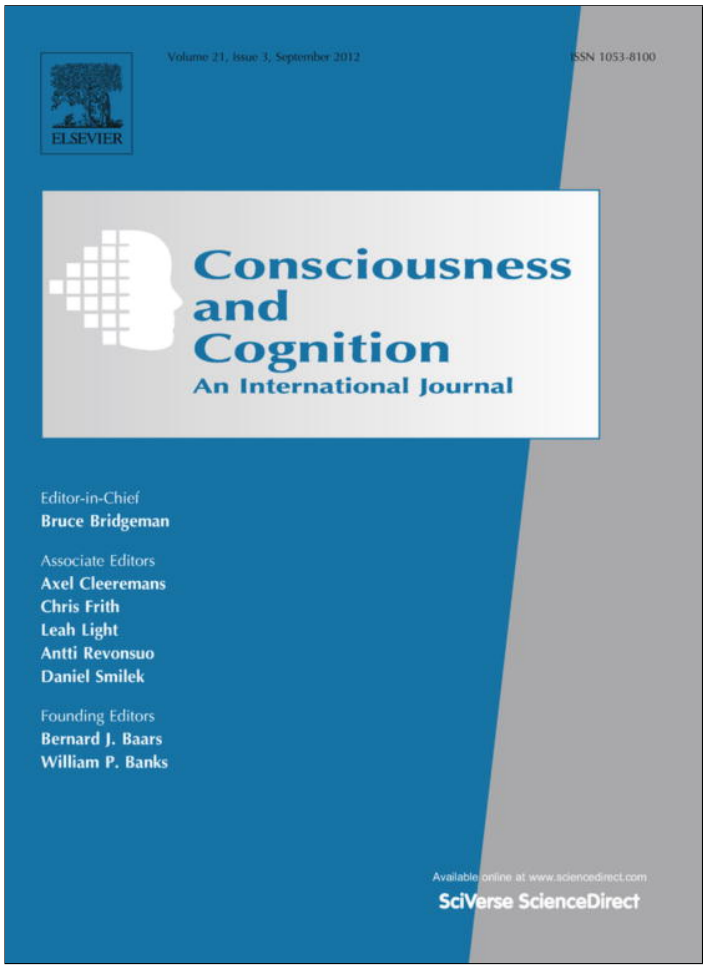

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Short Communication

Suppression of novel stimuli: Changes in accessibility of suppressed nonverbalizable shapes

Rhiannon E. Hart [a,*], Jonathan W. Schooler [b]

[a] Rochester Institute of Technology, 18 Lomb Memorial Drive, Rochester, NY 14623, United States
[b] University of California, Santa Barbara, United States

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ABSTRACT

Recently, a new method of considering successful intentional thought suppression has emerged. This method, the think/no-think (TNT) paradigm has been utilized over a multitude of settings and has fairly robustly demonstrated the ability to interfere with memory recall. The following experiment examined the effect of intentional thought suppression on recognition memory of nonverbalizeable shapes. In this experiment, participants learned word–shape targets. For some of the pairs, they rehearsed the shape when presented with the word; for others, they suppressed the shape when presented with the word. Finally, participants were shown multiple shapes, one at a time, and asked to identify which they had previously seen as paired with a word. Results of the experiment indicated that, similar to results involving words, participants were less accurate in identifying suppressed shapes, as compared to rehearsed shapes. Implications of these findings are discussed.

1. Introduction

Although it is inherently challenging to control the contents of thought (Wegner, Quillian, & Houston, 1996), there are many contexts in which cognitive control can influence subsequent memory performance. Research on intentional forgetting indicates that people can deliberately forget information in a manner that reduces its subsequent availability, as assessed by recall memory (Whetstone, Cross, & Whetstone, 1996). Retrieval-induced forgetting research has revealed that forgetting occurs when individuals selectively retrieve certain information, hampering the recall of competing, nonretrieved information (Anderson & Bell, 2001; Ciranni & Shimamura, 1999). Most recently, the think/no-think (TNT) paradigm has revealed that deliberate efforts to avoid thinking about previously learned associations can impair subsequent cued recall (Anderson & Green, 2001).

In the TNT paradigm, participants initially learn a set of paired associates, then subsequently engage in one of three types of post-encoding activities for each pair: rehearsal (participants view the cue and attempt to recall the target), suppression (participants view the cue and attempt to not think about the target), or control condition (participants do not view the cue). When given subsequent cued recall test with all items, results reveal (not surprisingly) that suppressed items are less likely to be recalled than items that were not seen since encoding. This means, in essence, that trying not to think about a target makes it more difficult to recall at a later time. The TNT paradigm has been demonstrated in a multitude of settings, including recall of visual, emotional, and arousing stimuli (Depue, Banich, & Curran, 2006; Hertel & Calcaterra, 2005; Marx, Marshall, & Castro, 2008), and in both normal and patient populations (Hertel & Mahan, 2008; Salame & Danion, 2007). In all of the literature concerning the TNT paradigm, however, the method of memory measurement has always been recall

* Corresponding author.
E-mail address: rxhgsh@rit.edu (R.E. Hart).

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memory. Participants are asked to come up with the target that they learned, without being presented with the potential target.

While demonstrating that the forgetting in a recall test may be induced due to intentional suppression, it remains unclear whether that same memory loss would remain in the face of extremely salient cues. It is possible that intentional thought suppression as demonstrated by the TNT paradigm inhibits the accessibility of information, but only to a modest degree. Perhaps when attempting a recall test, participants stop trying to access the memory too quickly. If the target were more successfully cued, it is possible that this potentially higher threshold might be lowered, showing normal memory abilities again. The question then becomes, would individuals still forget intentionally suppressed information, even when they are presented with one of the most salient cues possible, the target itself, in a recognition test?

The one study that has considered the effect of recognition tests in the TNT paradigm was reported by Tomlinson, Huber, Rieth, and Davelaar (2009). In their experiment, participants were trained to rehearse, suppress, hit enter to avoid processing, or not presented with learned word pairs. While it is not clear the number of repetitions participants experienced, the number of repetitions was not an independent variable. Their results indicated a decreased accessibility from the suppress and hit enter key groups, but no difference between those groups and baseline. In addition to these findings, they observed an extreme ceiling effect with all accuracies falling between .92 and .96. They discounted this ceiling effect, given that there was a difference for the rehearsal group, but it may be that there were trends not reported that would have been significant without the ceiling effect. Given the lack of a detailed discussion of these recognition findings (they were focusing to a greater degree on the recall results they were also considering), this study leaves many questions unanswered.

While the difference between recall and recognition memory results is not clear with the TNT paradigm, there have been research attempts to consider this in related research areas. Some intentional forgetting research has shown that memory deficits are observed both with recall (Fleck, Berch, & Shear, 2001; Sahakyan, 2004) and recognition (Sahakyan & Delaney, 2005; Tekcan & Aktürk, 2001) techniques, while other research has shown that recognition in intentional forgetting research serves to ameliorate the inhibitory effects seen with free recall (Basden & Basden, 1998; Elmes, Adams, & Roediger, 1970; Geiselman, Bjork, & Fishman, 1983). There have also been numerous studies demonstrating forgetting effects in retrieval-induced forgetting research using both recall (Anderson, Bjork, & Bjork, 1994, 2000) and recognition tests (Anderson & Spellman, 1995; Hicks & Starns, 2004; Spitzer & Bäuml, 2009; Veling & van Knippenberg, 2004). Within the realm of the TNT paradigm, however, the majority of research that has conducted has used recall as the dependent measure. Given that recognition memory results have, at times, diverged from recall memory results in other research on inhibitory mechanisms, it is important to consider whether the same might happen with this more recently identified source of forgetting.

Examining the impact of the thought suppression on recognition memory also affords the opportunity to address another question that would not be possible with recall memory, namely the impact of thought suppression on non-verbal memory. Whereas recall necessarily requires that participants be capable of verbalizing their memories, recognition can assess aspects of memory that people could never report. Research into the processes underlying the effect of verbalization on memory for faces has demonstrated that verbalization after learning, but prior to testing, results in reduced accuracy in facial recognition (Nakabayashi & Burton, 2008). The explanation presented was that, since we naturally learn faces nonverbally, when we try to verbalize them after the fact, we are changing the processing style. For stimuli that we initially process nonverbally, we are encumbered when we alter our approach.

With respect to the impact of thought suppression on non-verbal memory, although this issue has never been directly tested, there are reasons to think that even nonverbalizable experiences may be vulnerable to thought suppression. For example, there is a large body of literature on verbal overshadowing, which has demonstrated that post-encoding verbalization can affect recognition memory for a host of non-verbal stimuli, including faces (Nakabayashi & Burton, 2008), taste (Melcher & Schooler, 1996), mental maps (Fiore & Schooler, 2002), and nonverbalizable forms (Brandimonte & Gerbino, 1993). One interpretation of these findings is that verbalization induces a form of forgetting akin to that associated with other inhibition-based memory effects (Schooler, Fiore, & Brandimonte, 1997). From this we can see that the verbal overshadowing literature supports the possibility that TNT effects might also be observed with recognition of non-verbal stimuli.

While previous research considering the TNT paradigm have included myriad stimuli (e.g., Depue et al., 2006; Hertel & Gerstle, 2003), one stimuli type missing from the literature is nonverbalizable stimuli. Although no prior research has examined the generalizability of the TNT paradigm to nonverbalizable materials, this question has been examined within the context of retrieval-induced forgetting. Specifically, Ciranni and Shimamura (1999) found similar disruption with nonverbalizable shapes as has been found in other retrieval-induced forgetting paradigms (e.g., Anderson & Spellman, 1995).

While the Ciranni and Shimamura (1999) findings are largely consistent with the prediction that the TNT paradigm might also reduce accessibility of nonverbalizable stimuli, there are substantial differences in these paradigms that make it far from clear that similar forgetting would be observed within the TNT paradigm. For example, in contrast to retrieval-induced forgetting research, the TNT paradigm explicitly directs participants to attempt not to think about the target, given a cue item. Given the evidence that deliberate efforts at not thinking have been linked to increases in item accessibility (Wegner, 1992), the TNT paradigm is a useful tool for considering the universality of previously demonstrated ironic processes of thought suppression.[1]

[1] It is important to note that Wegnerian suppression and the suppression demonstrated in the TNT paradigm are the result of separate mechanisms. For more on those differences, see Stone, Coman, Brown, Koppel, and Hirst (2012).

The current experiment considered the question of recognition with nonverbalizable items, within the realm of the TNT paradigm. Participants were asked to make recognition judgments of nonverbalizable shapes. Consistent with previous research involving the TNT paradigm, intentional forgetting, and retrieval-induced forgetting research (e.g., Lee, Lee, & Tsai, 2007; Spitzer & Bäuml, 2007; Verde, 2009), it was anticipated that participants would be better able to recognize rehearsed information, and less accurate at recognizing suppressed information, as compared to information that was neither rehearsed nor suppressed during the experimental phase (hereafter referred to as NRS).

In the first phase, participants learned 50 word–shape pairs. The shapes were designed based on guidelines set by Attneave and Arnoult's Method I for the construction of nonverbalizable shapes (1957), such that they were difficult to verbalize. Following this, participants were trained to either rehearse or suppress each of the shapes, given the cue words. All words were rehearsed one or eight times, suppressed one or eight times, or not presented during this phase. Finally, all participants were tested on their ability to recognize the shapes they learned. They were presented with 100 shapes and asked to identify which they had previously seen. Sample shapes are presented in the Appendix.

2. Methods

2.1. Participants and design

Forty-nine students from the University of Pittsburgh participated in this 2 (Repetitions: 0, 1, 8) × 2 (Phase 2 activity: rehearsed, suppressed, NRS, baseline) repeated-measures design. Thirty-one of the participants were female, 18 were male, and ages ranged from 18 to 31, with a median age of 21.

2.2. Materials and procedure

Fifty words were paired with 50 nonverbalizable shapes, and were used as studied items. Eighty-three additional nonverbalizable shapes were used as fillers in the List Learn and TNT phases, and 50 additional shapes were used as foils in the Final Test phase. Shapes were designed to be specifically hard to verbalize, and obtained using guidelines set by Attneave and Arnoult's Method I for the construction of nonverbalizable shapes (1957). Shapes were either used as targets, distracters, or foil for the final test. That is, if a shape was designated as a target, it was never used as a distracter, if it was a distracter, it was not used as a foil in the final test, etc. Distracters were used multiple times in both phases one and two. The words selected were concrete, high-frequency nouns. They were selected from Affective Norms for English Words (Bradley & Lang, 1999).

During the initial phase of the study, the List Learn phase, participants were shown each word and shape pair side-by-side on a computer screen for 4 s. Order of initial presentation was randomized across all participants, such that each participant received a different order of presentation of pairs. Participants were given instructions to memorize the pairs for a later test, such that when they were presented with the word, they would be able to select the corresponding shape from four choices offered. They were additionally instructed not to attempt to verbalize the shapes presented, in order to assure that participants did not attempt to encode the shapes in memory as words.

Following the single presentation of each word–shape pair, participants were tested on their ability to recognize the shape that had been paired with a given word. This was accomplished by presenting the word on the screen for 3 s. Below the word, four shapes were shown, one of which was the shape paired with the word. Participants were asked to select the key on the keyboard that corresponded to the correct shape before the 3 s had elapsed. Following the presentation of the word and shapes, the correct shape was shown, and the test continued to the next item. At the end of the presentation of all pairs, accuracy was calculated. If they had achieved at least 50% accuracy, participants ended the phase. If they had not achieved at least 50% accuracy, they cycled through all the pairs again until they achieved 50% overall accuracy. All participants achieved at least 50% overall accuracy by the third presentation cycle.

Participants then began the experimental phase of the experiment. Here, participants were required to either rehearse or suppress the presented word–shape pairs in a manner similar to the previous phase. (Some pairs were not presented at all during this phase.) Participants were cued as to whether they should rehearse or suppress, based on the color of the fixation cross and word that immediately followed it. For pairs that were to be rehearsed, the method was the same as in the List Learn phase. Pairs that were to be rehearsed were presented in green following a green fixation cross. The word was presented at the center of the screen, and four shape options were shown at the bottom. Participants were instructed to identify the shape that matched the word on the center of the screen and key the correct response on the keyboard. Following this presentation, the correct answer was shown.

For items that were to be suppressed, the method was slightly different. The word was presented in red following a red fixation cross. Instead of seeing four possible shapes, participants were presented with four empty boxes at the bottom of the screen. They were instructed not to respond to the word in this situation, and instead to avoid thinking about the related shape. In the suppress trials, participants were not provided with the correct response. All pairs were presented one or eight times. Each pair that was presented was categorized as either rehearse, suppress, or never shown. Some pairs were rehearsed once, others were rehearsed eight times. Other pairs were suppressed once, others were suppressed eight times. As mentioned before, others pairs were not presented in this phase at all, and so were neither rehearsed nor suppressed (NRS).

As in the List Learn Phase of the experiment, all pairs were displayed in random order. In addition, items that were presented multiple times were never presented more than twice in a row. Finally, no more than five items of the same category (e.g., to be suppressed or to be rehearsed) were presented in a row.

Following a 5 min filler task, participants entered the Final Test phase. Participants were presented with 100 shapes. Of those 100 shapes, 50 were members of the word–shape pairs and 50 were shapes that were never paired with a word. For each shape, participants were asked whether they had previously seen it paired with a word. They were told to respond that they had seen the item, even if it was a shape they had been previously told to suppress. Shapes were presented one at a time, and stayed on the screen until participants made old/new judgments. None of the novel shapes had been used in any previous section of the experiment. After the presentation of all 100 shapes, participants were debriefed. Sample screen shots of all three phases are included in Appendix.

3. Results

An incomplete factorial analysis examining accuracy of old/new judgments showed significant differences overall, $F(5, 288) = 32.352$, $p < .001$. The false alarm rate for new items in this study was .31. The baseline hit rate for NRS items was .62. Overall, shapes that were rehearsed were more likely to be correctly identified as "old" than shapes that were suppressed, $t(194) = 10.327$, $p < .001$. When participants suppressed shapes, they were less accurate than when they were simply not exposed to cues at all during the TNT phase, $t(145) = 3.541$, $p < .001$. Additionally, items presented eight times were more likely to be recognized than items presented once, $t(194) = 3.750$, $p < .001$.

While there was no difference between shapes that were suppressed once and suppressed eight times, $p < .1$, shapes that were rehearsed eight times were significantly more likely to be judged as old than shapes that were rehearsed only once, $t(96) = 5.148$, $p < .001$. There was a significant difference between NRS shapes and all other conditions except shapes that were rehearsed once. That is, NRS shapes were significantly more likely to be identified as old than shapes that were suppressed at least once, S1: $t(96) = 3.665$, $p < .001$; S8: $t(96) = 2.349$, $p = .021$, and significantly less likely to be identified as old than shapes that were rehearsed eight times, R8: $t(96) = 7.622$, $p < .001$. (See Table 1.)

4. Discussion

There are two especially noteworthy findings to be taken from this experiment: First, the suppression effects of the TNT paradigm are applicable when using a stronger retrieval cue, in this case a recognition test. That the suppression effects do not disappear with the use of recognition tests is an important extension, in that it illustrates the strength associated with the forgetting of the TNT paradigm. Second, suppressing thoughts about the associates of previously studied items leads to reduced memory, even when the stimuli are nonverbal. Previous studies have shown that the TNT paradigm can cause reduced accessibility for suppressed items when they are words. The present experiment expands this finding to stimuli that cannot be thought of in lexical terms.

These findings are similar to previous TNT research in that rehearsed items remained better remembered than suppressed or NRS items, and suppressed items were less well remembered than rehearsed or NRS items. This indicates that, even though the information should be easier to access given the additional direct memory cues from recognition tests, the suppressed information appears to continue to be more inaccessible. The use of suppression, therefore, does appear to cause inhibition in memory beyond simply free or cued recall memory measures.

Recognition tests provide a powerful cue to remember the target. That participants saw "old" targets in a recognition test and still misidentified those targets as "new" demonstrates that participants now have less access to their suppressed memories. While this may not mean that participants have completely forgotten the target, it does mean that they may be less certain that they have seen the target, and therefore less likely claim a memory for having seen the image. This appears to align the TNT paradigm with retrieval-induced forgetting and some intentional forgetting research in that the TNT paradigm also demonstrates that recognition tests are fairly consistent with recall memory tests (Anderson et al., 2000; Hicks & Starns, 2004; Sahakyan, 2004).

Another significant aspect of the present research was the continued suppression effects of nonverbalizable stimuli. The fact that the TNT paradigm generalizes to nonverbalizable experiences greatly increases the range of memory phenomena to which it might in principle apply, as well as deepening our understanding of the effect of verbalization on recognition

Table 1
Proportion recognition accuracy by condition.

Phase 2 activity	Repetitions		
	One repetition	Eight repetitions	N/A
Rehearse	.68 (.19)	.86 (.13)	
Suppress	.49 (.17)	.54 (.15)	
NRS			.62 (.18)
Baseline			.69 (.12)

memory. While it was possible for participants to verbalize during the present experiments, the relative likelihood of them doing so, as well as the likely frequency is decreased. Given previous research on memory and verbalizing, this lack of verbalization should have made the recognition task easier. Instead, we see that there is still a deficit in recognition ability for suppressed items, despite the lack of verbalization. The next step in this research, then, is to attempt to actively interfere with participants' ability to articulate in any way the images presented.

This research has a noteworthy real-life extension: recognition memory is intrinsic to eyewitness identification. When a witness is asked to identify a face of a suspect, they experience the same problematic nonverbalizability of stimuli; that is, research has long shown that faces are difficult to correctly remember if verbalized, similar to the shapes used in this experiment. Given this, the logical next question is whether faces will be responded to in the same manner as the shapes from the present study.

When an eyewitness to a crime is asked to identify the suspect, they are presented with potential individuals that might be the criminal, and asked to recognize who they saw in a previous experience. Through this research, we can start to consider the effects of cognitive control mechanisms on the ability of individuals to make such an identification. From the present findings, it seems clear that when individuals try to avoid thinking about a target (as might be expected for a victim of a crime), they face the very real possibility of making an accurate identification more difficult. An important extension of this research is considering more complex, ecologically valid stimuli. Specifically, it is an interesting question whether these findings might extend to situations more similar to those experienced by eyewitnesses.

The fact that memory for nonverbalizable stimuli was found to be especially vulnerable to thought suppression potentially speaks to a possible relationship between the TNT paradigm and forgetting in a more naturalistic setting. Various researchers have speculated about the possibility that the TNT paradigm might provide a basis for understanding how individuals can come to seemingly forget episodes of childhood abuse (e.g., Conway, 2001; Kihlstrom, 2002; Levy & Anderson, 2002; Schacter, 2001). Although clearly the forgetting of nonverbalizable shapes is a far cry from forgetting trauma, it is nonetheless important to note that nonverbalizable shapes share several properties that arguably close the gap to a certain degree between these two domains. The nonverbalizable shapes involved in this study were novel and did not correspond to any pre-existing mental schemas. In the past, it has been suggested that the absence of a pre-existing way to understand sexual abuse may contribute to victims' apparent forgetting (Schooler, 2002).

In the present research, it is clear that memory for suppressed items is substantially altered, even when subjected to a strong retrieval cue (recognition memory test context). The fact that suppression can impair the recognition of nonverbalizable stimuli begs the question of what other types of stimuli and memory measures are vulnerable to suppression. If participants can successfully suppress to the point of forgetting items such as nonverbalizable shapes, does this mean that they could do the same for other nonverbalizable stimuli, such as sounds, smells, or faces? Would they be able to remember who gave them the instruction to suppress, or whether they were even told to suppress at all, especially after long periods of attempted suppression. From the present findings, it seems clear that when individuals try to avoid thinking about a target (as might be expected for a victim of a crime), they face the very real possibility of having difficulty making an accurate recognition decision. Thus, these findings suggest that the ecological implications of the TNT paradigm may include eyewitness identification.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.concog.2012.06.005.

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