Recognition-induced forgetting does not operate over objects lacking semantic information

Research Thesis

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By

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Abstract

Recognition-induced forgetting is a forgetting phenomenon in which memory for initially learned stimuli is negatively impacted by the recognition of categorically related stimuli. While this forgetting effect has been found to operate over categories of everyday objects (e.g., vases, chairs), objects of expertise, and episodic memory, the role of semantic information has yet to be fully explored. Here we seek to understand whether semantic information is the critical category-grouping cue behind recognition-induced forgetting in order to establish a model for its underlying mechanism. To this end, letters are utilized in the present study because they feature an automatic category grouping (e.g., A's of different fonts belong to a group) and little to no semantic information (e.g. there is no semantic information that belongs to all A's). If semantic information is critical to category groupings in recognition-induced forgetting, then categories comprised of letters will be immune to recognition-induced forgetting. Indeed, we found that recognition-induced forgetting did not operate over letters, suggesting that semantic information plays a critical role in categories that are susceptible to recognition-induced forgetting.

Introduction

Cognitive psychologists have long been interested in the limitations of human memory (Anderson, Bjork, & Bjork, 1994; Miller, 1956; Shepard, 1967). One such limitation is demonstrated in *recognition-induced forgetting* in which memory for initially learned stimuli is negatively impacted by recognizing semantically related stimuli (Maxcey, 2016; Maxcey & Bostic, 2016; Maxcey, Dezso, Megla, & Schneider, 2019; Maxcey, Glenn, & Stansberry, 2018; Maxcey, McCann, & Stallkamp, 2020; Maxcey & Woodman, 2014; Rugo, Tamler, Woodman, & Maxcey, 2017; Scotti, Janakiefski, & Maxcey, 2020). For example, when presented with two apples, one red and one green, and then repeatedly recognizing the green apple, the green apple will later show robust memory but the red apple is often forgotten (Maxcey & Woodman, 2014).

The recognition-induced forgetting paradigm traditionally features three phases: a study phase, practice phase and test phase. In the study phase, objects are presented one at a time to participants who are instructed to keep the presented objects in memory for a later test. Stimuli typically include everyday objects spanning across different object categories (e.g., mugs or bowties, but see Rugo et al. 2017, Scotti et al. 2020). Next, during the practice phase a subset of objects from the study phase are presented along with an equal number of new objects from the same object category. Memory for the studied objects is tested in an old-new recognition judgment task. Then, the final phase tests memory for all studied objects in an identical old-new judgment task featuring a larger subset of stimuli from the study phase.

The design of the paradigm creates three object types for which memory is tested: practiced, related and baseline objects (see **Fig. 1)**. *Practiced* objects appear once in the study phase, twice in the practice phase, and again in the test phase. Memory for these objects is unsurprisingly high at test. *Related* objects are drawn from the same category as practiced objects (e.g., types of mugs) but appear only twice in the experiment, once in the study phase and once in the test phase. *Baseline* objects also appear only twice in the experiment, once in the study phase and once in the test phase. Baseline objects are unique because they belong to categories of objects that were not practiced (e.g., butterflies or bowties). Baseline objects serve as a measurement of memory for categories of objects that are not involved in recognition practice. The hallmark of recognition-induced forgetting is reliably worse memory for related objects relative to memory for baseline objects (Maxcey & Woodman, 2014).

To understand the underlying mechanism of recognition-induced forgetting, our lab has asked whether the category-grouping cue (e.g., *apple* in the opening example, or mug, butterfly and bowtie in **Fig. 1**) must be based on semantic information. The role of semantic

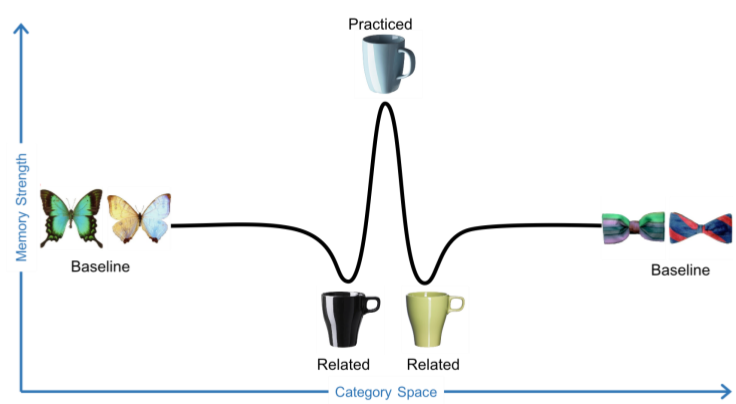

Figure 1. In a typical recognition-induced forgetting experiment, memory strength for practiced objects increases, while memory strength for related objects decreases due to the shared category between the two object types (e.g., mugs). Baseline objects serve as a baseline measurement of memory across all three experiment phases (e.g., butterflies and bowties).

information in category groupings is unclear for several reasons. First, categories employed in these experiments share both perceptual and semantic features. For example, all butterflies, bowties, and mugs have similar perceptual features (e.g., shape), which may be driving their grouping. Second, while our lab demonstrated that semantic, not episodic, information was the grouping cue driving recognition-induced forgetting (Maxcey et al. 2018), we have recently demonstrated that the effect can operate over episodic memory (Scotti et al. 2020). Third, we have shown that recognition-induced forgetting is a consequence of episodic memory tasks (e.g., an old-new recognition judgment task) not a semantic memory task (e.g., when making size judgments, Maxcey et al. 2020).

The present study

Here we tested the role of semantic information as a grouping cue in recognition-induced forgetting by employing a stimulus set that participants can categorize without instruction, but also lacks semantic features. To this end, we employed letters as the category (e.g., one category was ‘A’) and different fonts for the exemplars (e.g., the ‘A’ category consisted of ‘A’ in a variety of fonts such as Arial, Times New Roman, etc.). Letters are ideally suited to use in a recognition-induced forgetting paradigm because letters are a category of stimuli that are viewed daily, meaning participants are able to categorize them quickly and efficiently without instruction (e.g., A’s belong to a group) just like other stimuli employed in this paradigm (e.g., vases or cars belong to a group). Letters are also ideal for this particular study in which we sought a stimulus with little to no semantic information because letters have little to no semantic information (e.g., there is arguably no such thing as H-ness).

Hypotheses and Predictions

Here we test two competing hypotheses focused on the role of semantic information in recognition-induced forgetting. According to the *semantic-grouping hypothesis*, semantic information may be a critical category-grouping cue underlying recognition-induced forgetting. If semantic information is required for recognition-induced forgetting, then letters will not be susceptible to forgetting because letters have little to no semantic information. On the other hand, according to the *perceptual-grouping hypothesis*, semantic information may not be a necessary category-grouping cue underlying recognition-induced forgetting and perceptual similarity may be sufficient to cause recognition-induced forgetting. If semantic information is not required for recognition-induced forgetting, then letters will be susceptible to forgetting despite that they have little to no semantic information.

Methods

Stimuli

The categories were specific letters (e.g., the letter G will be one category) and the exemplars within that category are the fonts (**Fig. 2)**. This maps onto the opening example of recognition-induced forgetting of everyday objects, where the category was apple and the exemplars were a red and a green apple. The full stimulus set included all letters except the letters ‘I’ and ‘O’ which were excluded due to their lack of distinct

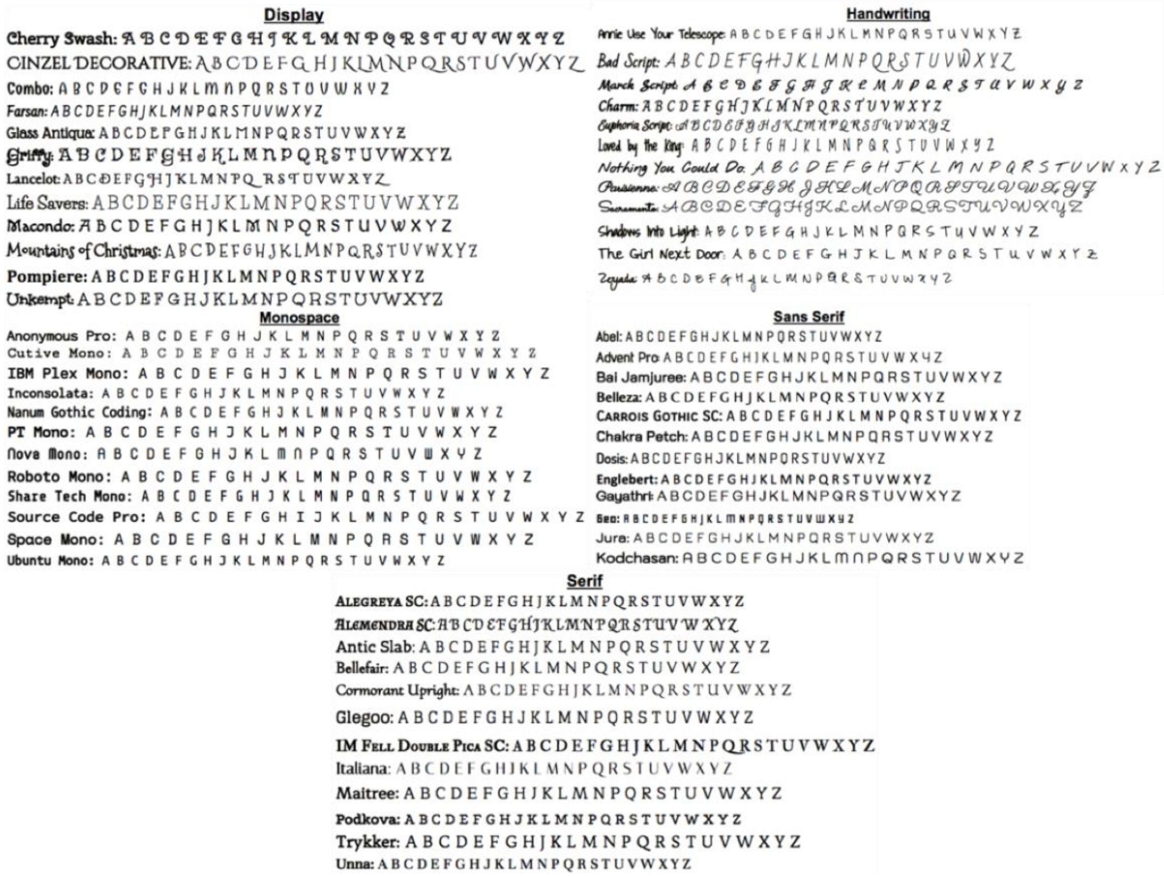

Figure 2. Display, Handwriting, Monospace, Sans Serif and Serif fonts are used from the Google Fonts catalog. Twelve unique fonts from each category are selected for their distinction and consistent thickness of line.

characteristics. Stimuli used include five font families from the Google Fonts Catalog: Serif, Sans Serif, Display, Handwriting, and Monospace (**Fig. 2**). Each individual subject saw 150 randomly selected letters across 10 letter categories and all 60 font exemplars.

Sample Size Rationale

The smallest effect size of the original recognition-induced forgetting study was $d_z = 1.38$ (Experiment 1, Maxcey & Woodman, 2014). Power analyses using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) determined the necessary sample size using that smallest effect size measured estimated that a sample size of 12 subjects was necessary to observe recognition-induced forgetting effects with 99% power, given a .05 criterion of significance. We anticipated null results (i.e., no recognition-induced forgetting as measured by baseline minus related), so we chose to quadruple that sample size to ensure adequate statistical power.

Exclusion Criteria

Participants were instructed to indicate whether English is their first language or if they are fluent in the language. Due to the nature of the experiment and the intricacy of fonts, subjects without language fluency would be at a disadvantage and their results excluded accordingly. We did not need to replace any subjects excluded based upon this language criterion.

Quantifying Recognition-Induced Forgetting

Recognition-induced forgetting occurs when memory for baseline items is reliably higher than memory for related items. The present study utilizes paired-samples two-tailed t-test at an alpha level p<0.05 to compare the accuracy between the related and the baseline letters and assess statistical significance. If hit rate (i.e. percent correct) for baseline letters is higher than hit rate for related letters, recognition-induced forgetting will have occurred. Hit rate for practiced letters is calculated to serve as a comparison point.

Methods

Participants

Participants were a group of 48 undergraduate students at The Ohio State University (mean age of 19.02, 25 female, 23 male) who earned course credit for their introductory psychology class by their participation. Participants reported normal or corrected-to-normal vision and normal color vision. All procedures were approved by the appropriate institutional review board and informed consent was obtained.

Study Phase

The experiment began with the study phase. Participants were presented with 6 distinct exemplars from 10 randomly selected letter categories totaling 60 trials. Each object was shown on the screen for five seconds and interleaved by a 500 ms fixation cross. Subjects were instructed to attend to both the letter presented and the font and remember it for a later memory test. When the study phase ended, a 5-minute break began in which a subject participated in a change detection task (Luck & Vogel, 1997) to prevent rehearsal of stimuli and ensure we are studying long-term memory.

Practice Phase

Next, in the practice phase, participants were presented with 60 trials of 15 previously seen letters (i.e., *practiced letters*) on two separate trials (totaling 30 trials of old letters) and 30 novel lures drawn from the same letter categories (**Fig. 3**). Subjects were instructed to indicate whether they had seen each letter in an old-new recognition judgment task by responding *old* or *new* via mouse click on buttons presented on the screen. An *old* item was an image presented in the study phase, while a *new* item was a previously unseen image. Participants had as much time necessary to respond as each letter was

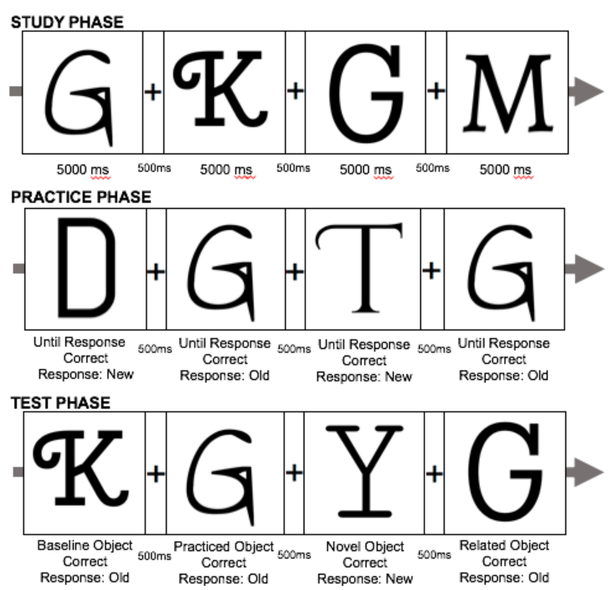

Figure 3. Recognition-induced forgetting features 3 phases: study, practice and test throughout which participants are presented with items to remember. Each Image is interleaved by a 500 ms fixation cross. During the practice and test phases participants access memory for previously presented items.

visible until response, thus stressing accuracy and not speed. After the practice phase ended, subjects completed the same 5-minute change detection task.

Test Phase

Finally, in the test phase, participants were presented with 120 trials consisting of the 60 study phase letters and 60 new letters. Study phase items included the 15 practiced letters, 15 related letters and 30 baseline letters. Recall that *related letters* were categorically similar to the practiced letters but were not themselves practiced (e.g. the letter G in Anonymous Pro font in **Fig. 3**) and *baseline letters* belonged to categories that were not practiced (e.g. the letter K in Cherry Swatch font in **Fig. 3**). New items were drawn from the same categories as the old letters and were not the same lures presented in the practice phase.

The participants task was identical to the practice phase. Participants were instructed to indicate whether the presented letter font pairings are *old* or *new*. In this phase, emphasis was placed on participant accuracy as opposed to speed, and, as in the practice phase, a 1:1 ratio of correct *old* to *new* answers was maintained to account for guessing. Upon completion of the test phase, subjects were offered the opportunity to type out any technical difficulties or share strategies used for remembering throughout the three phases[1].

Results

Average hit rates across the three old object types are shown in **Figure 4a** with memory for baseline letters indicated by the x-axis. The difference between related letters (.57) relative to baseline letters (.59) is not significant, indicating the absence of recognition-induced forgetting, $t(47) = .5159$, $p > .05$, scaled $JZS_{NULL} = 5.62$. This result is consistent with the semantic hypothesis in which semantic information is necessary for recognition-induced forgetting, and inconsistent with the perceptual hypothesis, according to which letters should show forgetting because they share basic perceptual features.

To confirm that letter stimuli are immune to recognition-induced forgetting, all participants with baseline memory at or below chance (50%) were removed, eliminating 13 participant's data (.41). Analyzing the remaining 35 participants, memory

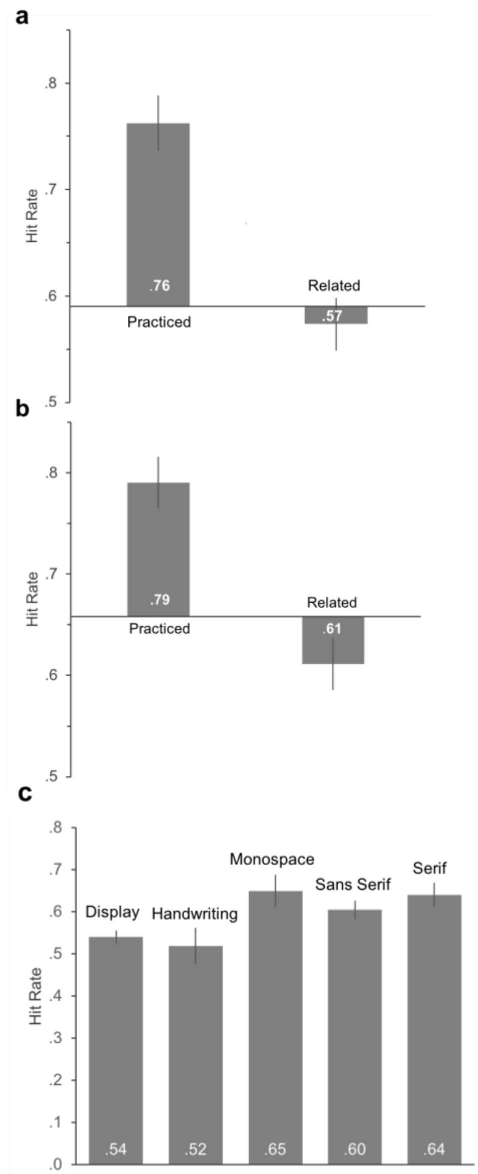

Figure 4. (a) Hit rate for object types throughout the experiment. Memory for baseline items indicated by the x-axis. (b) Hit rate for object types throughout the experiment for data with baseline accuracy above 50% to eliminate responses beyond chance. Memory for baseline items indicated by the x-axis. (c) Hit rate for baseline items across all five font categories. All error bars represent 95% confidence intervals as described by Cousineau (Cousineau, 2005) with Morey's correction applied (Morey, 2008).

1 This can be used in assessing what strategies may or may not be susceptible to recognition-induced forgetting.

for related letters (.61) was lower than baseline letters (.66), but not reliably, t(34) = .1179, p > .05, scaled JZS_{NULL} = 5.48 (**Fig. 4b**).

Perhaps recognition-induced forgetting was not found because the task was simply too hard. If the letter stimuli were too difficult to remember, then the mean values of baseline and related might not show enough spread to demonstrate forgetting. To test this possibility, we compared accuracy in the practice phase and accuracy for baseline letters to other recognition-induced studies in which everyday objects were the stimuli (Scotti et al. 2020; unpublished data from Maxcey lab). Average practice phase accuracy across three recognition-induced forgetting experiments with traditional stimuli (.84) compared to the present letters experiment (.69), reflecting that subjects had poorer memory for the letters during the practice phase. Furthermore, baseline object average accuracy, measured at test, across the same three recognition-induced forgetting experiments with traditional stimuli (.77) is considerably higher than baseline memory in the present letters experiment (.61). Both these comparisons illustrate the difficulty of remembering the letter stimuli in the present experiment. Finally, analyzing baseline memory strength for all five font categories in the present experiment (collapsing across letter identity) showed that the monospace font (.65) had the highest average accuracy and the handwriting font was the lowest (.52, **Fig. 4c**). Because recognition-induced forgetting can only be seen when baseline memory is high enough that related can be lower, we analyzed induced forgetting for just the monospace fonts, the category with the highest baseline letter accuracy and arguably the best memory for letters. However, recognition-induced forgetting is not found reliably t(11) = .4583, p > .05, JZS_{NULL} = 3.18. This suggests that while the stimuli used here were more difficult to remember than everyday objects, they may still not have been susceptible to induced forgetting because even the most memorable font did not induce forgetting.

Discussion

Here we asked whether semantic information is a critical category-grouping cue underlying recognition-induced forgetting. To this end we employed objects lacking in semantic information. Letters offer little semantic information by which to remember, rather they are identified using shared basic perceptual features. We found that letters were immune to recognition-induced forgetting. Removing participants with baseline memory performance that was below chance the results trended toward recognition-induced forgetting but were not reliable. Finally, we asked whether recognition-induced forgetting did not occur due to difficulty remembering the stimuli, rather than the lack of semantic information. We compared memory during the practice phase and for baseline items in the present experiment to other recognition-induced forgetting experiments employing everyday objects (Scotti et al. 2020; unpublished data from Maxcey lab). We found both practice phase accuracy and baseline memory to be lower in the present study using letters, illustrating the unique difficulty of stimuli in the present experiment.

Here we supported the semantic hypothesis, by which letters will not provide sufficient semantic information to induce forgetting, in contrast to the perceptual hypothesis by which perceptual-grouping information would be sufficient to cause recognition-induced forgetting. Despite analyses presented here suggesting that the letters were more difficult to remember than everyday objects, the most memorable font did not result in forgetting. An ongoing experiment is presenting participants with the letters for twice as long in the study phase to increase overall performance to determine the role of memorability in the letters immunity to induced forgetting.

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