Intentional forgetting in dysphoria: Investigating the inhibitory effects of thought substitution using independent cues

Saima Noreen[1] & Nathan Ridout*

Department of Psychology, School of Life & Health Sciences, Aston University,

Birmingham, UK.

*Address of correspondence:

Dr Nathan Ridout

Department of Psychology,

School of Life and Health Sciences,

Aston University,

Birmingham, UK, B4 7ET.

Tel: +44 (0) 121 204 4162

Fax: +44 (0) 121 204 4090.

Email: n.ridout@aston.ac.uk

[1]Present address: Department of Psychology, Goldsmiths, University of London, London, SE14 6NW, UK

Abstract

Background: Individuals with clinical and subclinical depression (dysphoria) exhibit problems intentionally forgetting unwanted memories on the think/ no-think (TNT) paradigm (Anderson & Green, 2001). However, providing substitute words to think about instead of the to-be-forgotten targets can improve forgetting in depressed patients. *Objectives:* to determine if thought substitution can enhance forgetting in dysphoric participants and to examine the potential mechanisms (blocking or inhibition) that might underpin successful forgetting. *Methods:* Thirty-six dysphoric and 36 non-dysphoric participants learned neutral word-pairs and then practiced responding with the targets to some cues (think trials) and suppressing responses to others (no think trials). Half the participants were provided with substitute words to recall instead of the original targets (aided suppression) and half were simply told to avoid thinking about the targets (unaided suppression). Finally, participants completed two recall tests for the targets; one cued with the original probes and one with independent probes. *Results:* Regardless of suppression condition (aided or unaided), dysphoric participants exhibited impaired forgetting, relative to their non-dysphoric counterparts, but only when cued with the original probes. Furthermore, higher depression scores were associated with poorer forgetting. In the aided condition, successful forgetting was observed on both the original and independent probe tasks, which supports the inhibitory account of thought substitution. *Limitations:* the non-clinical status of the dysphoric participants was not confirmed using a validated measure. *Conclusions:* Findings do not support the utility of thought substitution as a method of improving the forgetting in depressed participants, but do support the inhibition account of thought substitution.

Key words: think-no think**;** forgetting; depression; suppression; cued-recall; inhibition

Highlights

- Dysphoric participants exhibited impaired forgetting on the think-no-think task
- Higher depression scores associated with poorer forgetting on the think-no-think task
- Thought substitution led to successful forgetting for non-dysphoric participants only
- Forgetting found with original and independent probes supporting inhibitory account

1. INTRODUCTION

The ability to prevent unwanted, irrelevant or disruptive information from coming to mind is an important element of an effective memory system. Indeed, failures to control retrieval of unwanted memories can have significant negative consequences for an individual's ability to function. On the other hand, the ability to successfully forget negative experiences, and remember the good, has been shown to be associated with psychological well-being and quality of life in older adults (Kennedy, Mather & Carstensen, 2004). This is particularly pertinent to individuals exhibiting depressive symptoms, as depression is characterised by the presence of unwanted and uncontrollable negative thoughts and memories, which have been shown to contribute to the onset and maintenance of depressive episodes (Johannessen & Berntsen, 2011; Nolen-Hoeksema, 2000; Watson, Berntsen, Kuyken & Watkins, 2012). With this in mind, training depressed individuals to forget unwanted negative memories could potentially improve their ability to regulate their mood. Thus, it is important to gain a better understanding of the processes underpinning successful forgetting and how these might be affected by depression.

As noted by Joormann, Hertel, Brozovich and Gotlib (2005), forgetting in depression has traditionally only been considered in the context of studies examining recall and recognition memory for experimentally presented valenced material (see Williams, Watts, Macleod & Mathews, 1997). Forgetting in this context is a passive rather than active process. The first study to examine intentional (active) forgetting in depression was conducted by Power et al. (2000), who used the directed forgetting task and reported that clinically depressed patients exhibited impaired forgetting of negative words. However, the extent to which this task actually assessed intentional forgetting has been questioned (Joormann et al., 2005).

An alternative method of examining intentional forgetting is the think/no-think paradigm (TNT; Anderson and Green, 2001). The TNT task involves actively suppressing a memory associated with a particular cue. Anderson and Green (2001) asked participants to learn a series of unrelated word pairs. The learning of which was tested by presenting one of the words (cue) and asking the participants to recall the associated word (target). Once the participant had reached the learning criterion (50% successful recall) they were presented with a subset of the cues and asked to either recall the associated target (respond trials) or to prevent the target word from coming to mind (suppression trials). At final memory testing, participants were presented with all of the cues from the initial learning phase and asked to recall the corresponding targets, regardless of previous instructions. Their recall of targets from respond (think) and suppress (no think) trials was compared to their memory for targets from pairs that were presented only at initial learning (referred to as baseline words). Anderson and Green (2001) found that participants exhibited poorer recall of targets from suppression trials in comparison to baseline.

This below-baseline forgetting effect is usually considered as evidence of suppression-induced forgetting and has been replicated using the TNT task with a wide range of materials (see Anderson et al., 2004; Depue, Banich & Curran, 2006; Depue Curran & Banich, 2007; Hanslmayr et al., 2009; Hanslmayr et al., 2010; Hart & Schoolar, 2012; Noreen, Bierman & MacLeod, 2014; Noreen & MacLeod, 2015). It is notable that forgetting effects have also been observed using variants of the TNT task based on everyday memory processes, including autobiographical memory (Noreen & MacLeod, 2013, 2015; Stephens, Braid & Hertel, 2013). However, there have been a number of studies that have failed to replicate below baseline recall on the TNT (e.g. Buelvich, Roediger, Balota and Butler, 2006; Mecklinger, Parra & Waldhauser, 2009).

Below baseline forgetting has largely been interpreted within an inhibitory framework. According to this account, inhibitory control disrupts the accessibility of the unwanted memory, which subsequently leads to systematic forgetting (Anderson, 2003; Anderson & Green, 2001; Anderson & Hanslmayr, 2014; Schilling, Storm & Anderson, 2014). However, others have argued for a non-inhibitory explanation of forgetting, such as associative interference or blocking of competing memories at recall (see MacLeod, Dodd, Sheard, Wilson & Bibi, 2003; Raajimakers & Jakab, 2013). For example, Raajimakers and Jakab (2013) demonstrated that forgetting on the retrieval induced forgetting (RIF) paradigm was best explained in terms of competition at recall between items with differing retrieval strengths rather than the inhibition of one item at the expense of the other. Nevertheless, they concede that retrieval might be a dual process involving both competition and inhibition.

Research exploring intentional forgetting effects in depressed participants has found that the TNT task does not always lead to successful forgetting. For example, Hertel and Gerstle (2003) reported that individuals with subclinical depression (dysphoria) and healthy non-dysphoric participants failed to show below-baseline forgetting. Interestingly, however, dysphoric participants exhibited poorer forgetting than did non-dysphoric, which the authors attributed to a potential deficit in attentional control on the part of the dysphoric participants. This is consistent with evidence that depression is associated with impaired attentional control (De Raedt, Koster & Joormann, 2010; De Raedt & Koster, 2010; Owens, Koster & Derakashan, 2012; Rokke, Arnell, Koch, & Andrews, 2002). Similarly, Joormann, Hertel, LeMoult and Gotlib (2009) reported that clinically depressed patients exhibited impaired forgetting on the traditional TNT. Taken together these findings suggest that depression is associated with impaired forgetting on the TNT. However, other findings are inconsistent with this conclusion. For example, Joormann et al. (2005) used an emotional variant of the TNT task and reported that clinically depressed participants did exhibit below baseline

forgetting, but only for negative and not positive words. The inconsistency of the findings in studies using the TNT suggests that simply 'not thinking' about items is not a sufficient strategy to prevent these stimuli from coming to mind.

In an attempt to improve the level of forgetting on the TNT, Hertel and Calcaterra (2005) provided half of their participants with substitute words to think about on suppression trials in order to help them 'not think' about the targets, with remaining participants being given the standard 'no-think' instructions. Their results demonstrated that only participants who were provided with substitutes (aided condition) demonstrated clear evidence of below-baseline forgetting. Those not provided with substitutes (unaided condition) only demonstrated below baseline forgetting if they later reported that they had spontaneously chosen to use a thought-substitution strategy to avoid thinking about the targets. Taken together, these findings combined with the data from subsequent studies (e.g. Hotta & Kawaguchi, 2009) support the utility of thought-substitution as a method of improving forgetting.

Hertel and Calcaterra (2005) proposed that thought-substitution might be particularly useful in aiding individuals with depression to intentionally forget, by helping them to control their attention. To test this they split their sample into high and low scorers on the Beck Depression Inventory. They found no difference in forgetting between high and low scorers and interpreted this as evidence in support of their proposition. The findings of Joormann et al. (2009) are also consistent with this proposal, as they demonstrated below baseline forgetting in a group of clinically depressed patients using a thought substitution strategy. However, further work is required before it can be firmly concluded that thought substitution is an effective method of aiding forgetting in depressed individuals. For example, as noted by Hertel and Calcaterra (2005) themselves, the mild depressive symptoms in their sample may have masked depression-related deficits in forgetting. Consistent with this explanation, it has

been reported that cognitive deficits in dysphoria are only evident in participants that report at least moderate levels of depression (Rokke et al., 2002). With this in mind, the aim of the current study was to try and replicate the findings of Hertel and Calcaterra (2005) using more clearly delineated dysphoric and non-dysphoric groups in order to provide a more robust test of the utility of thought substitution in helping individuals in a depressed mood to intentionally forget. In addition to confirming the utility of thought substitution in depressed participants it is vital to investigate the processes underpinning successful forgetting, as this might also provide targets for future interventions.

According to del Prete, Hanczakowski, Bajo and Mazzoni (2015) there are two mechanisms by which thought substitution could result in enhanced forgetting of unwanted memories. The first explanation, is based on the interference theory which suggests that the repeated associations between the cue and substitute during the TNT trials strengthen the associative link between these words, such that, when the cue is presented at final recall, the substitute memory interferes with access to the target item and is more likely to come to mind than the original target. Thus, thinking about the substitute memory creates interference for the cue-target relationship, similar to the interference seen in the A-B, A-C procedure whereby learning 'bush-hammer' then 'bush-lamp' attenuates recall performance for target A (hammer) than target B (lamp) items (McGeoch, 1932, Barnes & Underwood, 1959).

Alternatively, the inhibitory model proposes that, when two or more items are associated with the same cue, attempts to retrieve one will be interrupted by the competition from the other associate(s). Inhibitory control is therefore required to resolve the conflict and suppress the memory of the competitor associates. The standard method of distinguishing between these two explanations has been to employ an independent probe for the targets in addition to the original cue. If forgetting is due to interference then using an independent probe, which has not been repeatedly associated with the target during the TNT trials, should

enable recall of the target. However, if the target has been inhibited then it should still be harder to recall than baseline words even when cued using an independent probe. Thus far the research relating to the mechanism underpinning the forgetting effects of thought substitution have been inconclusive. Bergström, de Fockert, and Richardson-Klavehn (2009) reported that thought suppression only resulted in below baseline forgetting on the test cued with the original probe, supporting the interference theory. However, Benoit and Anderson (2012) demonstrated similar levels of below baseline forgetting in original and independent cued tests, supporting the inhibitory explanation. This finding was replicated by del Prete et al. (2015). To our knowledge, no study examined the mechanism underpinning the forgetting benefits of thought substitution observed in depressed participants. Thus, this was the second aim of the current study.

1.1.Overview and predictions

Dysphoric and non-dysphoric participants were assessed on the modified TNT task from Hertel and Calcaterra (2005). They initially learned a series of neutral cue-target word pairs to criterion (>50% successful cued-recall) before practicing recalling targets to some cues (think) and suppressing the targets to others (no think). Half of the participants in each group (dysphoric and non-dysphoric) were provided with substitute words to help them to 'not think' about the targets during the suppression trials (aided suppression) and half were simply required to avoid saying or thinking about the targets (unaided suppression). Participants' memory for the words was then assessed using two separate tests. In the original cue test, participants were presented with all of the cues from the initial learning phases and were asked to recall the appropriate targets. In the independent probe test, participants were presented with a semantic category and the initial letters of the words and were asked recall the appropriate target. Based on Hertel and Gerstle (2003) and Joormann et al (2009) we

expected that dysphoric participants in the unaided condition would exhibit impaired forgetting compared to the non-dysphoric group. On the other hand, based on the findings of Hertel and Calcaterra (2005) and Joormann et al. (2009) we expected that no group differences in forgetting would be evident in the aided condition, with all participants demonstrating below baseline recall of targets from the no think trials. We also predicted that thought substitution would result in below baseline forgetting of words from the no think trials on both the original and independent probe tasks, in line with the inhibition theory of forgetting (Benoit & Anderson, 2012; del Prete et al., 2015).

2. METHOD

2.1. Participants

A total of 96 undergraduate students volunteered to take part in the study in exchange for £5 or course credit. Participants self-reported that they had no history of depression and current levels of depression were measured using the Beck Depression Inventory II (BDI-II; Beck et al., 1996). The main experimental session took place 7 to 14 days (median = 9) after the screening session. Participants were invited to take part in the main study based upon their BDI scores. In line with Kao, Dritschel and Astell (2006) participants with a BDI score of 5 or below on both occasions were categorised as non-dysphoric and those with a BDI score of 15 and above on both occasions were classified as dysphoric. Following this procedure 72 participants were invited to take part in the main study. 18[1] dysphoric (4M, 14F; mean age = 22.44; SD = 5.8) and 18 non-dysphoric participants (5M, 13F; mean age = 24.11; SD = 8.7) were allocated to the thought substitution (aided) condition. A further 18 dysphoric participants (6M, 12F; mean age = 20.83; SD = 4.1) and 18 non-dysphoric

[1] Sample size required to detect a significant interaction (estimated medium effect size; f=.25) on the mixed ANOVA with a power of .80 was 16 participants per cell according to our calculations using G*Power (Faul et al., 2007).

participants (5M, 13F; mean age = 22.67; SD = 5.2) were allocated to the unaided condition. There was a high degree of stability in the self-rated depression scores across sessions (Cronbach's α = .97).

2.2.Measures

A 7-item screening questionnaire was devised by the experimenter (SN) to screen for a history of depression, anxiety or other psychiatric conditions. The latest version of the Beck Depression Inventory (BDI-II; Beck et al., 1996) was used to assess the severity of participants' depressed mood and to allocate participants to groups. This measure has been shown to have excellent reliability (α = .90) in non-clinical student populations (Storch, Roberti & Roth, 2004) The Spielberger State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was used to assess levels of dispositional and situational anxiety. This is important, because trait anxiety has been shown to impair forgetting on the TNT task (Marzi, Regina & Righi, 2014). Both state (.94) and trait scales (.91) have been shown to have excellent reliability within the general population (Crawford et al., 2011). The National Adult Reading Test (NART; Nelson & Williamson, 1991) was used to provide an estimate of general intellectual function (IQ), in order to ensure that any group differences in memory performance could not be ascribed to variations in IQ. The NART correlates strongly (.9) with measures of IQ, e.g. the WAIS (Crawford et al., 1990) and is not influenced by depression (Crawford et al., 1987), making it ideal for estimating general intellectual function in dysphoric samples. The Strategies Questionnaire (Hertel & Calcaterra, 2005) was included to establish the extent to which participants used a strategy during the suppression phase and also the extent to which participants attempted to circumvent the instructions to supress. The reliability of this measure in the current sample was acceptable (Cronbach's α=.75).

2.3.Materials

Thirty-six adjective-noun pairs (e.g. porcelain-doll), drawn from Hertel and Calcaterra (2005), were used as the experimental stimuli. An additional ten pairs, also drawn from Hertel and Calcaterra (2005), were included as practice and filler stimuli. The 36 experimental trials were divided into six sets of six pairs (an additional filler pair was allocated to each set). All pairs were presented during initial learning and then three of the sets were subsequently assigned to suppression trials (0, 2 or 8 repetitions) and the remaining three sets to respond trials (0, 2 or 8 repetitions). The allocation of these pairings was fully counterbalanced for each participant, so that the word pairs were presented roughly equally often in the respond, suppress and baseline (0 repetitions) conditions across the study. Substitute nouns for each adjective were included for use during the suppression trials in the aided condition (e.g. the noun 'goblet' was included for the adjective 'porcelain'). These nouns were also drawn from Hertel and Calcaterra (2005).

2.4. Procedure

In the first session participants completed the screening questionnaire, the BDI-II and the trait scale of STAI (STAI-T). In the main session, participants were assessed on the NART, the TNT task and BDI-II (to confirm stability of depression).

2.4.1. Think/ No-think (TNT) Task: overview

Participants were informed that that they would be taking part in a study on attention which would involve them attending to some items and ignoring others. They were told that not thinking about the target items to some cues would help them to recall items to other cues more quickly. Participants initially learned a series of adjective-noun pairs, and learning was

assessed using cued recall, whereby they were presented with a cue (adjective) and asked to recall the associated target (noun). Those who achieved the learning criterion (minimum 50% correct recall) were then presented with a random sequence of cues (half in green ink and half in red), which consisted of two thirds of the cues from the initial learning phase (half were repeated twice in the sequence and half were repeated eight times) interspersed with a series of the cues from the filler pairs from the initial learning phase (all presented in green and repeated eight times). Participants were asked to recall the targets in response to green cues (respond trials) and to 'not think' about the targets in response to red cues (suppression trials). Participants in the aided condition were provided with substitute nouns to think about during suppression trials instead of the targets. Finally, participants completed two memory tests in a counterbalanced order. In the cued recall test they were presented with the cues from the initial learning phase and asked to recall aloud the targets to all cues, regardless of previous recall instructions. In the independent probe test participants were presented with cues to the target words (the initial letters plus the semantic category to which the word belonged) and were asked to recall the words aloud. They were informed that all targets were presented during the initial learning phase. On both tests, participants' recall of the targets from the respond and suppression trials was compared to targets from pairs that were only presented at initial learning (referred to as baseline words). The TNT task is described in more detail in the subsequent sections (2.4.2 to 2.2.4).

2.4.2. Think/ No-think (TNT) Task: learning phase

Participants were presented with a random sequence of 42 adjective-noun pairs (each shown for 5 seconds) and were asked to create a self-referential mental image for each pair, which they subsequently rated for personal meaningfulness using a 5-point scale (with higher scores equating to greater personal meaningfulness). Each trial was separated by an inter-trial

interval (ITI) of 600ms. In order to minimise primacy and recency effects, two filler word-pairs were presented at the beginning of the sequence and an additional two filler pairs were presented at the end. Learning of the word pairs was assessed using a cued recall task. Participants were presented with the cues (adjectives) and asked to recall aloud the associated target (noun). The cues remained on screen until the participant responded (or for a maximum of 5200ms). All trials ended with a presentation of the correct target for 2000ms. Each trial was separated by an inter-trial interval (ITI) of 300ms. The recall task was repeated (up to three times) until participants were able to recall a minimum of 50% of the targets[2].

2.4.3. Think/ No think (TNT) task: TNT phase

This phase consisted of 184 experimental trials, 120 of which featured the cues from 24 (out of 36) experimental pairs. Twelve of the cues were presented in green ink and 12 in red, with half of the cues in each colour being repeated twice and half repeated eight times[3]. The remaining 64 trials consisted of the cues from eight filler pairs, each presented eight times in green ink. Each trial began with a focus cross (presented centrally for 200ms) followed by a cue word (for 3000ms) in red or green ink. On respond trials (green cues) participants were asked to recall the appropriate target aloud. Incorrect or absent responses resulted in the correct target being displayed in blue ink (for 500ms). On suppression trials (red cues) participants were instructed to 'not think' about the targets. Suppression trials always began with a display of three large red Xs (for 500ms) to warn participants of an upcoming

[2] This criteria is consistent with previous studies (Anderson & Green, 2001; Hertel & Calcaterra, 2005; Noreen & MacLeod, 2012). Only one participant in the current study failed to achieve the learning criterion and their data were completely excluded from the study.

[3] The cues were repeatedly presented to examine if suppression improved with practice. Previous studies (e.g. Hertel & Gerstle, 2003) have used up to 16 repetitions. However, given that Hertel and Gerstle (2003) reported that there was no significant difference in performance between 8 and 16 repetitions (a finding that we confirmed in an unpublished study; Noreen & Ridout, 2010) the number of repetitions in the current study was limited to eight. Furthermore, we did not want participants, particularly those in the dysphoric group, to experience boredom or fatigue effects during the main TNT phase, because motivation has been shown to be crucial in intentional forgetting.

suppression trial, as stronger forgetting effects are observed when suppression trials are primed (Hanslmayr, Leipold & Bauml, 2010). If participants recalled the targets to suppression cues then then the red Xs were displayed again (for 500ms) as a reminder to not think about the targets on suppression trials.

Prior to the TNT phase, the 12 cues from the suppression trials were each paired with a new noun and presented (for 3000ms) to the participants in the aided condition, who were asked to learn the new word pairs, but to not think about the original target associated with that cue. On suppression trials, during the TNT phase, participants in the aided condition were instructed to think about these new nouns in order to help them to 'not think' about the original targets. If a participant in the aided condition responded with a target to a suppression cue they were presented with the red Xs (for 500ms) followed by the relevant substitute noun in blue ink (for 500ms).

Prior to the TNT phase, all participants completed a series of 26 practice trials, which consisted of the cues from nine of the filler pairs, each presented in green ink and repeated twice, and the cue word from the remaining filler pair presented in red ink and repeated eight times. Participants were asked to recall the targets in response to green cues and to 'not think' about the targets in response to red cues. Participants in the aided condition were provided with a noun to think about instead of the target on suppression trials.

2.4.4. Think/ No think (TNT) task: Final memory testing

Participants completed a cued recall task and an independent probe task in a counterbalanced order. During the cued recall task participants were presented with a random sequence of the cues from the 36 word pairs presented at initial learning. The cues from two of the filler word-pairs were always presented at the beginning of the sequence and a further two filler cues were always presented at the end. Participants were asked to recall the targets to all cues

regardless of previous recall instructions. Those the aided condition were told that they could also recall the substitutes, but must try to recall the original targets. Each trial began with a centrally presented black cross (for 200ms) followed by a cue in black ink (for 4000ms), during which time participants were required to recall the targets. Each trial was separated by an ITI of 400ms and no feedback was given on performance. During the independent probe task participants were presented with the initial letters of a word along with the semantic category to which it belongs (presented for 4000ms) and were asked to recall the word aloud. Each trial began with a centrally presented cross for 500ms and was separated by an ISI of 400ms. The order of trials was fully randomised and participants were informed that all targets were nouns that had been presented during the initial learning phase. On both memory tests, the percentage recall of targets from the respond and suppression trials was compared to the recall of nouns from pairs presented only at initial learning (referred to as baseline words). Upon completion of the final memory test participants were asked to complete the strategies questionnaire, the BDI and state scale of the STAI.

3. RESULTS

3.1. Participant Characteristics

Separate 2 (group; dysphoric vs. non-dysphoric) x 2 (condition; aided vs. unaided suppression) univariate ANOVA were used to analyse participants' age, NART error scores, and STAI scores (see Table 1). Results for age revealed no main effects of group or condition and no group x condition interaction; $F(1, 68)$, 1.4, $p>.05$, $\eta^2_p=.02$; $F(1, 68)=1.1$, $p>.05$, $\eta^2_p=.02$ and $F<1$, $\eta^2_p=.001$ respectively. Similarly, for NART error scores, there were no main effects and no interaction; $F(1, 68)=1.5$, $p>.05$, $\eta^2_p=.02$; $F(1, 68)=3.3$, $p>.05$, $\eta^2_p=.05$ and $F<1$, $\eta^2_p=.01$ respectively. Dysphoric participants reported higher levels of state anxiety (39.8, SD=9.6) than did non-dysphoric participants (30, SD=6.0), $F(1, 68)=28.7$,

$p<.001$, $\eta^2_p=.3$. Similarly, they reported higher levels of trait anxiety (43.8, SD=7.6); F(1, 68)=30.4, $p<.001$, $\eta^2_p=.3$. However, analysis of state and trait anxiety scores revealed no main effect of condition (aided vs. unaided) and no group x condition interaction, all tests $p>.05$. Importantly, participants in aided and unaided conditions did not differ on self-rated depression (dysphoric =10.9, SD=8.9; non-dysphoric= 10.2, SD=8.2); t(70)=.74, $p>.05$.

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

	Dysphoric		**Non-dysphoric**		
	Aided (n=18)	**Unaided (n=18)**	**Aided (n=18)**	**Unaided (n=18)**	**p- value**
Age	22.44 (5.8)	20.83 (4.1)	24.11 (8.7)	22.67 (5.2)	p > .05
Gender	4M; 14F	6M; 12F	5M; 13F	5M; 13F	p > .05
NART	27.39 (5.5)	23.17 (8.1)	24.17 (5.4)	22.28 (8.9)	p > .05
STAI-S	39.28 (10.1)[a]	40.33 (9.1)[b]	31.11 (6.5)[c]	28.22 (5.5)[d]	p < .001[1]
STAI-T	43.83 (6.5)[e]	43.72 (8.7)[f]	33.78 (8.1)[g]	33.78 (7.4)[h]	p <.001[2]
BDI	19.10 (4.2)[i]	18.6 (2.8)[j]	2.70 (1.9)[k]	2.9 (2.0)[l]	p < .001[3]

M = Male F = Female; NART =Error score on the National Adult Reading Task; STAI-S = State anxiety subscale of the State trait anxiety inventory; STAI-T = Trait anxiety subscale of the STAI; BDI = Beck Depression Inventory Score on the day participants completed modified TNT task.

[1] mean (a + b) > mean (c + d); [2] mean (e + f) > mean (g + h); [3] mean (i + j) > mean (k +l)

3.2.Memory for target words (same probe)

The percentages of respond and suppress words recalled on the final cued recall test (same probe) were analysed using a 2 (group; dysphoric vs. non-dysphoric) x 2 (condition; aided vs. unaided suppression) x 2 (instruction; respond vs. suppress) x 3 (number of repetitions; 0 vs. 2 vs. 8) mixed factorial ANOVA. Analysis revealed significant main effects of condition, $F(2, 142)=53.83$, $p<.001$, $\eta^2_p= .44$, and repetition; $F(2, 142)=4.17$, $p<.05$, $\eta^2_p=.06$, which were qualified by a significant condition x repetition interaction (see Figure 1), $F(2, 142)=14.42$, $p<.001$, $\eta^2_p=.18$.

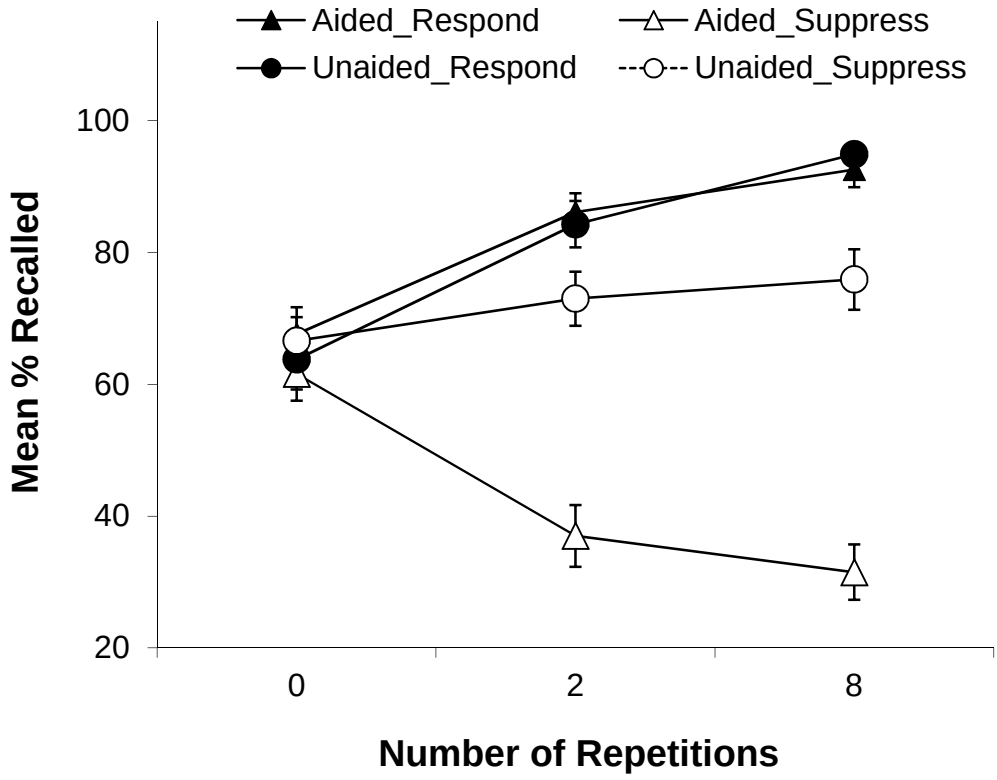

Figure 1: Percentage of words recalled (original probe) by the participants in the unaided and aided conditions, as a function of the type of suppression instructions and the number of times the words were presented during the suppression phase (Error bars show ± one standard error of the mean).

Subsequent pairwise comparisons revealed below-baseline recall in the aided condition, as participants recalled significantly fewer words that had been suppressed twice (M = 37.04, SD = 28.48) or eight times (M = 31.48, SD = 25.44) than words presented only at baseline (M = 61.57, SD = 24.82); t(71)= 3.89, p < .01 and t(71)= 5.17, p < .01 respectively. On the other hand, there was no evidence of below baseline recall in the unaided condition, as participants recalled fewer baseline words (M = 66.67, SD = 21.45) than words that had been suppressed twice (M = 73.61, SD = 26.54) or eight times (M = 75.93, SD = 27.73); t(71)= 1.61, p > .05 and t(71)= 1.69, p > .05 respectively.

The condition x instruction x repetition interaction was not further qualified by an interaction with BDI group; p>.05. However, a significant group x instruction interaction was evident, F(1, 68)=13.87, p<.001, η^2_p=.17. Subsequent pairwise comparisons revealed that dysphoric participants recalled a greater percentage of to-be-suppressed words (M=64.0%, SD=19.0) than did non-dysphoric (M=51.39%, SD=24.7); t(70)=2.44, p<.01. However, the two groups did not differ in their recall of respond words (dysphoric M=79.94%, SD=14.8; non-dysphoric M=83.18%, SD= 15.0); t(70)=.93, p>.05. In order to confirm that this effect was independent of baseline recall, we compared the groups on their recall of baseline and to-be-suppressed words (collapsed across repetition conditions 2 and 8). Dysphoric participants recalled a greater percentage of the to-be-suppressed words (M = 61.81%, SD = 26.46) than did non-dysphoric (M = 47.22%, SD = 31.87); t(70)=2.1, p<.05. However, the two groups did not differ in their recall of baseline words (M = 68.52, SD = 17.72 vs. M = 59.72, SD= 27.13); t(70)=1.6, p>.05.

3.3.Compliance and forgetting in the unaided condition

The extent to which participants complied with suppression instructions might explain the lack of below baseline forgetting in the unaided condition. To tests this, we followed the

procedure from Hertel and Calcaterra (2005) and calculated a compliance score (sum of responses on questions1-3 of strategies questionnaire), which was correlated with the magnitude of the instruction effect (% recall of respond nouns minus % recall of suppress nouns). Results revealed that the size of instruction effect was negatively correlated with the degree of compliance; $r(36)= -.34$, $p<.05$, which shows that participants who did not comply with instructions exhibited less forgetting.

3.4. *Mood, compliance and forgetting*

The size of instruction effect, in both the aided and unaided conditions, was negatively related to depression; $r(36)= -.3.5$, $p<.05$ and $r(36)= -.41$, $p<.05$ respectively. Participants with higher depression scores exhibited poorer forgetting. In the unaided condition, compliance was negatively related to depression; $r(36)= .31$, $p<.05$, such that individuals with higher depression scores were less compliant with suppression instructions. However, forgetting and compliance were not related to participants' scores on state or trait anxiety; all tests $p>.05$.

3.5. Memory for target words (independent probe)

The percentage of words from the respond and suppress conditions that were recalled from on the final cued recall test (independent probe) were analysed using a 2 (group; dysphoric vs. non-dysphoric) x 2 (condition; aided vs. unaided suppression) x 2 (instruction; respond vs. suppress) x 3 (number of repetitions; 0 vs. 2 vs. 8) mixed factorial ANOVA.Only significant main effects and interactions are reported.

Analysis revealed significant main effects of group $F(1, 68)=4.2$, $p<.05$; $\eta^2_p= .06$ and instructions; $F(1, 68)=12.38$, $p<.01$; $\eta^2_p= .15$. Furthermore, the instructions x condition and condition x repetitions interactions were both significant; $F(1, 68)=5.83$, $p<.05$; $\eta^2_p= .08$ and $F(2, 136)=3.36$, $p<.05$; $\eta^2_p= .05$. However, these need to be considered in the light of a

significant condition x instructions x repetitions interaction (Figure 2); F(2, 136)=12.6, p<.001; η^2_p= .16.

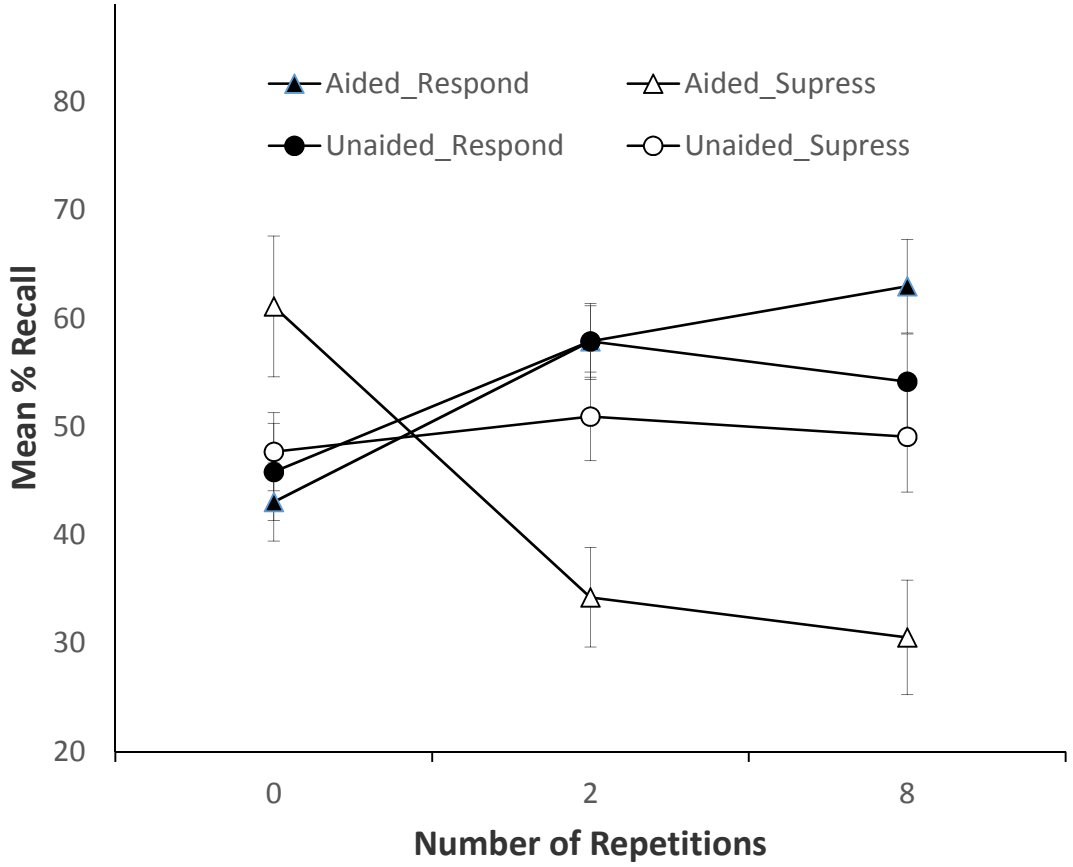

Figure 2: Percentage of words recalled (independent probe) by the participants in the unaided and aided conditions, as a function of the type of suppression instructions and the number of times the words were presented during the suppression phase (Error bars show ± one standard error of the mean).

Subsequent pairwise comparisons revealed that participants in the aided condition recalled more of the targets presented twice and eight times during the think trials than words presented only at baseline; t(35)=3.1, p<.01 and t(35)=3.4, p<.01 respectively. Similarly, participants in the unaided condition recalled a greater percentage of targets presented twice and eight times than words presented only at baseline; t(35)=2.2, p<.05 and t(35)=1.4, p=.09

(one-tailed). In the no think condition, participants in the aided condition recalled significantly fewer targets presented twice and eight times than words presented only at baseline; $t(35)=3.8$, $p<.01$ and $t(35)=6.0$, $p<.001$, demonstrating clear below baseline recall of suppressed targets. On the other hand, participants in the unaided condition failed to demonstrate below baseline recall of words in the no-think trials, as their recall of the words repeated twice and eight times did not differ from their recall of baseline words, all tests $p>.05$.

3.6.Compliance and forgetting in the unaided condition (Independent probe)

The instruction effect on the memory test using the independent probe was negatively correlated with compliance score; $r(36)= -.39$, $p<.05$, which shows that participants who failed to comply with instructions during the no-think trials exhibited poorer forgetting.

3.7.*Mood, compliance and forgetting (Independent probe)*

In the unaided condition, the instruction effect on the memory test using the independent probe was not significantly related to depression score, $r(36)= -.2$, $p>.05$. Similarly, in the aided condition there was no relationship between depression and the size of the instruction effect on the memory test using the independent probes; $r(36)=.09$, $p>.05$.

4. DISCUSSION

The primary aim of our study was to determine if using thought substitution would improve forgetting in a group of participants with subclinical depression (dysphoria). We also aimed to investigate potential mechanisms (blocking or inhibition) that might underpin any observed forgetting effects. To these ends, dysphoric and non-dysphoric participants learned neutral word pairs to criterion (>50% recall) before practicing responding to some cues (think trials) and suppressing the responses to others (no think trials). Finally, participants

completed two different recall tests for the targets; one cued with the original probes and one cued with independent probes.

When cued with the original probes, dysphoric participants had greater difficulty in forgetting previously-suppressed words than did their non-dysphoric counterparts, regardless of suppression condition (aided or unaided). Furthermore, the degree of forgetting on the original probe task was negatively related to depression, with those reporting greater levels of depressed mood exhibiting poorer forgetting of previously suppressed words. Importantly, this relationship was evident in both aided and unaided conditions. The current data are consistent with the findings of Hertel and Gerstle (2003) and the unaided condition of Joormann et al. (2009) who reported impaired forgetting of emotional words in dysphoria and clinical depression respectively. However, forgetting was not related to trait anxiety, which is inconsistent with the findings of Marzi et al. (2014) and suggests that their results might have been a consequence of concurrent depression in their group with high trait anxiety.

Interestingly, there were no group differences (dysphoric vs non-dysphoric) in recall of the targets from the no think trials when memory was cued with independent probes. Furthermore, the instruction effect was not significantly related to depression, which suggests depression did not influence forgetting in the independent probe condition. However, given that independent probes tend to lead to smaller forgetting effects, it is possible that group differences were masked on this task.

In line with Hertel and Calcaterra (2005) and Joormann et al. (2009), we found that participants in the aided condition demonstrated successful below-baseline forgetting, which was enhanced by greater suppression practice. We also replicated the finding of successful forgetting in participants in the unaided condition who self-reported spontaneously using a thought-substitution strategy. However, in general, participants in the unaided condition failed to demonstrate below-baseline forgetting, which is consistent with the findings of

Hertel and Calcaterra (2005) and with several other studies using the TNT task (e.g. Bulevich, Roediger, Balota & Butler, 2006; Hertel & Gerstle, 2003; Mecklinger et al, 2009). One explanation for this finding concerns compliance with suppression instructions, given the observed relationship between forgetting and self-rated compliance, which is consistent with Hertel and Calcaterra (2005). Another possible explanation for the lack of below baseline forgetting in the unaided condition is that, in line with Hertel and Calcaterra (2005), we used related word pairs in contrast to the unrelated word pairs that were used in Anderson and Green (2001). It is also possible that the lack of below baseline in unaided condition was because, in line with other studies that have failed to shown below baseline forgetting (e.g. Bulevich et al., 2006; Hertel & Calcaterra, 2005), we did not play an auditory sound as a warning to participants when they had erroneously responded on a 'no think' trial[4]. Nevertheless, we did display a warning (three large red Xs) at the start of suppression trials to prime the forgetting of targets and repeated this display whenever participants responded with targets on 'no think' trials, so whilst it is possible that the auditory warning may have been more effective than a visual warning a lack of compliance is probably a better explanation.

It is notable that below baseline recall of targets from the no think trials in the aided condition was also observed in the recall test cued with independent probes. This is consistent with Benoit and Anderson (2012) and del Prete et al. (2015) and supports the inhibitory account of thought substitution. However, it is inconsistent with Bergström et al. (2009), as they found no evidence of below baseline forgetting when their participants were cued with independent probes.

In the current study, repeated retrieval of items in the respond condition did not lead to enhanced recall of these targets at final memory testing. One possible explanation for this finding is that respond words were only repeated for a maximum of eight times, whereas

[4] We thank reviewer 1 for this helpful suggestion

previous studies have typically used 12 (Hertel & Calcaterra, 2005) or 16 repetitions (Hertel & Gerstle, 2003). The fact that both groups in the current study showed a similar pattern (i.e. recall of words repeated 2 and 8 times was equivalent) suggests that more rehearsal may have been required in order to lead to enhanced recall, particularly given that the material is of a neutral valence. Future studies should ensure sufficient repetitions to ensure clear rehearsal effects. Nevertheless, it should be noted that the critical question for the current study concerned differences in the recall of previously suppressed words and not words from the respond condition.

As noted above, regardless of suppression condition (aided or unaided), dysphoric participants exhibited poorer forgetting of previously-suppressed words than did their non-dysphoric counterparts. These findings do not support the utility of thought substitution as a viable method of improving forgetting in depressed states, at least not for neutral material. This is contrary to previous studies in clinically depressed patients (Joormann et al., 2009) and dysphoric participants (Hertel & Calcaterra, 2005). Given that the participants in Hertel and Calcaterra (2005) only exhibited mild depression this might account for the lack of a depression-related deficit in their study. However, this explanation cannot account for the contrast in findings between the current study and Joormann et al. (2009). The type of substitutes, on the other hand, might provide an explanation for the variation in findings between these two studies. Joormann et al. (2009) provided participants with emotional words, whereas we used neutral substitutes. Given that emotional material is processed more elaborately than non-emotional (Payne & Corrigan, 2007), it is plausible that emotional substitutes would have been more effective at enabling the participants to suppress targets than would neutral. It remains to be established if emotional substitutes could aid forgetting in dysphoric participants.

It is worth considering the extent to which the current findings can be extended to depressed individuals' everyday memory experiences. As a laboratory based paradigm the TNT may be somewhat removed from the way in which people tend to use their memory in their everyday lives. Furthermore, it is clear that memory processes of depressed and dysphoric individuals tend to be dominated with largely negative personal memories (Dalgleish & Werner-Seidler, 2014) rather than neutral words with little personal relevance. It is also the case that forgetting on the TNT is initiated by the experimenter and not by the individual themselves. Nevertheless, there is evidence, in healthy participants at least, that individuals who exhibit higher levels of laboratory-induced forgetting tend to recall fewer negative (and more positive) autobiographical memories than those who exhibit poorer forgetting (Storm & Jobe, 2012). Therefore, an implication of the current findings is that dysphoric participants would be expected to recall fewer positive and a greater number of negative autobiographical memories. In line with this prediction, there is a body of work demonstrating this pattern in depressed and dysphoric participants (Williams et al., 2007). Also consistent with this notion are studies using variants of the TNT task that have provided evidence of intentional forgetting of autobiographical memories (Noreen & MacLeod, 2012; 2013; Stephens et al., 2013).

Another implication of the current findings is that individuals with depression would be expected to experience greater mind wandering (task irrelevant thought) in comparison to non-depressed participants. In line with this notion, Smallwood, O'Connor, Sudbury and Obonsawin (2007) reported that, in comparison to non-dysphoric participants, dysphoric individuals experienced greater mind wandering, which has been shown to result in the encoding of less detailed episodic memories (Smallwood, Baracaia, Lowe, & Obonsawin, 2003). Interestingly, the content of the task irrelevant thought was not necessarily negative in valence. Importantly, Smallwood et al. (2007) proposed that the decoupling of attention from

the current environment that occurs during mind wandering could contribute to the well-documented tendency of depressed and dysphoric individuals to recall less detailed autobiographical memories (Williams et al., 2007). This notion is supported by findings of Williams, Teasdale, Segal, and Soulsby (2000) who reported that mindfulness based cognitive therapy, which reduces task irrelevant thought, improved the retrieval of specific memories in previously depressed patients. Taken together, it would appear that the current findings, which suggest that dysphoric participants have a problem with general inhibitory control of their memories, have clear implications for their everyday memory experiences.

A limitation to the current study that needs to be considered is the sample size. Although our study was sufficiently powered to detect medium effect sizes, some of the observed effects were smaller and hence the cell sizes may have been too small to establish a reliable effect (Lakens & Evers, 2014). Future studies examining forgetting in dysphoria need to ensure that sample sizes are sufficient to ensure stability of the observed effects.

In conclusion, we confirmed previous findings that thought substitution improves forgetting on the think-no-think task and that repeated practice at suppression using this method improves forgetting. Moreover, we demonstrated below-baseline forgetting on the independent probe task, which supports the inhibitory account of thought substitution. However, we also found clear evidence that subclinical depression (dysphoria) is associated with impaired forgetting of previously suppressed items and that thought substitution did not eliminate this deficit. Taken together, our data do not support the utility of thought substitution as a method of improving forgetting in depressed individuals.

Conflicts of Interest

Neither Dr Ridout nor Dr Noreen have any conflicts of interest to declare

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