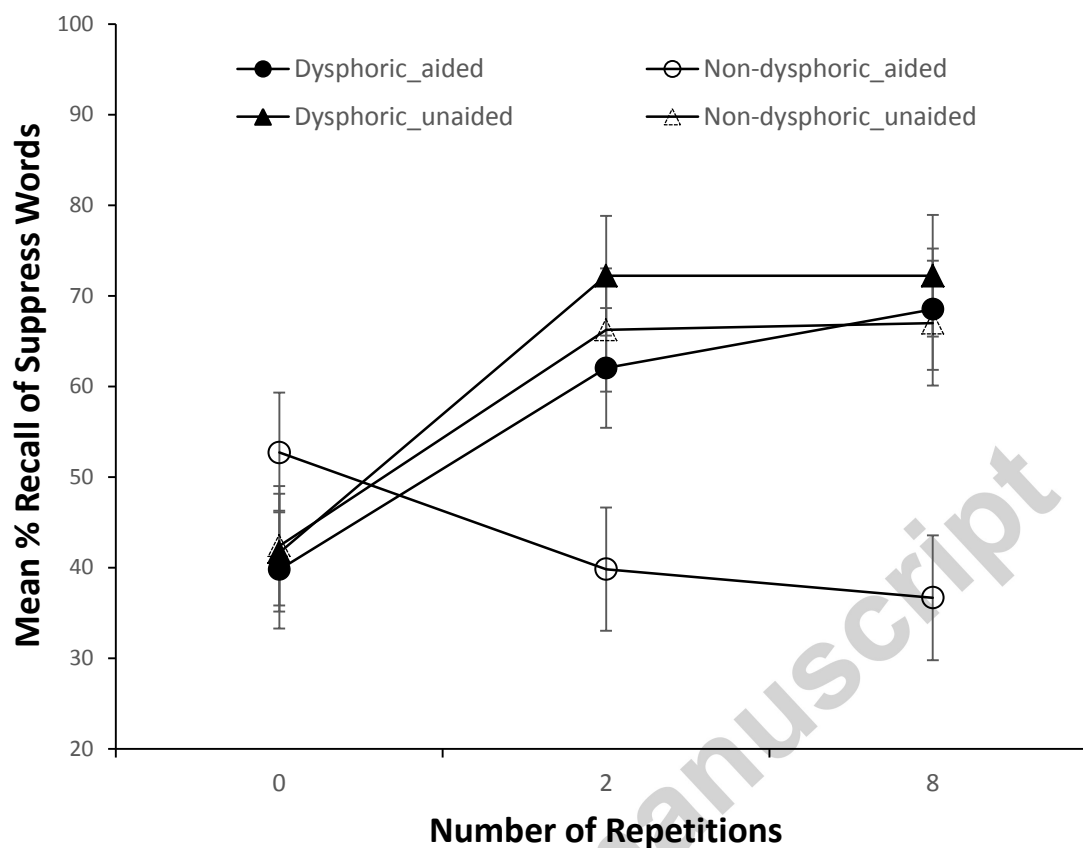


Figure 1: Study one. Percentage of words recalled by the participants in the unaided and aided conditions, as a function of the type of suppression instructions and the number of times the words were presented during the suppression phase (Error bars show  $\pm$  one standard error of the mean).

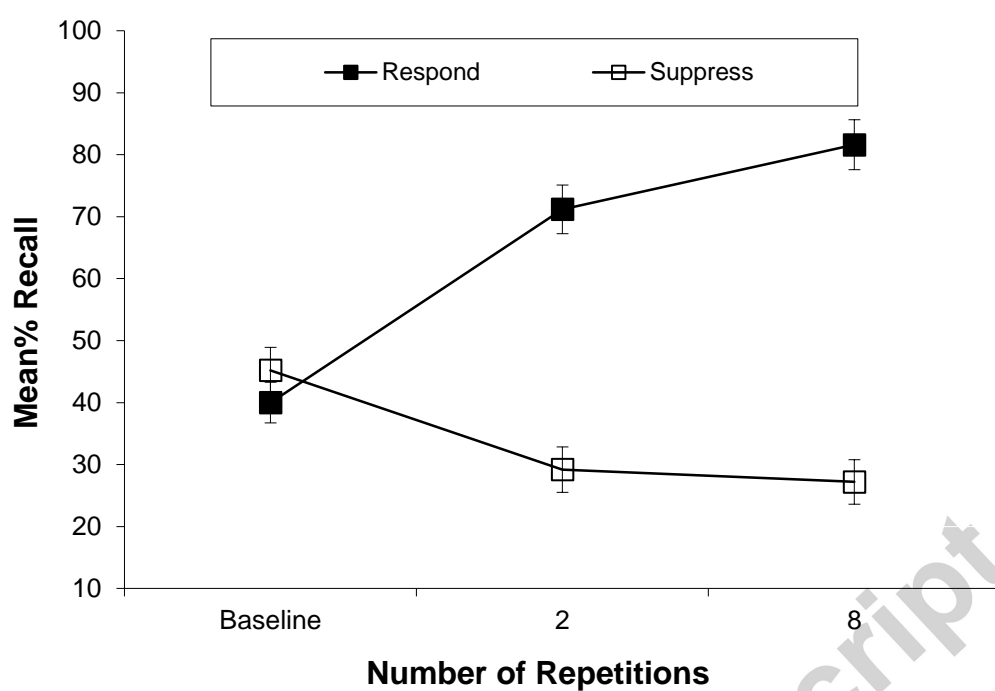


Figure 2 Study two. Mean percentage of respond and suppress words recalled on the final cued recall test prior to the mood induction, as a function of the number of times the words were recalled or suppressed during training (error bars represent + one standard error of the mean).

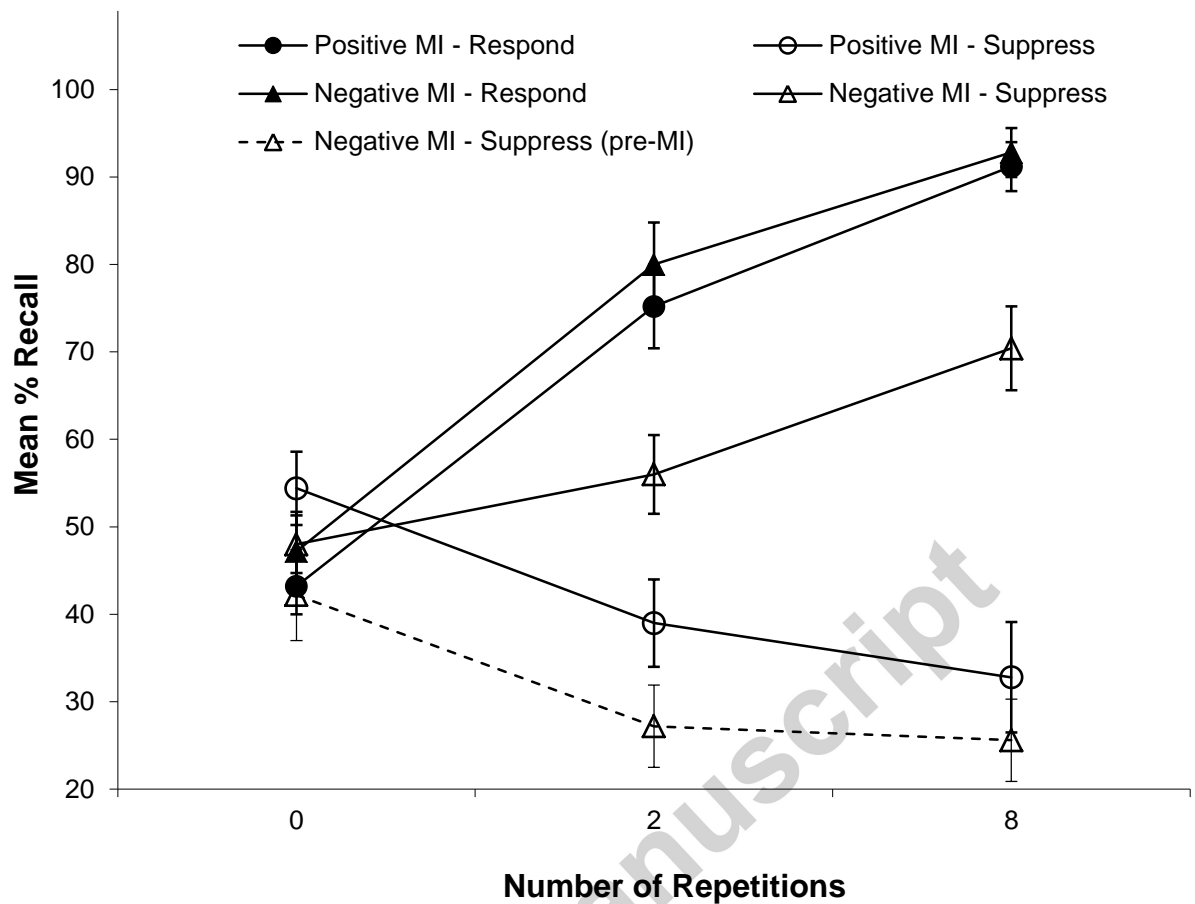


Figure 3. Study two. Mean percentage of respond and suppress words recalled by the two MI groups on the second TNT task (post MI), as a function of the number of times the words were suppressed during training (error bars represent + one standard error of the mean). The means for the negative MI group in the suppression condition pre MI (dashed line) are included for comparison

### Highlights

- Dysphoric participants and those induced into a negative mood exhibited impaired forgetting of emotional words, even when using a thought substitution strategy

- Greater depression severity in dysphoric participants was associated with poorer forgetting
- There was no evidence of a specific deficit in forgetting of depression-relevant words

Accepted manuscript