Retrieval Inhibition and Consciousness State in Recollection

Suzuki Ikuo
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SUZUKI IKUO (鈴木郁生)1
(Tohoku University)

This paper experimentally examined the kind of consciousness state in which the directed forgetting effect occurs, and whether the effect is observed for items that subjects were not asked to forget that were episodically related to the to-be-forgotten items. Thirty students (15 men, 15 women) were assigned to two groups. The forget instruction group were to forget the presented items, and the control instruction group were not. All the subjects were given a cued recall test. The subject’s consciousness state in recollection was classified into four types by the subject’s combination of key presses: (1) comes-to-mind response: the target item comes to mind, (2) remember response: the target item was remembered directly, (3) awareness-before-vocal response: subjects were aware that the word that came to mind was a studied item before their vocal response, (4) awareness-after-vocal response: subjects were aware that the word that came to mind was a studied item after their vocal response. The directed forgetting effect was observed only in the remember response ($p = .0231$). Moreover, the directed forgetting effect spread to the episodically related items. These results are discussed in terms of retrieval inhibition theory.

Key words: directed forgetting, retrieval inhibition, consciousness state

Introduction

The directed forgetting effect is a phenomenon that indicates that the performance of some events is reduced by trying to forget intentionally. In the general directed forgetting paradigm, subjects try to remember some items and forget others during study. During the test, subjects are unexpectedly asked to retrieve both kinds of study items. The performance for the items the subjects are asked to forget is lower than that for those they are asked to remember. Directed forgetting effects have been explained mainly by invoking either differential processing at encoding (e.g., Bjork, 1972; Paller, 1990) or inhibition at retrieval (Bjork, 1989). Bjork (1972) and Paller (1990) explained the directed forgetting effect in terms of differences in the rehearsal of the to-be-forgotten and to-be-remembered items. On the other hand, Bjork (1989) argued that an inhibition process at retrieval prevents to-be-forgotten items from being recovered.

To solve this problem, this study introduced items related to the to-be-forgotten items that subjects were not asked to forget. If trying to forget to-be-forgotten items reduces performance for the items that are not asked to be forgotten, it cannot be caused by the encoding differences, such as rehearsal or organization, between the to-be-forgotten items and the control items. The most likely explanation is that inhibition of to-be-forgotten items spreads to the related items. This study used episodic-related items. An episodic-related item is defined as a newly learned association that

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1. Department of Psychology, School of Arts and Letters, Tohoku University, Kawauchi, Sendai 980-8576, Japan or e-mail (ikuo@sal.tohoku.ac.jp).
is not pre-experimentally associated (McKoon & Ratcliff, 1979; Tulving, 1983). It has been assumed that episodic-related items are based on episode memory, because they are not associated semantically or phonologically, but are associated during a special episode, such as an experiment. If the forget instruction affects episodic-related items, then the inhibition that operated on the to-be-forgotten items must have spread to the episodic-related items.

In recent years, studies have been interested in the consciousness state in recollection. Johnson (1994) suggested that the directed forgetting effect is observed in tests that require conscious recollection of previous experiences (explicit memory), but not in tests that do not require conscious or intentional recollection (implicit memory). Nevertheless, the previous studies have noted only whether recollection occurs with or without consciousness. There seem to be various states of consciousness, even in explicit memory. In some cases, subjects may remember a target item directly; in other cases, subjects may be aware that the words that came to mind were a studied item. Therefore, this study noted the type of consciousness state in recollection. This study proposed three quite distinct consciousness states in recollection, "comes-to-mind", "awareness", and "remembering". Comes-to-mind indicates that studied items come to mind, but subjects are not aware that the word was studied. Awareness indicates that subjects are aware or recognize that the word that comes to mind was a studied item. Remembering indicates that subjects directly remember the study items. In this study, subjects pressed different keys when a word was remembered, aware, or came to mind. Their consciousness state was classified by the combination of key presses.

As mentioned, we consider whether the directed forgetting effect is observed in episodic-related items that subjects are not required to forget, and experimentally investigated whether there are differences in the directed forgetting affect on recollection in various consciousness states.

**Method**

**Subjects**

Thirty Tohoku University students (15 male and 15 female) between 19 and 28 years of age participated in the experiment. Each subject had normal or corrected-to-normal vision. The subjects were assigned to two groups of 15.

**Design**

The study had a 2 (instruction: forget vs. control) × 4 (response: comes-to-mind vs. remembering vs. awareness-before-vocal vs. awareness-after-vocal) × 4 (list: List 1 vs. List 2 vs. List 3 vs. List 4) mixed design, with repeated measurements of the second and last factors.

**Apparatus**

In the experiment, an Apple PowerMacintosh 7200/120 (Apple, Cupertino) and an Apple Multiple Scan 15-inch display were used to present the stimuli. This experiment was controlled using PsyScope 1.2.1 (Carnegie Mellon University, Pittsburgh). A tape recorder was used to
record the subjects’ vocal responses.

**Stimulus**

The materials consisted of a pool of 115 words from Fujita, Saito, and Takahashi (1991). All of the words were nouns consisting of five Hiragana letters. They had a high familiarity (3.51-5.00). The initial two or three letters (the stem) of all the words had to be unique, and for each stem, the Shuueisha Japanese Dictionary (Morioka, Tokugawa, Kawabata, Nakamura, & Hoshino, 1993) had to list at least three common words with the same stem. The 115 words were divided into five sets of 23 words each (Lists 1, 2, 3, 4, and 5). The mean number of common words with the same stems was 15.7 - 17.9. The words in List 1 were paired with the words in List 2, and the words in List 3 were paired with the words in List 4. These pairs had no relation semantically or phonologically. The pairs were used in the first session. The test and practice lists consisted of the stems of the words in all the lists. The stems of the words in List 5 were used as distracter items. The stems were followed by blanks, and the letters of the stems were changed from Hiragana to Katakana (e.g., しん____). For practice, three stems each were selected from Lists 1, 2, 3, 4, and 5. The test list consisted of the remaining 100 stems.

**Procedure**

The experiment consisted of three sessions. All the subjects were tested individually. In the first session, the item pairs were presented randomly. Before the experiment began, all the subjects were told that the purpose of the experiment was to select appropriate words for another experiment. They were not told that their memory of the presented items would be tested at a later stage. The subjects were asked to rate the difficulty of making a sentence using the two presented words on a 4-point scale, with 4 indicating very easy and 1 indicating very difficult. The stimulus duration was 4 s and the inter-trial interval was 1 s. The subjects viewed the list twice consecutively, and they were informed that they should use each viewing to confirm their rating. After the first session word pairs had been presented, the subjects rested for five minutes.

In the second session, subjects were told that the next experiment was a new experiment. The subjects were asked to rate the familiarity of the presented word on the 4-point scale, with 4 indicating very familiar and 1 indicating very unfamiliar. First, the items in List 1 were presented; stimulus duration was 2 s and inter-trial interval was 1 s. After List 1, the subjects in the forget and control instruction conditions were given the forget or control instructions, respectively. The forget instructions were: “What you have done thus far has been practice. The list you will see next is the true experiment. However, I’m afraid that your criterion and the words in the practice will interfere with the true experiment. Please repeat “forget” silently to forget these criterion and words for one minute.” The control instructions were: “The first portion of the list has now been presented. Please rest for one minute while repeating “1-mu-ke-ne” silently.” 1-mu-ke-ne is a nonsense syllable. All the subjects engaged in the required work for one minute. Therefore, the items in List 1 in the forget instruction condition were the to-be-forgotten items, and the items in List 2 that were paired to those in List 1 in the first session were episodic-related items, which the subjects were not asked to forget. Then, List 3 was presented. The procedure for List 3 was the
Immediately after List 3 had been presented, the memory of the subjects was tested (third session). The test list followed the practice list. The word-stems remained on the screen for 12 s, and the intertrial interval was 1 s. All the subjects were told that the next experiment was a memory test and they should use the stems to aid their attempts at recall. Furthermore, they were required to give not only the recalled words, but also other words that came to mind that completed the stems. There was no limit to the number of words that subjects could give. Three response keys (comes-to-mind key, remember-or-awareness key, and awareness-after-vocal response key) were used to determine the consciousness state in recollection. When a word came to mind without consciousness, subjects pressed the comes-to-mind key. When the subjects remembered a studied word directly, or when they were aware before their vocal response that the word that came to mind was a studied item, they pressed the remember-or-awareness key. The subjects spoke the words that came to mind or were remembered aloud. If subjects were aware that the spoken word was a studied item after the vocal response, they pressed the awareness-after-vocal response key. Subjects were told to press the key as quickly as possible.

The subjects’ consciousness state in recollection was classified into four types by the combination of the key presses (Fig. 1). (1) Comes-to-mind response (CTM response): only the comes-to-mind key was pressed and the subjects spoke the word aloud. (2) Remember response (R response): only the remember-or-awareness key was pressed and the subjects spoke the word aloud. (3) Awareness-before-vocal response (ABV response): the comes-to-mind key was pressed and the remember-or-awareness key was also pressed before the vocal response. (4) Awareness-after-vocal response (AAV response): the comes-to-mind key was pressed and the awareness-after-vocal response key was pressed after the vocal response. All the subjects practiced the required operations before they were tested. The key and vocal responses of the subjects were recorded.
"A word comes to mind"

1. Comes-to-mind Response

"A word is remembered"

2. Remember Response

"Subjects are aware that the word have been studied"

3. Awareness-before-Vocal Response

"Subjects are aware that the word have been studied"

4. Awareness-after-Vocal Response

Figure 1 The four states of consciousness in recollection.

In the test session, the word-stems were presented. Subjects recalled the studied items vocally and pressed keys. The state of consciousness in recollection was classified into four types according to the combination of key presses. (1) Comes-to-mind response: studied items come to mind (the subjects pressed the comes-to-mind key and spoke the word aloud), but subjects are not aware that the word was studied. (2) Remember response: subjects directly remember the study item (only the remember-or-awareness key was pressed and the subjects spoke the word aloud). (3) Awareness-before-vocal response: studied items come to mind (the subjects pressed the comes-to-mind key) and subjects are aware that the word was studied (the remember-or-awareness key was pressed) before the vocal response. (4) Awareness-after-vocal response: studied items come to mind (the subjects pressed the comes-to-mind key) and subjects are aware that the word was studied (the awareness-after-vocal response key was pressed) after the vocal response.

Results

The mean percentage of stems completed with the study list targets in each experimental condition is displayed in Fig. 2. We performed a $2 \times 4 \times 4$ mixed factorial analysis of variance (ANOVA) with instruction (forget vs. control), response (CTM vs. R vs. ABV vs. AAV), and
List (1 vs. 2 vs. 3 vs. 4) as factors. The performance of the distracter (List 5) was not included in the data. An alpha level of .05 was applied to all multiple comparisons.

The main effect of instruction approached significance, $F(1, 28) = 3.49, p = .0722$. The main effect of response was significant, $F(3, 84) = 57.12, p = .0001$. However, the effect of list was not significant, $F(3, 84) = 1.49, p = .2224$. The three-way interaction was not significant, $F(9, 252) = 0.41, p = .9307$. The instruction $\times$ response interaction was significant, $F(3, 84) = 3.63, p = .0163$. The response $\times$ list interaction was significant, $F(9, 252) = 9.55, p = .0001$. The list $\times$ instruction interaction was not significant, $F(3, 84) = 0.16, p = .9212$.

Simple main effects of instruction were computed for each response. Only for the R response was there a significant simple main effect between the control and forget instruction groups, $F(1, 28) = 5.78, p = .0231$.

The simple main effect of response was significant both in the forget instruction group, $F(3, 42) = 10.73, p = .0001$, and in the control instruction group, $F(3, 42) = 90.65, p = .0001$. The multiple comparison analysis revealed that the R response was more significant than any other responses in both the forget instruction and control instruction groups. Moreover, in the control instruction group, there was a significant difference between the CTM and ABV responses.

There were simple main effects of List on the CTM response, $F(3, 42)p = 15.97, p = .0001$, and R responses, $F(3, 42)p = 8.75, p = .0001$. However, there was no effect of List on the ABV responses, $F(3, 42)p = 1.65, p = .1916$, or AAV response, $F(3, 42) = 0.51, p = .6782$. The multiple comparison analysis for the effect of List on the CTM response according to the contrast suggested that there were significant differences between List 2 and List 4,
between List 1 and List 3, and List 4 was marginally higher than List 3. The multiple comparison analysis for List for the R response suggests that there was no significant difference between List 1 and List 3; List 1 was higher than List 4, but the difference between List 3 and List 4 was marginal, and List 4 was marginally better than List 2. For the ABV and AAV responses, there were no significant differences between the lists.

Tests for simple main effects detected significant differences between responses in Lists 1 (\(F(3, 42) = 56.81, p = .0001\)), 2 (\(F(3, 42) = 49.32, p = .0001\)), 3 (\(F(3, 42) = 49.72, p = .0001\)) and 4 (\(F(3, 42) = 44.31, p = .0001\)). The multiple comparison analysis suggested that the R response was more frequent than any other responses in all the lists. In Lists 1 and 3, no other effects were close to being significant. In List 2, there were significant differences between the R and CTM responses, and between the CTM response and the other responses. Similarly, in List 4, there were significant differences between the R and CTM responses and between the CTM response and the other responses. In addition, the CTM response was marginally more frequent than the AAV response. The patterns for Lists 1 and 3, and for Lists 2 and 4 were similar. This was because Lists 1 and 3 were both presented in the first and second sessions, while Lists 2 and 4 were only presented in the first session; the items in these lists were the items associated with the items in Lists 1 and 3, respectively.

Discussion

This experiment considered the kind of consciousness state in recollection in which directed forgetting occurs, and whether the directed forgetting effect is observed in episodic-related items that subjects are not required to forget. The results show a significant interaction between the instruction and response factors, and the performance in the forget instruction condition was lower than that in the control instruction condition only for the R response. Johnson (1994) suggested that the directed forgetting effect only occurs when one intentionally retrieves information from a particular learning episode (i.e., explicit memory). Furthermore, our experiment demonstrated that the directed forgetting effect was observed only when the subjects directly remembered the target, but not when the targets came to mind or when subjects were aware that the comes-to-mind item was a studied item. If the performance of the R response and any other responses involves a trade-off relationship, the facilitatory effect would be apparent in the CTM, ABV, or AAV responses. However, this effect did not emerge. The R response might be independent from any other responses. The results suggest that the R response reflects a different access route to the studied item in memory from that used for any other responses, and that directed forgetting works only on this access route.

Moreover, the list \(\times\) instruction interaction was not significant. Even in List 2, the performance in the forget-instruction condition was lower than that in the control instruction condition, as in List 1. In other words, the directed forgetting effect was observed in the episodic-related items that the subjects were not asked to forget (List 2), just as it was observed in the to-be-forgotten items (List 1). It is difficult to argue that the encoding processes for the episodic-related items differ between the two instruction conditions, because the subjects were not
asked to forget the episodic-related items. The results suggested that the directed forgetting effect is unrelated to encoding processes, such as rehearsal. The most likely explanation is that inhibition of a to-be-forgotten item spreads to episodic-related items. These results seem consistent with the retrieval inhibition theory (Geiselman, Bjork, & Fishman, 1983; Bjork, 1989). The forget instruction inhibits the access route that works to remember the studied items in memory, but does not inhibit any other routes. Moreover, the inhibition spreads to items related to the to-be-forgotten items episodically, although subjects were not asked to forget the related items. The process of "spreading inhibition" is analogous to that of spreading activation (Tipper, 1985). The directed forgetting effect also occurred in Lists 3 and 4. List 3 was presented after the forget (control) instruction, and List 4 was the items that were paired with the items in List 3 in the first session. It was expected that the directed forgetting effect would not be observed in Lists 3 and 4. Geiselman et al. (1983) showed the facilitatory effect of forget instructions in the list presented after the instruction. Our results are not consistent with prior results. There are several ways to reconcile these results. One explanation is that the subjects’ motivation was reduced by the forget instruction. Next, it is possible that the forget instruction did not selectively operate on List 1. In this experiment, subjects were asked to forget List 1 in the second session. However, subjects might try to forget all of the words presented before the instruction, so they might forget the items in the first session, which included Lists 1, 2, 3, and 4. Third, the directed forgetting effect might spread to lists that were presented after the instruction.

In summary, in this study, the directed forgetting effect was observed only when the subjects directly remembered the target, and the effect occurred with episodic-related items, which the subjects were not asked to forget. These results were consistent with the retrieval inhibition theory. However, it is difficult to draw a firm conclusion because there are other explanations. Moreover, the performance of the CTM, ABV, and AAV responses was markedly lower, so the results in which the directed forgetting effect only occurred for the R response was a floor effect. Further study is needed to explore these problems.

References


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(Received December 20, 1999)  
(Accepted May 1, 2000)