Research Article

SEMANTIC GENERATION CAN CAUSE EPISODIC FORGETTING

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Abstract—*The repeated retrieval of a subset of previously learned items can cause forgetting of the nonretrieved items. The study reported here investigated whether retrieval-induced forgetting generalizes to a situation in which the retrieved and nonretrieved items are not part of the same experiential episode and task. Subjects learned an item list that they had to recall later in the experiment. In a separate intermediate phase, they repeatedly generated related items from semantic memory, or were presented the same items intact for study. Only the semantic generation of items, and not their presentation for study, induced forgetting of the initially learned items. This result indicates that, first, semantic generation can cause recall-specific episodic forgetting and, second, retrieval-induced forgetting can occur even if the retrieved and nonretrieved items belong to different experiential episodes and tasks. Connections of the present results to other memory phenomena, such as part-set cuing and the generation effect, social cognition, and eyewitness memory, are discussed.*

The repeated retrieval of previously learned items, in general, improves recall of these items on a later test (Allen, Mahler, & Estes, 1969; Carrier & Pashler, 1992). This positive effect of retrieval practice, however, is often accompanied by a negative side effect. As was shown in a number of recent studies, whereas the repeated retrieval of a subset of previously learned items can facilitate subsequent recall of the practiced items, it can impair subsequent recall of the nonpracticed items (Anderson, Bjork, & Bjork, 1994; Anderson & Spellman, 1995; Bäuml & Hartinger, in press; Smith & Hunt, 2000). This retrieval-induced forgetting is not due to increased competition arising from the strengthening of the practiced items, but rather is caused by the recall process itself (Anderson, Bjork, & Bjork, 2000; Bäuml, 1996, 1997; Ciranni & Shimamura, 1999).

Retrieval-induced forgetting was first demonstrated using categorizable item lists (Anderson et al., 1994). In these experiments, subjects studied lists of category-exemplar pairs (e.g., fruit-orange, fruit-banana) from several categories. Subjects then performed guided retrieval practice on half of the items from half of the categories by completing a series of cued-stem tests (e.g., fruit-or_____). The key finding of these experiments was that recall for unpracticed items that belonged to the same category as practiced items (e.g., fruit-banana) was lower than recall for control items (i.e., unpracticed items from unpracticed categories). Such retrieval-induced forgetting was also demonstrated for other internal representations. Retrieving previously studied traits about a person, for instance, can impair subsequent memory for other previously studied, nonretrieved traits of the same person (Macrae & MacLeod, 1999). Also, the retrieval of specific previously presented crime-scene details can diminish accessibility of nonretrieved details of the scene (Shaw, Bjork, & Handal, 1995). Finally, retrieval-induced forgetting can occur not only for verbal and visual material, but also for visuospatial material (Ciranni & Shimamura, 1999).

A common feature of all these demonstrations of retrieval-induced forgetting is that the retrieved and nonretrieved items are learned during the same episode and, in this sense, compete for conscious recall (Anderson et al., 1994; Raaijmakers & Shiffrin, 1980, 1981). The question arises whether the retrieval of items can still cause forgetting of related items if the retrieved and nonretrieved items are from separate experiential episodes and belong to different tasks. Suppose subjects learn a categorizable item list and later, in a separate phase of the experiment, are instructed to generate related items from semantic memory. Can this semantic generation induce forgetting of the previously learned material, or does the difference in experiential episode and task eliminate the forgetting? The question whether the semantic generation of items can cause episodic forgetting is important because it addresses the issue of whether it is necessary that items share a common learning episode for retrieval-induced forgetting to occur. Alternatively, the sharing of a common semantic cue may be sufficient to cause retrieval-induced forgetting.

If semantic generation is sufficient to cause retrieval-induced forgetting, memory for an event might be impaired simply by generating general knowledge associated with cues related to the event, even if that knowledge was acquired in a quite different context. As mentioned, retrieving previously studied traits of a person can impair memory for other previously studied traits of the same person. But can one also induce forgetting of this person's previously studied traits if general characteristics of the stereotyped category to which this person belongs are generated without reference to the particular individual? Suppose, for instance, you invite your new neighbor for dinner. In the course of the evening, you get acquainted with him and, among other things, learn that he is a lawyer. A few days later, you have a conversation with your daughter, who just started studying jurisprudence, about general characteristics of being a lawyer. Will the generation of several of the general characteristics of the social category "lawyer" impair your memory for certain individual traits of your new neighbor? If so, then generating general knowledge associated with a previously observed crime might similarly diminish eyewitness memory for observed episodic details.

The question of whether semantic generation can cause episodic forgetting is interesting not only because of its possible connection to social cognition and eyewitness memory, but also because it bears implications for other memory phenomena, like part-set cuing and the generation effect. Experiments on the generation effect showed that actively generating, for instance, a synonym or antonym of a cue item leads to better performance on a later recall test than does passively reading the same item aloud (Jacoby, 1983; Slamecka & Graf, 1978). Because the generation of items in these experiments reflected some form of semantic generation, the question arises whether the recall improvement shown in the generation effect might be accompanied by a recall impairment for previously learned items. Such a pattern of improvement and impairment would mirror the typical retrieval-practice effect (i.e., recall improvement for the practiced items and recall impairment for the nonpracticed items).

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There is also a connection between the question of whether semantic generation can induce episodic forgetting and experiments on part-set cuing. In experiments on part-set cuing, subjects learn an item list and at test are presented a number of semantically related items as a retrieval cue. Quite often, the presentation of the retrieval cues does not facilitate but rather impairs the recall of the previously learned items (Roediger, Stellon, & Tulving, 1977; Watkins, 1975; see Nickerson, 1984, for a review). Demonstrating that the semantic generation of items induces forgetting of related previously learned items would reveal a parallel between retrieval-induced forgetting and part-set cuing. Such a parallel could be of theoretical interest because in recent years researchers have often explained the two types of forgetting with different forgetting mechanisms (Basden & Basden, 1995).

The experiment reported here was designed to examine whether the generation of items from semantic memory can cause episodic forgetting. Subjects studied an item list consisting of items from different semantic categories. For half of these categories, subjects were subsequently asked to generate categorically related items from semantic memory. The subjects were told that the data were being collected to develop category norms for verbal categories. The instructions explained that the subjects would be provided the category and subcategory labels together with the items' unique initial letters, and they should complete each word stem with the first item that came to their mind. Then, they completed a cued-recall test in which they had to recall the initially learned items. The question of interest was whether the intervening task of generating related items from semantic memory would induce recall-specific forgetting of the initially learned items. An additional condition controlled for the possibility that any observed forgetting might not be recall-specific, but rather caused by increased competition arising from the subjects' encoding of the generated items; in this condition, subjects were presented intact items for study rather than having to generate them from semantic memory. If semantic generation induced forgetting but presentation of the same items did not, this result would indicate that semantic generation can cause recall-specific episodic forgetting.

METHOD

Subjects

A total of 104 psychology students at the University of Regensburg, Regensburg, Germany, participated in the experiment. The subjects were tested individually.

Materials

Items from 10 experimental categories were selected. Each category included items from two different semantic subcategories, three items from Subcategory A and five items from Subcategory B. The category "tree," for instance, contained three exemplars belonging to the subcategory "deciduous tree" and five exemplars belonging to the subcategory "conifer"; the category "four-legged animal" contained three exemplars belonging to the subcategory "predator" and five exemplars belonging to the subcategory "hoofed animal." The items were drawn from several published norms (Battig & Montague, 1969; Mannhaupt, 1983; Scheithe & Bäuml, 1995) and had a rank order between 1 and 27 according to these norms ($M = 9.31$, $Mdn = 7$, $SD = 9.12$). The initial letter of each Subcategory A item was unique with respect to that

item's category, and the initial two letters of each Subcategory B item were unique with respect to that item's category.[1]

Each subject saw two item lists. List 1 consisted of the Subcategory A items for all 10 categories. List 2 consisted of the Subcategory B items for half of the 10 categories used in List 1[2] and varied across subjects according to which categories were included. Four items from each of 3 additional categories served as fillers. They were drawn from the same published norms as the items from the 10 experimental categories. A different exemplar from each of the 3 filler categories was presented at the beginning and end of each list.

Overview

The experiment was conducted in three main phases separated by distractor tasks. In Phase 1, subjects were presented the List 1 items for study. After a subsequent distractor task, half the subjects participated in a semantic-generation condition and half participated in a presentation condition (Phase 2). In the semantic-generation condition, the List 2 items had to be generated from semantic memory; in the presentation condition, they were presented intact for study. After another distractor task, subjects completed a final cued-recall test in which the items learned in Phase 1 of the experiment had to be recalled (Phase 3).

This design created several different types of items. All items in List 2 were either generated by (Ge+) or presented to (Pr+) the subjects. Items in List 1 came either from a category that was used in List 2 or from a category that was not used in List 2. If the category was used in List 2, the List 1 items were Ge− or Pr− items, depending on whether the subject was in the semantic-generation or presentation condition, respectively. If the category was not used in List 2, the List 1 items were control items, items for which no related items were generated from semantic memory (Nge) or presented (Npr) in Phase 2. The items in each List 1 category served equally often as Ge− (Pr−) and Nge (Npr) items across subjects. The item conditions were perfectly matched between the semantic-generation and presentation conditions. The hypothesis was that if semantic generation causes episodic forgetting, then the generation of Ge+ items would induce lower recall for Ge− items than Nge items. In addition, if this forgetting is generation-specific, the presentation of Pr+ items would induce the same recall for Pr− items and Npr items.

Procedure

Presentation of List 1 items (Phase 1)

List 1 consisted of 30 (10 × 3) experimental items and 6 (3 × 2) filler items. Each item, together with its category and subcategory label, was displayed on a computer screen for 6 s (e.g., "Four-Legged Animal," "Predator," "Lion"). The item was presented within a frame underneath the subcategory label, which in turn was presented underneath the category label. Subjects were instructed to spend the whole

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1. English translations of the (originally German) item lists are available on request via e-mail.

2. If retrieved and nonretrieved items share a common category but are from different subcategories, retrieval-induced forgetting can be observed; if the retrieved and nonretrieved items belong to the same category and same subcategory, the forgetting is largely eliminated (Bäuml & Hartinger, 1999, in press). List 1 and List 2 items were therefore from the same categories but different subcategories.

exposure time relating the exemplar to its category and subcategory label and to rehearse only this very item in order to maximize recall performance. The experimental items were presented in blocked random order. That is, a random sequence of three blocks with 10 items each was presented to the subjects. Each block consisted of one randomly selected exemplar from each of the 10 categories. The order of the categories within a block was also random, with the only restriction being that a block's last item never belonged to the same category as the next block's first item. At the beginning and end of each list, one item from each of the 3 filler categories was presented.

First distractor task

The subject counted backward by 3s from a random three-digit number for 30 s and then engaged in a 5-min distractor task. A series of nonfamiliar human faces (black-and-white portraits) was presented on the computer screen, and the task was to rate the attractiveness of each face.

Semantic generation and presentation of List 2 items (Phase 2)

In Phase 2, the subjects either generated (semantic-generation condition) or were presented (presentation condition) List 2, consisting of 25 (5 × 5) experimental items and 6 (3 × 2) filler items. In the presentation condition, the items were presented using largely the same procedure as in Phase 1. The only difference was that this time each item was presented with its category and subcategory cue for 7 s rather than 6 s, and subjects were instructed to name the item. The list was presented twice, with a short interval of 30 s between the two presentations.

In the semantic-generation condition, the category and subcategory labels for each to-be-generated item were presented with the two or three initial letters of the target item as a retrieval cue (e.g., "Four-Legged Animal Hoofed Ho____"). Two initial letters were used for items with less than eight letters, and three initial letters were used for all other items.[3] The order in which the stems were presented was exactly matched with the items' order in the presentation condition. The subjects were told that the data were being collected to develop category norms for verbal categories and that they should complete each word stem with the first item that came to their mind. During the 7 s that each retrieval cue was displayed on the computer screen, the subjects attempted to generate the target item, and the response (nearly always the target item) was written down by the experimenter. After this 7-s interval, a signal indicated the presentation of the next retrieval cue. All subjects went through List 2 twice. Before the second trial, they were told that they would get a second chance to generate those items they had not recalled in the first trial, but that they should generate those items already recalled the first time as well.

Second distractor task

Subjects counted backward by 3s from a random three-digit number for 30 s and then engaged in another 5-min distractor task. For this task, the series of nonfamiliar human faces from the first distractor task was presented again. This time, however, the task was to estimate each face's age.

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3. In pilot studies, both the presentation of two initial letters in the case of shorter words and the presentation of three initial letters in the case of longer words led to recall performance of about 90% for the items in List 2.

Test phase (Phase 3)

In the final, test phase, subjects were presented the (unique) first letter of each item learned in Phase 1 together with the item's category and subcategory labels. Each retrieval cue was displayed on the computer screen for 10 s. During this time, the subjects were to write down the target item on one page of a test booklet consisting of 30 blank pages. After this 10-s interval, a signal indicated the presentation of the next retrieval cue. The order in which the items were tested was blocked by category. Mean testing position was the same for all categories across subjects. Testing orders in the semantic-generation and presentation conditions were perfectly matched.[4]

RESULTS

Success of Semantic Generation

The repeated generation of the Ge+ items during the semantic-generation phase was successful. In the overwhelming majority of cases (97.8%), the Ge+ items were correctly generated.

Effects of Semantic Generation and Presentation

On average, 78.4% of the Nge items and 70.1% of the Ge− items were recalled (see Fig. 1). The difference of 8.3% between the two conditions was reliable, $F(1, 51) = 9.46$, $MSE = 190.9$, $p = .003$, thus demonstrating that the semantic generation of the Ge+ items in Phase 2 induced forgetting of the Ge− items learned in Phase 1. In contrast, on average, 80.1% of the Npr items and 79.7% of the Pr− items were recalled. The difference of 0.4% between the two conditions was not reliable, $F(1, 51) < 1$, thus demonstrating that the presentation of the Pr+ items in Phase 2 did not induce forgetting of the Pr− items presented in Phase 1.

The indication that only the semantic generation but not the presentation of List 2 items induced forgetting of List 1 items was confirmed through the results of a two-factorial analysis of variance. This analysis revealed a main effect of experimental condition (semantic-generation vs. presentation condition), $F(1, 102) = 5.40$, $MSE = 308.8$, $p = .022$; a main effect of item type (control Nge and Npr items vs. experimental Ge− and Pr− items), $F(1, 102) = 6.11$, $MSE = 163.2$, $p = .015$; and a significant interaction between the two factors, $F(1, 102) = 4.98$, $MSE = 163.2$, $p = .028$. Thus, semantic generation and presentation differed reliably in their effects on the recall of the Ge− and Pr− items.

DISCUSSION

Previous studies showed that the repeated retrieval of a subset of previously learned items can cause forgetting of the nonretrieved items (Anderson et al., 1994, 2000; Bäuml & Hartinger, in press; Smith & Hunt, 2000). In these studies, the retrieved and nonretrieved items were

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4. After the cued-recall test of the Phase 1 items, subjects in the presentation condition were asked to recall the items studied in Phase 2. The testing procedure was identical to the one used for the Phase 1 items. The average recall rate for the Phase 2 items was 86.4%, compared with 80.1% for the Phase 1 items. The difference in recall performance reflects the fact that the Phase 2 items were presented twice to the subjects, whereas the Phase 1 items were presented just once.
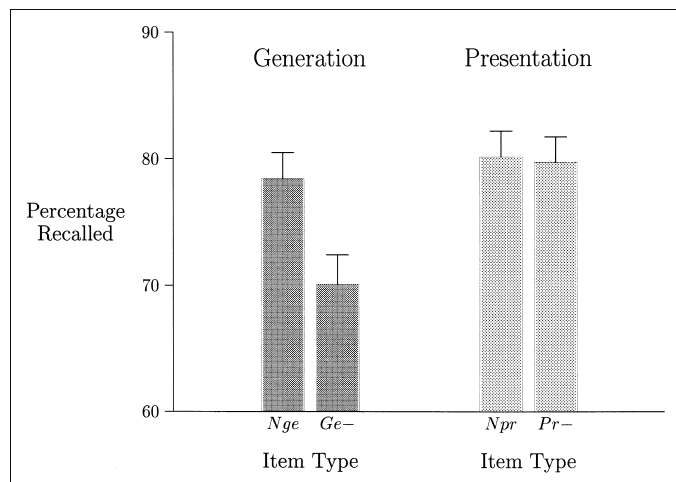
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Fig. 1. Recall percentages and standard errors on the cued-recall test as a function of item type and experimental condition. Ge− = List 1 items for which related items were generated from semantic memory in Phase 2; Nge = List 1 items for which no related items were generated from semantic memory in Phase 2; Pr− = List 1 items for which related items were presented for study in Phase 2; Npr = List 1 items for which no related items were presented for study in Phase 2.

part of the same learning episode and, in this sense, competed for conscious recall. If the retrieved and nonretrieved items belong to different experiential episodes and tasks, this might eliminate the competition and, thus, eliminate the forgetting as well. By demonstrating that the semantic generation of items can cause forgetting of items learned in a separate previous episode, the present results show that retrieval-induced forgetting can still occur if the retrieved and nonretrieved items are not part of the same learning episode. They thus indicate that it is not necessary that items share a common episodic cue for retrieval-induced forgetting to occur. Rather, sharing a certain degree of semantic relatedness can be sufficient for the retrieval of an item to induce forgetting of another item.

The fact that the generation of related items from semantic memory induced forgetting whereas the presentation of the same items for study did not induce forgetting suggests that the observed forgetting was caused by the generation process. A priori, forgetting could have been due to increased competition arising from the subjects' encoding of the semantically generated items. Given that the presentation of the same items for study did not induce forgetting, however, the encoding of additional items per se appears not to have been the cause of the generation-induced forgetting. The present results thus generalize results from previous experiments in which recall-specific effects of episodic retrieval were demonstrated (Anderson et al., 2000; Bäuml, 1996, 1997; Ciranni & Shimamura, 1999).

Semantic generation induced recall-specific forgetting of previously learned items from the same category relative to control items from other categories. Although this result demonstrates that a certain degree of semantic relatedness can be sufficient to induce generation-induced forgetting, it leaves open whether semantic relatedness is necessary to induce this forgetting. Previous studies on the effects of episodic retrieval practice found that retrieval-induced forgetting occurs mostly within categories and less, if at all, across categories (Roediger & Schmidt, 1980; Shaw et al., 1995). This result may generalize to the effects of semantic generation. That is, semantic relatedness may also be necessary for generation to induce episodic forgetting.

Although in the present experiment original learning and semantic generation belonged to different experiential episodes, they occurred within the same experimental session and context. Can semantic generation still cause episodic forgetting if learning and generation belong to different contexts or are separated in time by more than just a few minutes? MacLeod and Macrae (2001) showed that a time delay of 24 hr between learning and episodic retrieval practice reduces the amount of retrieval-induced forgetting, but does not eliminate the forgetting. This reduction might occur because context-item associations decrease with time (Mensink & Raaijmakers, 1988), so that a delay interval decreases the competition between the items as well. Even if major changes in context—whether temporal or spatial—decrease competition between items and thus reduce the inhibitory effect of both episodic retrieval and semantic generation, it is likely that retrieval competition is never eliminated completely. Changes in context, therefore, should lessen but not eliminate retrieval-induced and generation-induced forgetting.

Actively generating items from semantic memory typically has positive effects on a later test and induces better recall performance than passively reading the same items aloud (Jacoby, 1983; Slamecka & Graf, 1978). By showing that semantic generation can induce episodic forgetting, the present results indicate that the generation of items can have negative side effects as well and can impair the later retrieval of previously learned items. The effect of generation thus appears to mirror the effect of episodic retrieval practice, inducing recall improvement on the one hand and recall impairment on the other. The finding that both the retrieval of previously presented material and the generation of items from semantic memory can cause episodic forgetting is closely related to findings about the negative effects of cuing, known as part-list and part-set cuing (Nickerson, 1984). The fact that both retrieval-induced/generation-induced forgetting and cuing-induced forgetting are insensitive to whether the inhibitory event is episodic or semantic establishes a new restriction for models of forgetting and thus may help to improve understanding of the exact relationship between the two forms of forgetting.

The fact that semantic generation can cause episodic forgetting is of potential relevance for a number of situations: For example, memory for individual traits of a new colleague or neighbor may be impaired if general characteristics of the stereotyped category to which this person belongs are generated; eyewitness memory for specific details of an observed accident or crime may be impaired by generating related semantic knowledge. If recent results about the negative effects of episodic retrieval practice generalize to semantic generation, such memory impairment may arise easily. In fact, episodic retrieval practice can induce forgetting through the retrieval of just one single item (Bäuml & Hartinger, in press) and one single retrieval trial (Macrae & MacLeod, 1999). However, after about a day, the forgetting effectively is gone (MacLeod & Macrae, 2001). If generation-induced forgetting is similarly transient, the harmful effects of generating related general knowledge on episodic recall might remain moderate in many cases.

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