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Suppression-induced forgetting on a free-association test

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The repeated suppression of thoughts in response to cues for their expression leads to forgetting on a subsequent test of cued recall (Anderson & Green, 2001). We extended this effect by using homograph cues and presenting them for free association following suppression practice. Cue–target pairs were first learned under integrating imagery instructions; then in the think/no-think phase students practised suppressing thoughts connected to some homograph cues, with or without the assistance of thought substitutes that changed their meaning. Below-baseline forgetting on the subsequent free-association test was found in the production of suppressed targets. Following aided suppression this effect was also obtained in the production of other responses denoting the target-related meaning of the homograph cues. Discussion emphasises the ecological value of the test; rarely do people deliberately attempt recall of unwanted thoughts.

Keywords: Forgetting; Implicit memory; Suppression; Inhibition; TNT.

Much of our everyday ''remembering'' seems to occur on an involuntary basis as we are indirectly cued to experience thoughts of related events from the past. This often-fortunate mental characteristic has been observed in the laboratory on tests of implicit memory. The characteristic becomes unfortunate, however, when the thoughts that come to mind are unwanted as well as not deliberately sought (see Brewin, 2006). Implicit tests should therefore provide evidence about the circumstances under which unwanted and unbidden thoughts can be reduced.

Research performed with the think/no-think (TNT) paradigm reveals that repeated attempts to suppress unwanted thoughts clearly reduce the likelihood that they will be later recalled when deliberately sought (Anderson & Green, 2001; Anderson & Levy, 2009). TNT experiments consist of a first phase of learning cue–target pairs, followed by a phase of recalling targets given some cues and suppressing thoughts of targets given other cues; finally all cues, including some not shown during the TNT phase (baseline), are presented for final recall. Below-baseline recall of suppressed targets constitutes evidence of suppression-induced forgetting (SIF). According to Anderson and Levy, the mechanism responsible for SIF is inhibition at the level of the target's representation in memory, because SIF has been obtained not only with the original cues but also with independent cues semantically related to the targets. Forgetting obtained with the original cues can be explained with other interference mechanisms of associative cueing, particularly given evidence that SIF is exaggerated by the use of thought substitutes during suppression attempts (e.g., Hertel & Calcaterra, 2005). In the current endeavour we were interested in interrupting associative cueing in the absence of deliberate attempts to remember. Unwanted and possibly

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intrusive thoughts that are associated with original cues constitute the troublesome thoughts likely to be the targets of suppression attempts. Thus assessing SIF with original cues on an implicit memory test is an important step in investigations of desirable forgetting.

To our knowledge there is just one set of experiments performed to assess SIF with an implicit test: Algarabel, Luciano, and Martinez (2006) found above-baseline latencies on a lexical-decision task with the original cues as primes. Unfortunately lexical decisions provide poor models for thought intrusions. And we cannot be certain that the effects were strategy-free, given that they were found only for longer SOAs. Several different implicit tests have been used to investigate the related phenomenon of retrieval-induced forgetting (RIF). In RIF the cause of forgetting is the practice of retrieving only some items connected to category cues during learning, with the effect of impairing recall of unpractised items from those categories relative to items from unpractised categories. RIF and SIF are similar when substitutes are employed to aid suppression in the TNT paradigm. Without substitutes the two phenomena differ because SIF is achieved more directly and therefore depends on mechanisms of control to a greater extent (Bergstrom, de Fockert, & Richardson-Klavehn, 2009; Hanslmayr, Leipold, Pastoetter, & Bäuml, 2009).

RIF has sometimes not been found on the perceptually based implicit tests of stem completion and perceptual identification (Perfect, Moulin, Conway, & Perry, 2002; but see Bajo, Gomez-Ariza, Fernandez, & Marful, 2006). These attempts involved shifts from learning and retrieval-practice phases that were primarily conceptual to a test phase that emphasised perceptual or lexical features. Changing the nature of the processing seems to be one way to disrupt RIF and maybe SIF. Indeed, two reports (Camp, Pecher, & Schmidt, 2005; Perfect et al., 2002) document below-baseline forgetting on category generation and verification—tests inviting associative procedures similar to those invoked in prior phases. These findings encourage the use of a conceptually guided implicit test in the TNT paradigm. Moreover, conceptual tests correspond to real-world situations in which unwanted thoughts are conceptually cued. We therefore chose the implicit test of free association.

Because no measure of memory is process pure, minimising effects of controlled recollection during free association was an important goal in designing this implicit measure. To this end we chose homographs as cues, believing that their multiple meanings might encourage less-obvious connections to earlier phases. Furthermore, homographs can clearly function as cues for forgetting on explicit tests. Shivde and Anderson (2001) found RIF in the explicit recall of targets connected to the dominant meanings after participants had practised recalling targets connected to the weaker meanings. Hertel and McDaniel (2009) found SIF for targets that established emotionally negative meanings after participants suppressed those targets with or without the help of substitutes denoting benign meanings, although the substitutes exaggerated the effect for participants who scored high on a measure of repressive coping. In the case of an implicit free-association test, homographs have the additional advantage of providing another means of evaluating SIF, beyond the measure of exact target production. Responses to homographs can be categorised in terms of the meaning of the cues that they reflect, and homographs thereby provide a wider net for capturing evidence of SIF through responses that denote non-target related meanings. If the original cue–target pair was *chest–hair*, for example, we scored categorical performance to reflect the extent to which participants produced words like *muscle*, *breast*, or *hair* (target-related responses) versus *drawer*, *cabinet*, or *treasure* (target-unrelated responses) when given *chest* for free association.

For comparison purposes the present design included a condition in which participants were given substitutes to aid suppression (e.g., *treasure* to aid the suppression of *hair* in response to *chest*). Practising the alternative meaning of homographs in the aided condition clearly should establish SIF on the free-association task; the question was whether categorical performance would remain at baseline levels or above in the unaided condition. A continued focus on the target-related meaning of the cues might even result in above-baseline responding, whereas spontaneous reinterpretation of cues should lead to below-baseline responding. (See Anderson & Bjork, 1994, for discussion of cue-bias models of forgetting.) More generally, compared to results from explicit tests, below-baseline forgetting via either implicit measure—categorical or target performance—would provide a broader basis for recommending the practice of suppression for the purpose of eliminating unwanted thoughts.

In short, we performed a TNT experiment with several atypical features, the most important of which was an implicit test of free association to cues from the studied pairs. Second, half of the cue–target pairs contained homographs as cues. The non-homograph cues were included to reduce attention to the homographic nature of the homographs, but only the homographs were used on the free-association test. Third, we included a factor for whether suppression attempts during the TNT phase were unaided or aided by substitutes designed to encourage forgetting through cue reinterpretation. Our goal was simply to provide evidence of SIF on a test that does not instruct deliberate recall, given that unwanted memories should rarely be sought deliberately. We gauged forgetting in terms of the below-baseline production of suppressed targets from the learning phase as well as below-baseline production of responses that denoted target-related meanings of the cues. In the latter regard, we predicted that suppression aided by reinterpretive substitutes would produce the best forgetting on our implicit test.

METHOD

Participants and design

Students in an introductory psychology and neurosciences courses at Trinity University (43 men and 45 women) participated for course credit.[1] With the constraint of equal cell sizes, students were assigned randomly to combinations of the aided or unaided method of suppression (40 and 48 participants to each condition respectively),[2] the TNT role of suppression or baseline, and to one of four list conditions for counterbalancing materials with experimental role.

Materials and design

Experimental materials consisted of 24 homographic and 24 non-homographic triplets (cue, target, substitute; e.g., *straw*, *hat*, *glass*; *canvas*, *tent*, *painter*). Within cue type these triplets were organised into four sets of six. For each participant one set of homographs and one set of non-homographs were used to cue responding during the TNT phase and another set of each type cued suppression. A third set of each was learned but did not appear in the TNT phase and served as baseline cues on the free-association test. The remaining two sets served as new cues on the free-association test and therefore did not appear in prior phases. All sets were counterbalanced with experimental roles. (Six additional non-homograph pairs were used as fillers during learning and TNT phases and 16 served as test fillers.) Prior to the current experiment these materials had been used to replicate SIF on a traditional test of cued recall.[3] Sets were balanced on the forward association strength between each cue and its corresponding target and substitute (Nelson, McEvoy, & Schreiber, 1998) and the mean concreteness ratings of the targets and substitutes (obtained from 18 Trinity University students). In addition, homographic sets were balanced on category frequency of targets and substitutes, obtained by summing the forward associations between each homograph and all responses reflecting the same interpretation as the target and (separately) the substitute (e.g., for the cue *pitcher* we summed across *beer*, *tea*, *lemonade*, etc., separately from *baseball*, *catcher*, *ball*, etc.). The categories chosen for targets were higher in frequency than those chosen for substitutes ($M = .52$ vs .28)—a choice intended to facilitate substitutes' ability to incur retrieval-induced forgetting (see Shivde & Anderson, 2001).

[1]Students were screened on the basis of their repressive orientation by modifying the system used by Myers and Derakshan (2004); we chose individuals who fell below the median on a test of trait anxiety and above the median on a test of social desirability. The use of this screening procedure was informed by Hertel and McDaniel's (2009) finding that repressors produced superior below-baseline forgetting.

[2]The data from one male student in the unaided suppress condition were set aside, due to self-reported depression at the end of the session. (See Hertel & Gerstle, 2003, for evidence that depressed students fail to show SIF.)

[3]Suppressed targets were recalled less well than baseline targets, $F(1, 32) = 22.54$, $MSE = 170.15$, $p < .001$, $\eta_p^2 = .41$. Furthermore, SIF depended on the suppression method, $F(1, 32) = 4.50$, $p = .042$, $\eta_p^2 = .12$. The effect was larger in the aided condition, but it was also significant in the unaided condition, $F(1, 16) = 8.05$, $MSE = 72.93$, $p = .012$, $\eta_p^2 = .34$. Apart from trends for main effects of method and cue type, all other effects were non-significant, $p > .384$. Although homographs tended to be less well recalled (and less well learned initially) than non-homographs, SIF did not depend on the nature of the cues.

Procedure

Learning phase. All phases were programmed in Superlab Pro (Version 4.07; Cedrus Corporation, San Pedro, CA). The 36 word pairs in the learning phase were organised into six randomised blocks, each block containing two cues (one homograph and one non-homograph) that would later play the TNT role of cueing a response, two for cueing suppression, and two to be reserved for baseline. Three filler pairs appeared at the beginning and three at the end. We instructed participants to construct a mental image of each pair to help them remember the targets. Each pair was presented for 5.2 seconds in black against a white background and followed by a blank screen for 500 ms and then a scale for rating the vividness of the image (1 = not vivid, 7 = very vivid). Ratings were reported aloud and keyed by the experimenter.

As a check on learning we next presented the cues and asked participants to respond with the targets. Each cue remained on the screen for a maximum of 5.2 seconds (less if the response occurred earlier), after which time the target was displayed in blue for 2 seconds. Block order replicated the order of initial presentation, with the exception that all six fillers appeared at the beginning. If participants recalled fewer than four of the six targets (for each type of cue) to be assigned to baseline or suppression conditions in the TNT phase, another recall test was given. (Every participant met these criteria by the third test.)

TNT phase. Next, participants engaged in a practice phase of think/no-think with the six filler cues, followed by an interactive questionnaire to encourage compliance. Then the aided participants studied the 12 cue–substitute pairs, reading them aloud during their presentation in black at a 5-second rate. In the main TNT phase the 12 cues for suppression and the 12 cues for responding were each presented for 3 seconds on 12 occasions; in each round their order replicated the randomised-block order in the learning phase.[4] Green cues signalled the recall of targets, which were presented in blue at the end of the 3 seconds if the participants failed to recall them aloud to the experimenter. Red cues signalled suppression, and instructions emphasised the importance of looking at the cues while preventing thoughts of the targets from coming to mind. Participants in the aided condition were also instructed to think about and recall the substitute aloud. If participants responded with the target on suppression trials, large red Xs appeared on the screen. If aided participants failed to say the substitute, it was presented in blue at the end of the trial.

Following the TNT phase we administered a questionnaire to assess compliance with suppression instructions and to provide a mock ending to the experiment. Participants filled it out privately and placed it in an envelope, with the understanding that the experimenter would not see its contents.

Free-association test. Following the compliance questionnaire (the "end" of the experiment), the experimenter delivered the cover story by asking for help with a pilot study for a named professor. The experimenter said that for some participants there might be minor overlap in materials, but the tasks are entirely different, because the professor is studying free associations. Participants were asked to blurt the first word that comes to mind and were told they could say more than one if more than one occurred to them.

The test presented 6 old homographs from the learning phase, 6 new homographs (that served as old cues for other participants), and 16 new non-homograph fillers. Thus 21% of the cues had been seen before the test as cues for either suppression or baseline. Although it made detection of SIF more difficult, the manipulation of TNT role as a between-participants factor was necessary as a means of reducing recollective tendencies.

All cues were presented in white on a blue background. First, four fillers were presented, then six blocks of four cues each: one old homograph (a prior cue for suppression or baseline), one new homograph (from the set never presented in earlier phases), and two fillers. Each cue was presented for 2 seconds, with a 1-second inter-stimulus interval. Participants responded aloud, and the experimenter noted the responses.

The test was followed by another questionnaire, beginning with a short paragraph about individual differences in free associations and this preamble: "When responding to items on the free association test, how often did you ..." Seven items were listed, each with five response alternatives (0 = never, 1 = rarely, 2 = sometimes, 3 = frequently, 4 = very frequently). Most items were

[4]The same randomised-block order was maintained across phases to reduce variability associated with differential delays.

included merely to disguise our interest in their responses to Item 5 (“deliberately respond with words from the experiment”) and 7 (“respond quickly off the top of your head”).

Results and discussion

We measured performance on the free-association task in two main ways: Percentage of responses indicating that the cue was interpreted to have the meaning denoted by the target (categorical responses) and percentage of targets produced (target production). Each variable was submitted to a mixed-design analysis of variance, with between-subjects factors for suppression method (unaided vs aided) and TNT role (baseline vs suppress) and the within-subjects factor of prior exposure in earlier phases (whether cues were old or new).

Categorical responding

The three-way interaction was significant, $F(1, 83) = 7.05$, $MSE = 455.49$, $p = .009$, $\eta_p^2 = .08$. (All other effects in the design were also significant, $p < .012$.) As expected, categorical responses to new cues on the free association test did not differ significantly according to any factor in the design ($p > .844$, $M = 50.3$, $SD = 19.2$). Moreover, the mean percentage for new cues corresponded closely to the mean category frequencies obtained from the South Florida norms ($M = 52.3\%$). For old cues the simple interaction of suppression method and TNT role was significant, $F(1, 83) = 12.52$, $MSE = 465.15$, $p = .001$, $\eta_p^2 = .13$. As depicted in Figure 1 this interaction signifies that below-baseline production of categorical responses was more impaired if prior suppression had been aided by substitutes. Yet unaided participants did produce fewer categorical responses if the targets had been suppressed than if they served as baseline, $F(1, 83) = 4.95$, $p = .029$, $\eta_p^2 = .06$.

Even though SIF was obtained in the unaided condition, responses related to the target category were produced more frequently if the cues had been used for suppression than if they were new, $t(22) = 2.38$, $SE = 7.44$, $p = .027$. In contrast, participants who used substitutes produced fewer categorical responses to suppression cues than to new, $t(45) = -2.38$, $SE = 7.06$, $p = .028$.

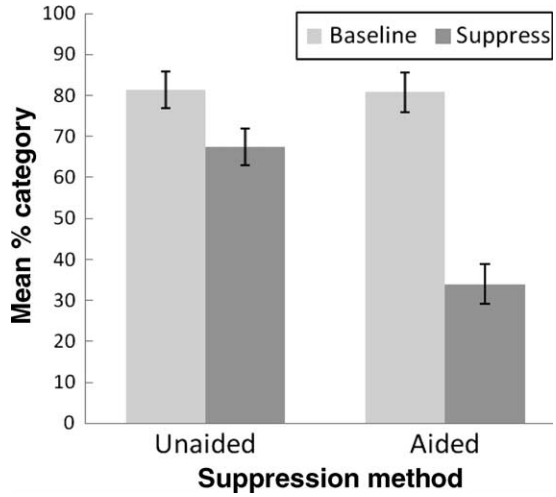

Figure 1. Mean percentages of categorical responses to homographs (responses denoting the same meaning of the cue as established by the targets). Error bars represent one standard error of the mean. Categorical responses to new homographs occurred at a 50% rate.

Target production

Table 1 reports the mean percentages of targets produced. The three-way interaction was not significant ($p = .193$). All other effects reached significance ($p < .028$). To facilitate comparison with the categorical results, however, we analysed target production within each level of prior exposure. This analysis revealed no significant effects in responding to new cues ($p > .532$, $M = 11.1$, $SD = 12.0$). Again, production levels in response to new cues were similar to those obtained from the South-Florida norms ($M = 9.5\%$). For old cues the simple interaction of suppression method with TNT role was not significant, $p = .082$, but significant simple main effects of method and TNT role obtained: Substitutes impaired target production, $F(1, 83) = 7.58$, $MSE = 517.56$, $p = .007$, $\eta_p^2 = .08$; and targets were produced less often if they had been suppressed, $F(1, 83) = 19.99$, $p < .001$, $\eta^2 = .19$. Pursuing our comparison with the categorical results, we found that the production of suppressed targets by unaided participants fell below baseline production, $F(1, 83) = 3.99$, $p = .049$, $\eta_p^2 = .05$.

Other responses indicating target-denoted meaning

An additional analysis was performed on the difference between categorical and target production

TABLE 1
Mean percentages of targets, other target-related responses, and substitutes produced in free association (*SD*)

	Old		*New*	
	Baseline	*Suppress*	*Baseline*	*Suppress*
Targets				
Unaided TNT	58.2 (23.1)	44.9 (25.3)	10.6 (11.9)	11.2 (11.0)
Aided TNT	53.3 (22.2)	22.8 (19.6)	12.7 (15.2)	10.0 (10.0)
Other target-related responses				
Unaided TNT	23.2 (20.9)	22.5 (22.0)	40.1 (19.2)	38.5 (20.7)
Aided TNT	27.5 (20.6)	11.2 (12.6)	37.5 (16.9)	40.8 (14.6)
Substitutes				
Unaided TNT	3.9 (7.8)	3.6 (7.0)	8.6 (11.2)	6.7 (11.1)
Aided TNT	4.3 (9.4)	43.5 (24.8)	6.0 (10.0)	6.0 (8.4)

Unaided baseline $n = 24$, aided baseline $n = 20$, unaided suppress $n = 23$, aided suppress $n = 20$.

in response to old cues, to determine whether SIF on the categorical measure actually reflected a reduction in non-target responses that reflected the target-related meaning of the homograph.[5] These means are also reported in Table 1 (as are mean responses to new cues for which all effects were non-significant, $p > .224$). In the analysis of responses to old cues the main effect of TNT role was significant, $F(1, 71) = 4.20$, $MSE = 348.68$, $p = .044$, $\eta_p^2 = .06$. However, it was qualified by the interaction of role with suppression method, $F(1, 71) = 4.06$, $p = .048$, $\eta_p^2 = .05$. Without the provision of substitutes, means in the baseline and suppress conditions were obviously similar ($p = .907$). In the aided condition, however, participants who used substitutes to suppress thoughts of the targets produced fewer responses that denoted the target meaning of the homograph, compared to those who used substitutes for other purposes (baseline), $F(1, 32) = 12.45$, $MSE = 214.31$, $p = .001$, $\eta_p^2 = .28$. Thus the use of substitutes that changed the meaning of the cues reduced not only the percentage of target responses but also the percentage of other words that indicated a similar interpretation of the cue.

Substitute production

The results from analyses of substitute-related responses (including substitutes) mirrored those from categorical responses. Along with all lower-order effects, the three-way interaction was significant, $F(1, 83) = 11.90$, $MSE = 345.45$, $p = .001$, $\eta_p^2 = .12$. Substitute-related responses to old cues were not significantly greater in the unaided suppression condition than in the unaided baseline condition, $p = .259$ ($M_{suppress} = 22.9$, $SD = 21.5$; $M_{baseline} = 16.5$, $SD = 16.6$). The corresponding difference in the aided condition was significant, $F(1, 83) = 50.46$, $MSE = 369.28$, $p < .001$, $\eta_p^2 = .38$ ($M_{suppress} = 59.8$, $SD = 22.6$; $M_{baseline} = 16.7$, $SD = 15.3$). Substitute-related responses to new cues averaged 39.9% ($SD = 19.4$) and did not differ significantly according to other conditions ($p > .262$).

Means for exact substitute production are reported in Table 1. In addition to all lower-order effects, the three-way interaction was significant, $F(1, 83) = 28.60$, $MSE = 132.69$, $p < .001$, $\eta^2 = .26$. The large percentage produced to old cues in the aided suppression condition accounts for all effects, and the difference in response to old cues between unaided suppression and baseline conditions was non-significant ($p = .903$). These results (and the results from the analysis reported in the previous section) failed to support the spontaneous use of cue reinterpretation as a strategy during unaided suppression.[6]

[5]To reduce error variance a list factor representing the rotation of materials across conditions was also included in the design.

[6]Other, unanalysed responses to the cues for free association included words indicating a third meaning of the homographs (a total of 6 out of 522 responses), words of unknown inspiration (9), and cue repetition (1). On 10 occasions participants failed to respond. These frequencies were distributed approximately evenly across experimental conditions, with the exception of the third-meaning responses; five of the six instances occurred in the unaided suppress condition and are consistent with efforts to reinterpret cues.

Criterial learning

Percentages correct on the learning test in phase 1 (the test that met the criterial level of recall within each category) were analysed by including a within-subjects factor for cue type (homographs vs non-homographs). The only significant effect in this four-factor design was the main effect for cue type, $F(1, 83) = 30.90$, $MSE = 115.98$, $p < .001$, $\eta_p^2 = .27$ ($M = 86.0$ for homographs and 92.4 for non-homographs). Because test cues were all homographs, we also performed the analysis by excluding non-homographs and found no significant effects, $p > .130$. Therefore differences in free association probably did not depend on the degree of initial learning.

Self-reported strategy use

A measure of non-compliance with suppression instructions during the TNT phase was computed from responses to three items on the questionnaire administered at the end of that phase (the mock ending to the experiment). No significant differences according to suppression method or TNT role on the test were found, $p > .192$. Reported compliance was excellent; the overall mean of .73 ($SD = .66$) indicated that participants very rarely tried to remember targets on suppression trials (1 = rarely). Another item on this questionnaire enquired about the voluntary use of substitutes by unaided participants; the reported frequency of use did not differ according to TNT role on the test, $p > .567$ ($M = 3.06$, $SD = 1.28$; 3 = *frequently*).

The final questionnaire asked participants to report about the use of two main strategies during free association. Table 2 presents the mean ratings for how quickly participants responded "off the top of their heads". The overall mean rating was 3.5 ($SD = .63$)—somewhere between *frequently* (3) and *very frequently* (4)—and did not depend on experimental conditions, $p > .16$.

Table 2 also presents mean ratings for the deliberate production of words from "the experiment". Participants reported using this strategy somewhat more than rarely ($M = 1.4$, $SD = 1.3$, where 1 = *rarely* and 2 = *sometimes*). Ratings did not depend significantly on experimental conditions, $p > .367$; although they tended to be higher in the baseline conditions. Ratings were non-significantly correlated with the percentage of categorical responses, $r(85) = .11$, $p = .324$, but significantly correlated with the percentage of targets, $r(85) = .29$, $p = .007$. However, correlations with target production within each condition were non-significant ($p > .174$) in all except the aided baseline condition, $r(19) = .47$, $p = .035$. In general participants seemed to have treated the test as an implicit test, although baseline target production might have been inflated by deliberate recall following substitute-aided suppression; this outcome suggests that SIF might have been overestimated in the aided condition.

In an effort to further address the issue of contamination by recollective processes and as a final set of analyses, we omitted the free-association data from the participant who reported the most deliberate use of targets in each materials condition (used for counterbalancing) within each cell of the design. The resulting means for categorical and exact target responses to old cues are presented in Table 2. The patterns of means are close to those obtained for the full set of participants, although with the reduction in power SIF was non-significant in the unaided condition for both measures ($p = .177$ for categorical and $p = .133$ for exact target). In the aided condition SIF was significant. For categorical responses, $F(1, 30) = 58.54$, $MSE = 353.15$, $p < .001$, $\eta^2 = .66$; for exact targets, $F(1, 30) = 17.41$, $MSE = 425.12$, $p < .001$, $\eta^2 = .37$.

TABLE 2
Mean strategy ratings and adjusted mean categorical and exact target percentages (*SD*)

	Unaided baseline	*Unaided suppress*	*Aided baseline*	*Aided suppress*
Fast responding	3.6 (.58)	3.6 (.66)	3.4 (.60)	3.4 (.69)
Deliberate use of experiment words	1.5 (1.1)	1.3 (1.3)	1.6 (1.6)	1.4 (1.1)
Adjusted percentage of categorical responses	79.5 (18.2)	68.8 (29.5)	80.4 (15.9)	29.6 (21.3)
Adjusted percentage of exact targets	55.8 (22.7)	43.8 (26.7)	49.4 (22.0)	19.0 (19.1)

Values for the rating scale: 0 = never, 1 = rarely, 2 = sometimes, 3 = frequently, 4 = very frequently. Adjusted percentages computed for 20 participants in each unaided condition and 16 participants in each aided condition.

GENERAL DISCUSSION

Following the same procedures that have produced SIF on tests of cued recall, we report SIF as participants freely associated to the same cues in an ostensibly unrelated task. Participants produced fewer targets if they had suppressed thoughts of those targets during the TNT phase, regardless of assistance from experimentally provided substitutes but clearly helped by them. Moreover, the effect was found in a between-participants comparison with baseline performance (the first evidence obtained in this way) and with inherently related cue–target pairs—both features being ones that, on logical grounds, would appear to increase the difficulty in obtaining evidence of SIF. On a theoretical level the target-production results suggest that an explicit test is not necessary for achieving SIF, although they do not provide undisputable evidence against the involvement of controlled recollection, which is reduced but probably not eliminated on implicit tests. Our new approach to measuring SIF in free association—the evaluation of performance according to whether the responses reflected the same meaning of the homographic cues as did the targets—similarly revealed SIF. This categorical measure was also designed to assess the possible reinterpretation of homographs as a spontaneous strategy for suppression. Categorical responses aligning with substitutes occurred more frequently following suppression cues in the unaided condition, compared to baseline, although not significantly so, and thereby failed to support a voluntary cue-reinterpretation strategy. When the strategy was provided, however, it was used with obvious success.

Because no memory test is a pure measure of automatic responding, a possible explanation for the free-association results is that the test invited reflection on prior experimental phases. Camp et al. (2005) found RIF on a conceptual implicit test only when participants were aware of a connection between test items and prior phases. We did not assess such awareness because we thought a brief mention of the possibility of overlapping materials followed by a refocus of purpose would sidestep temptations to speculate. In further efforts to discourage deliberate reflection on prior phases, we allowed only 3 seconds for both reading and responding to the cue. Self-report ratings on the questionnaire indicated some intentional use of ''experiment'' words, but the correlation between ratings and target production was significant only for participants who received baseline cues following aided suppression. Thus the test might have functioned more implicitly in the unaided condition. On the other hand, we found similar patterns when the data from the more deliberate participants were set aside. It is also important to consider that self-report ratings might merely indicate awareness that accompanies retrieval instead of intentional attempts to retrieve; even in that regard, such awareness was not related to results in the unaided condition. More generally, given the occasional reported failure to find SIF in the TNT paradigm (e.g., Bulevich, Roediger, Balota, & Butler, 2006), evidence of SIF on a task that perhaps merely minimises recollection instead of eliminating it is notable for extending the generality of the effect, particularly to situations with better applicability to the problem of intrusive thoughts. (See Anderson & Huddleston, 2011, for a review of the many replications of SIF.)

A question likely to be raised concerns the relevance of our results to inhibition accounts of SIF (Anderson & Levy, 2009). In an earlier use of free associations to homographs to test the role of inhibition in semantic memory, Johnson and Anderson (2004) examined the production of words related to the stronger meanings of the cues after eight trials of retrieving words related to the weaker meanings (e.g., *prune*, *fruit*, *trim*) and found a non-monotonic relation between repetition and target production that can be explained by inhibition operating against initial interference. Their free-association cues were independent associates of the stronger meaning (e.g., *yogurt–fruit*), whereas we merely cued with the original homographs. Once our cues were reinterpreted through practice with substitutes, there was no requirement or opportunity to reconsider their initial meanings. Viewed differently, homograph cueing does not assess inhibition-based explanations of SIF. In the only other published test of SIF on an implicit test, Algarabel et al. (2006) failed to find slowing in lexical decisions following independent cues. However, our results are not inconsistent with an inhibition account. Even success at SIF via substitutes does not belie the sufficiency of an inhibition account, given that substitutes can function like practised items in an RIF paradigm and invite the inhibition of targets that initially come to mind.

An important distinction for the interpretation of the free-association results, particularly in the aided condition, concerns the difference between the tendency to produce the target in response to the cue and the ability to do so, given more opportunity. Although we instructed participants that more than one response could be produced in response to the cues, the speed with which cues were presented (in order to discourage recollection) functionally prevented multiple responses. The paradigm, therefore, constitutes a free-association version of a modified free recall test, in which the first response that comes to mind is produced, instead of a modified free recall test, which allows memory for multiple associates to be revealed. (See Anderson & Neely, 1996, for a review of early interference paradigms.) This consideration might explain the SIF effect in the aided condition, in which recently practised substitutes were frequently produced on the free-association test. (In contrast, this time constraint does not operate on explicit tests; e.g., the recall experiment we performed with these same materials; Hertel & Calcaterra, 2005; Hertel & McDaniel, 2009.) On the other hand, free associations in the unaided condition were logically less susceptible to alternative dominant responses, and SIF was still found. Nevertheless, a conservative approach to interpreting the free-association data dictate a conclusion about the reduced *tendency* to respond with targets following suppression practice, instead of a reduced ability. The tendency, after all, is what counts in the real world as thoughts pass quickly through our minds.

We close by considering the relation between our findings and results from Wegner's thought-suppression method (e.g., Wegner, Schneider, Carter, & White, 1987). Such results are offered as justification for recommending against the suppression of intrusive thoughts, because when periods of suppressing a specific thought are followed by periods in which the thought is allowed expression, rebound effects sometimes occur (cf. Purdon & Clark, 2000). Like our free-association task, this expression period is not initiated by recall instructions (as is typical in TNT experiments), yet we found SIF and not rebound. It is also worth noting that a thought substitute prevented rebound in the original study by Wegner et al. Clearly, other methodological details beyond substitutes and instructions for expression distinguish the two paradigms; however our results should help to reopen investigations of the utility or folly of suppressing unwanted thoughts.

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