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# The effect of repeated writing on memory

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Repeated writing, or rehearsal by writing, is a common memory strategy for the Japanese, especially when learning new logographic characters. The to-be-remembered items are written down not as external prompts, as with reminder notes, but to be memorized in the course of writing them down over and over again. In this study, we investigated whether the strategy was effective, and if so, in which condition. Experiment 1 showed that repeated writing improved memory for graphic designs but not for Chinese characters, words, or syllables. Experiment 2 showed that the effect occurred for both Japanese and American subjects, suggesting that it was not the result of a cultural background associated with a logographic language. Instead, the effect seemed to be accounted for by the encoding specificity of visual-motor information, because repeated writing improved free recall—that included writing—but did not improve recognition (Experiment 3). In Experiment 4, the strategy was applied to learning the Arabic alphabet. Finally, similarities between repeated writing and Type 1 rehearsal are discussed.

Various memory aids are used to remember things. Some, such as reminder notes, are external, while others, such as mental rehearsing, are internal. In general, external aids are preferred (Harris, 1984), but internal aids are used when one cannot rely on external prompts or when external aids would be undesirable or inconvenient (Intons-Peterson & Fournier, 1986). In the latter conditions, a memory aid that is commonly used by the Japanese is *repeated writing*, or *rehearsal by writing*, which involves writing down to-be-remembered items over and over on a piece of paper, on a table top, or even in the air. Although it produces external feedback and therefore may share some characteristics of external aids, it is not entirely external because the purpose of repeated writing is to learn the items by heart while writing, but not to make an external prompt or a reminder note for later use; that is, it is the writing action itself, not the output, that is important. Interestingly, while it does not appear in the list of 19 memory aids put up by Intons-Peterson and Fournier (1986), repeated writing was shown to be one of the most popular memory aids among Japanese subjects (Kusumi, 1992).

Although the strategy is often observed among the Japanese, and especially among Japanese children learning new logographic Chinese characters (Mann, 1985; Onose, 1987, 1988; see Figure 1), systematic studies of its effect are very few and the results are still inconclusive. For example, Takahashi (1985) presented Japanese undergraduates with 45 familiar words as an incidental learning task. Each word appeared for 2 sec on a computer screen and was followed by a blank interval during which the subjects were instructed to rehearse the word as many times as possible, either by articulating it or by writing it. Interstimulus intervals were 4, 8, or 12 sec. Overall recognition was better for the articulation condition than for the writing condition. Moreover, although recognition in the articulatory condition increased with increasing interval, no interval effect was observed for the writing condition. In terms of recall, no difference between the two rehearsal conditions was observed, nor was any change due to rehearsal interval. These results suggested that writing rehearsal did not facilitate either recognition or recall of words. In another study by Takahashi and Shimizu (1989), the effect was examined in the natural setting of a fourth-grade classroom. The subjects were first instructed to translate words written in Hiragana, a syllabary, into Chinese characters (pretest) and they then were presented with correct Chinese characters and instructed to study them by repeated writing for 10 min. Then they were retested (posttest). The results for those who rehearsed intensively (i.e., those who wrote down characters more than the average number of times during the study session) were analyzed separately from the results of those who did not. No difference was observed between the two groups, suggesting that the amount of rehearsal did not affect the learning of Chinese characters. Although the scores increased from pretest to posttest in both groups, the increase could be attributed to the fact that the subjects took the same test twice.

Naka and Takizawa (1990), however, did find a repeated-writing effect. They studied the effect of rehearsal with and without writing on recall and recognition of three different types of item—namely, words, syllables, and graphic designs. To find out whether rehearsal affected the inter-item or intra-item processing, the

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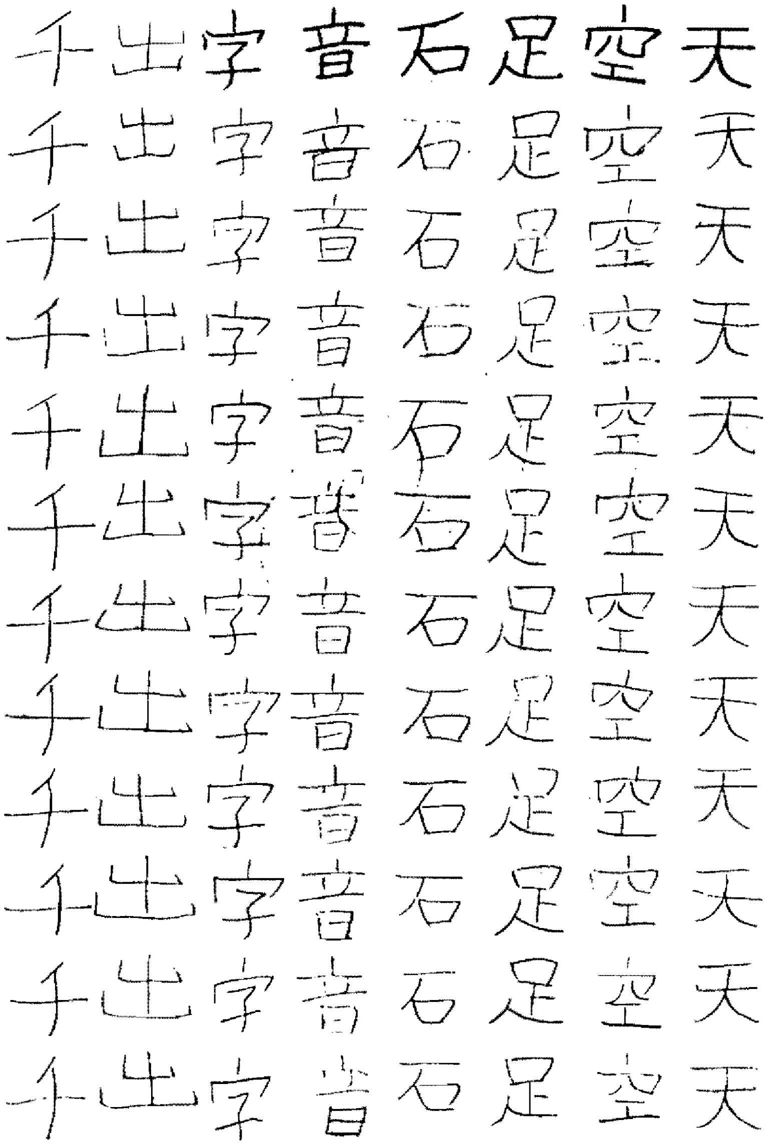



**Figure 1. An example of repeated writing: A page from the school notebook of a Japanese first-grade child learning Chinese characters. Such repeated writing continues page after page.**

items of each type were presented either in pairs (Experiments 1 and 2) or singly (Experiment 3). The subjects were asked to rehearse them either by writing (i.e., writing the item down as many times as possible) or by reading (i.e., reading or looking at them silently as many times as possible) for 10 sec for each pair of items or for 5 sec for each single item, and then were given an intervening task, followed by a free-recall test and a recognition test. Although in Experiments 1 and 2, in which the subjects studied items in pairs, there was no effect of repeated writing, in Experiment 3, in which they studied items singly, free recall for the syllables and graphic designs was better for the writing condition than for the reading condition. The effect was greatest for the graphic designs. The results are still inconclusive, however, because different items were used in Experiments 1 and 2 than were used in Experiment 3, and thus no direct comparison could be made. Nevertheless, repeated writing seemed to facilitate at least intra-item processing of visual information (i.e., graphic designs). A similar effect of visual-motor strategy on pictorial stimuli in a discrimination learning task was reported by Levin and colleagues (Levin, Ghatala, DeRose, & Makoid, 1977; Levin, Ghatala, DeRose, Wilder, & Norton, 1975).

The purpose of the present report was to determine whether or not repeated writing facilitates learning, and, if it does do so, in which condition. In Experiment 1, we examined the effect of repeated writing on memory of various types of items in paired-item and single-item conditions. In Experiment 2, we studied whether the effect was linked to the cultural background associated with a logographic language. In Experiment 3, we compared the effect of repeated writing on recall and on recognition to see whether it was accounted for by encoding specificity; if it was, we would expect the effect to occur in the recall (i.e., retrieval with writing) condition but not in the recognition (i.e., retrieval without writing) condition. Finally, in Experiment 4, we applied the strategy to learning the Arabic alphabet.

## EXPERIMENT 1

### Method

**Subjects**. Forty Japanese undergraduates at Chiba University participated. They were randomly assigned to either the single-item list condition ($n$ = 20) or the paired-item list condition ($n$ = 20).

**Materials**. Four types of item were used—namely, (1) 60 words in Chinese characters (e.g., 目標 [moku-hyo], a goal), (2) 60 words in Hiragana (e.g., そら [so-ra], sky), (3) 60 meaningless syllables in Katakana (e.g., エウ [e-u]), and (4) 60 meaningless graphic designs (e.g., □+ )[1] (see Appendix A). For each type, 20 items were used as target items—10 for the writing condition and 10 for the reading condition. The other 40 items were used as distractors in a multiple-choice recognition test that was composed of 20 sets of 3 items—a target and two distractors.

**Procedure**. Testing was done individually. For each type of item, the subjects were given a 9 × 13 cm booklet containing instructions, together with either 20 pages of target items (one item per page) or 10 pages of target pairs (one pair per page), an intervening task (writing down the English alphabet backward [i.e., z, y, x, w, etc.]), a free-recall test, and a multiple-choice recognition test. For the writing condition, a blank rectangular space was provided under each item/pair.[2]

The subjects were instructed to learn each item/pair by writing or by reading. The instructions were: "Each page shows a(n) item/pair to remember. If you see a rectangular space under the item/pair, try to remember it by writing. Otherwise try to remember it by reading. When you hear the sign, turn to the next page." This sign was an oral signal, "hai [next]," given by the experimenter. Prior to this, the subjects were to write/read the item/pair as many times as possible. The order of items was randomized with the restriction that items for the writing condition alternated with those for the reading condition.

A preliminary study showed that the subjects took twice as much time to write down Chinese characters as they did to write down other items. Therefore, the rehearsal time per item was set at 10 sec for Chinese characters and at 5 sec for other items. For pairs, the rehearsal time was doubled. The subjects were told not to use strategies such as chunking, imagining, or overt rehearsing.

After the learning session, the subjects engaged in a 30-sec intervening task, followed by a 120-sec free-recall test and then a 90-sec multiple-choice recognition test. Subjects in the paired-item condition were encouraged to recall items in pairs and put them down next to each other, and they were instructed to match the recognized items by connecting them with a line. This last phase lasted for 60 sec. The subjects carried out this procedure for each of the four types of item (Chinese characters, words, syllables, and graphic designs), each of which was presented in a separate booklet. The order in which the booklets were presented was counterbalanced between subjects.

**Design**. A 2 (single-item or paired-item list) × 2 (rehearsal by writing or by reading) × 4 (Chinese characters, words, syllables, or graphic designs) mixed design was used. Only the first factor was between subjects.

### Results

The number of correct responses by free recall and by recognition was counted. In this and the following experiments, free recall of graphic designs was judged to be correct if the subject's reproduction of it had all the components of the original, and no additional ones. The judgment was made by authors in Experiments 1 and 2 and by a trained assistant in Experiments 3 and 4.

Figures 2 and 3 show graphically the number of correct responses, respectively, for free recall and for recognition. As seen in Figure 2, repeated writing facilitated

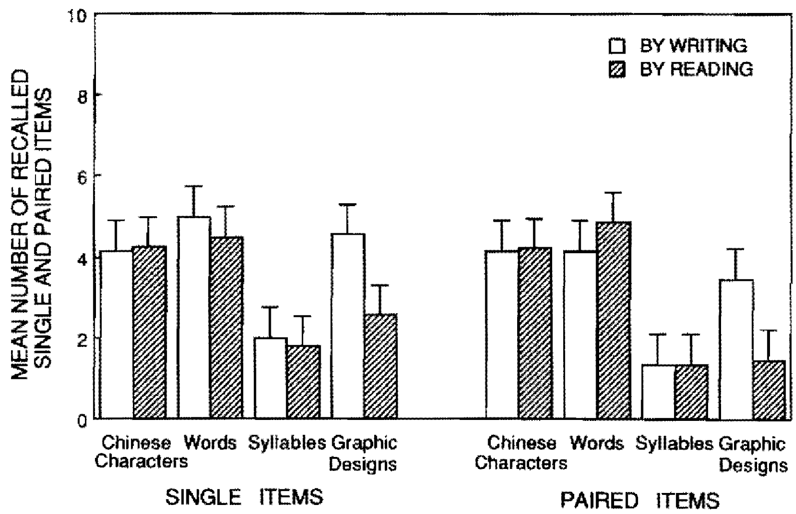



**Figure 2. Results from Experiment 1: Correct free recall of Chinese characters, words, syllables, and graphic designs in the (writing vs. reading) × (paired-item vs. single-item) conditions. Within-subjects error bars indicate one standard error of the mean.[3]**

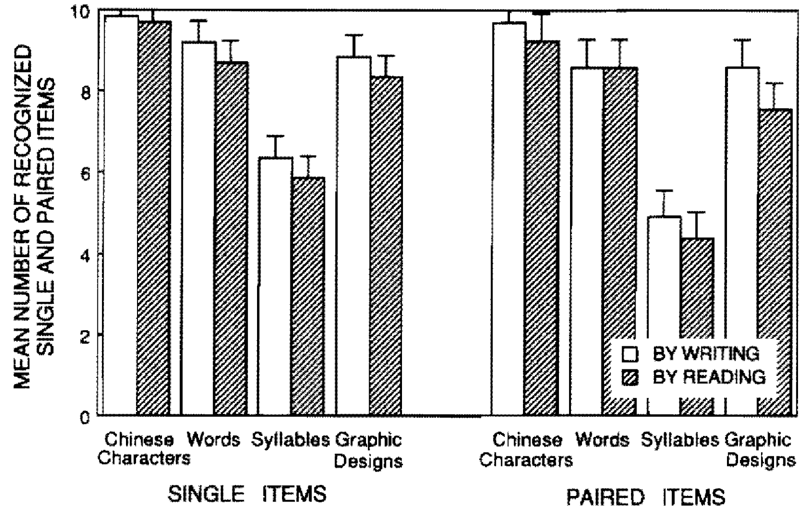



**Figure 3. Results from Experiment 1: Correct recognition of Chinese characters, words, syllables, and graphic designs in the (writing vs. reading) × (paired-item vs. single-item) conditions. Within-subjects error bars indicate one standard error of the mean.**[4]

recall of graphic designs but not of other items in both single-item and paired-item conditions, while Figure 3 shows that in terms of recognition, although repeated writing facilitated the overall performance [$F(1,38) = 4.61$, $MS_e = 4.01$, $p = .03$], there was no significant interaction between rehearsal and type of item.

Contrary to the findings of Naka and Takizawa (1990), the repeated-writing effect was observed in both single-item and paired-item conditions. However, this finding does not necessarily mean that repeated writing facilitated the inter-item processing. The bar graph in Figure 4 shows the number of correctly matched pairs by free recall and by recognition in the two different rehearsal conditions (reading vs. writing). No effect of rehearsal was observed.

**Discussion**

The main finding was that the strong effect of repeated writing occurred for the graphic designs but not for the other types of item. While Chinese characters and words may be encoded semantically, and syllables phonetically, meaningless graphic designs may be encoded neither semantically nor phonetically, but only in visual images. Accordingly, we suggest that repeated writing

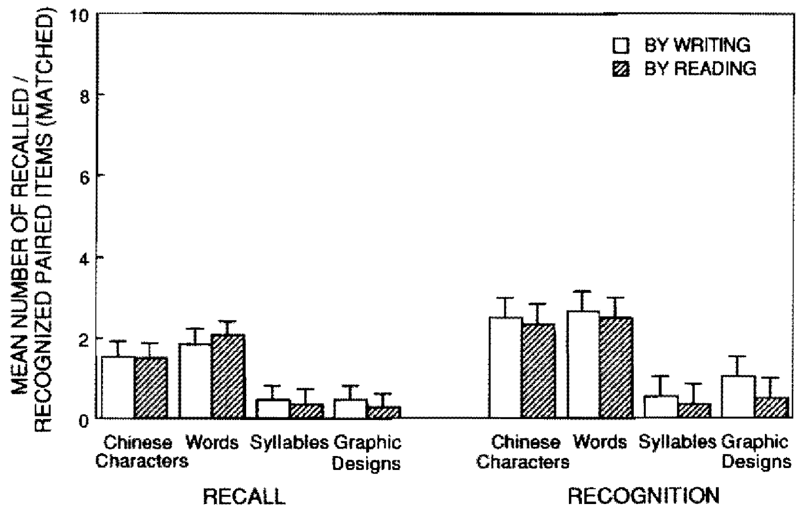



**Figure 4. Results from Experiment 1: Correctly matched pairs by free recall and by recognition of Chinese characters, words, syllables, and graphic designs, in both the writing and the reading conditions (paired-item–list condition only).**

facilitates the encoding of visual information of graphic designs.

Second, there was no effect of repeated writing on the number of correctly matched pairs in free recall or recognition, which suggests that repeated writing facilitates only intra-item processing. Repeated writing may be viewed as a kind of visual rehearsal (or re *see* sal [Klatzky, 1980]) that may affect memory for intra-item visual information rather than memory for such inter-item information as the semantic and functional relationship between two items.

In Experiments 2 and 3, we attempted to find out why repeated writing facilitates memory for graphic designs.

## EXPERIMENT 2

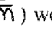
The effect of rehearsal by writing may be accounted for by a cultural background associated with a logographic language. Because Chinese characters have many homonyms, orthography plays an important role in communication. Sasaki (1987) noted that the Japanese use *Ku-sho* (finger-writing in the air) in the course of conversation to identify an orthography of Chinese characters. As mentioned before, it is also well known that Japanese children start learning letters and characters by copying or writing them down repeatedly (Mann, 1985; Onose, 1987, 1988). Such a cultural background may have formed a learning strategy that is especially effective for learning *new* logographic materials—namely, in this case, graphic designs. If this cultural-background hypothesis is correct, we would expect the effect to be observed only among logographic-language users.

An alternative hypothesis might be that the effect of rehearsal by writing is caused by more fundamental visual-motor processes that are required in writing regardless of any cultural background. For example, one may need briefly to hold a visual image of an item until it has been written down (Levin et al., 1977; Sloboda, 1980; Tenney, 1980), and one may need to plan and execute a particular motor movement in order to write the name of an item (Thomassen & Teulings, 1983). According to this fundamental-processing hypothesis, such visual-motor processes in writing may enhance memory for graphic designs.

Although these hypotheses are not mutually exclusive, it should be useful to determine which of the two is more responsible for the observed effect. In Experiment 2, we compared the effect for Japanese and American subjects. If the cultural factor is dominant, the effect would be greater for Japanese subjects than it is for American subjects. If, however, the effect is mainly due to the fundamental visual-motor processes, it would be equal for American and Japanese subjects.

### Method

**Subjects**. The subjects were 32 Japanese undergraduates at Chiba University and 32 American undergraduates at Duke University. All of the Japanese subjects had studied English for at least six years and had no trouble dealing with English and alphabetic items.

**Materials**. Twenty English words (e.g., *ant*), 20 pseudowords (e.g., *zok*), 20 nonwords (e.g., *bgq*), and 20 graphic designs (e.g., ) were used (see Appendix B). Five items of each type were used for the writing condition and five of each type were used for the reading condition. The other 10 items of each type were used as distractors in the recognition test. Items for the writing and reading conditions, as well as those for targets and distractors, were counterbalanced between subjects.[5]

**Procedure**. The experiment was conducted on small groups of 5–10 subjects at a time. The subjects were given a booklet measuring 19.5 × 21 cm and consisting of instructions, five pages of items for the writing condition, five pages of items for the reading condition, an intervening task involving writing down the alphabet backward,[6] a free-recall test, and a recognition test. Each page contained four blocks of five items of each type, for either the writing or the reading condition. The pages for the writing and the reading conditions were arranged alternately, and in addition, the location of both items and blocks was different on each page so as to prevent a serial-order effect from occurring.

The instructions were as follows: "The purpose of this experiment is to see in which condition one learns better, writing or reading. You are to learn 40 words/non-words by writing or by reading. In *writing* condition ("*write*" instruction is given at the top of the sheet), you write the word/non-word in a blank space. In *reading* condition ("*read & check*" instruction is given at the top of the sheet), you read the word/non-word. To make sure you read, mark each letter with a circle. Each word/non-word appears repeatedly five times in this booklet. Just concentrate on writing/reading and try not to use any other mnemonics or strategies. Do not spend too long time on each item. Five seconds for an item would be maximum." (A translation of these instructions was given to the Japanese subjects.) After the subjects had finished learning the items, they completed an intervening task, followed by the free-recall and recognition tasks, at their own pace.

In contrast to Experiment 1, in which each page contained an item or a pair of items which the subjects were instructed to rehearse as many times as possible until a signal was given (i.e., duration to rehearse, but not the number of repetitions, was controlled), in Experiment 2, the number of repetitions (five times per item), rather than rehearsal duration, was controlled.

**Design**. A 2 (Japanese or American subjects) × 2 (rehearsals by writing or reading) × 4 (words, pseudowords, nonwords, or graphic designs) experimental design was applied. Only the first factor was between subjects.

### Results

Figures 5 and 6 show graphically the number of correct responses for free recall and for recognition. As seen in Figure 5, for both the Japanese and the American subjects, repeated writing facilitated the recall of graphic designs but not of other items, while in the recognition task, although the overall effect of repeated writing was significant [$F(1,62) = 7.36$, $MS_e = 0.66$, $p = .008$], there was no interaction between rehearsal and type of item.

### Discussion

The results of Experiment 1 were replicated insofar as the effect of repeated writing occurred for the graphic designs but not for the other types of item. Fundamental visual-motor processes seem to have been more responsible for the effect.

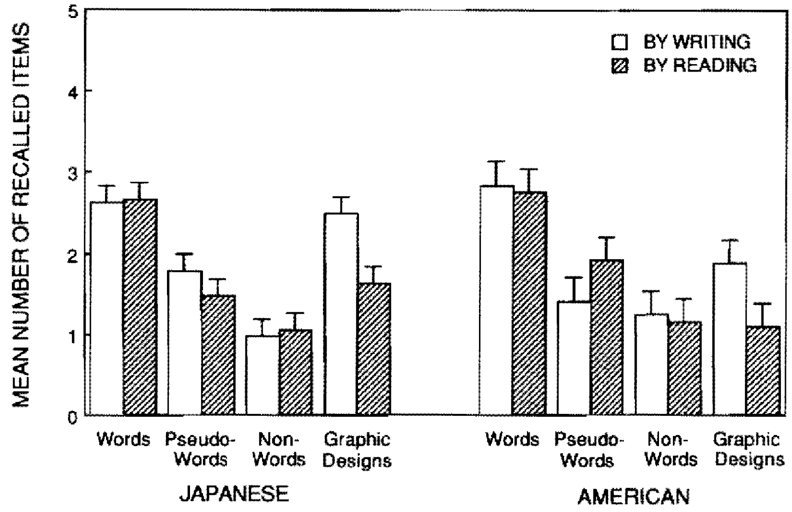



**Figure 5. Results from Experiment 2: Correct recall of words, pseudowords, nonwords, and graphic designs in the (Japanese vs. American) × (writing vs. reading) conditions.**

As in Experiment 1, repeated writing did facilitate overall recognition. However, this effect may have been overestimated because the subjects were tested on the same materials for both tasks (i.e., free recall and recognition; Darley & Glass, 1975). In Experiment 3, we assessed the effect of repeated writing on free recall separately from its effect on recognition in order to see whether or not the effect is related to the method of retrieval.

## EXPERIMENT 3

The results of Experiment 2 suggested that the effect was accounted for not by cultural background but, rather, by fundamental processes required in writing. One possible explanation may involve the degree to which visual-motor information matches between encoding and retrieval; it is known that target information encoded with motor components is remembered better when the retrieval process includes the same motor components (Glass, Krejci, & Goldman, 1989; Lee & Hirota, 1980). If this is true, we would expect items learned by writing to be retrieved better when the retrieval process includes writing (i.e., when free recall is used) than when it does not (i.e., when recognition is used), and particularly so for those items—namely, graphic designs—whose retrieval by memory depends upon visual-motor information.

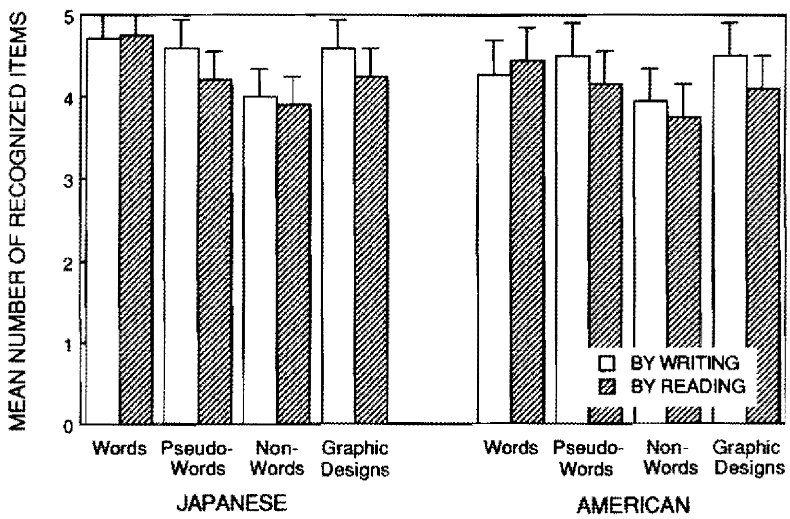



**Figure 6. Results from Experiment 2: Correct recognition of words, pseudowords, nonwords, and graphic designs in the (Japanese vs. American) × (writing vs. reading) conditions.**

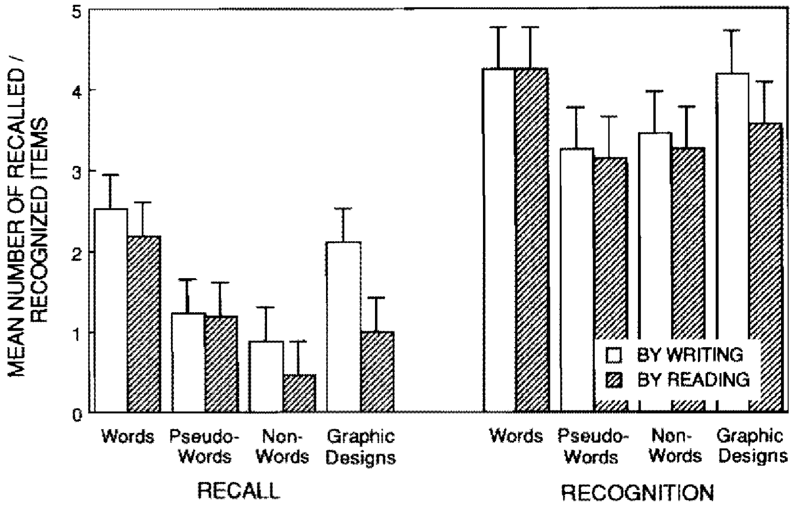



**Figure 7. Results from Experiment 3: Correct recall and recognition of words, pseudowords, nonwords, and graphic designs in both the writing and the reading conditions.**

### Method

**Subjects.** The subjects were 40 Japanese undergraduates at Chiba University. They were randomly assigned to either a recall condition ($n = 20$) or a recognition condition ($n = 20$).

**Materials.** The materials were the same as those used in Experiment 2.

**Procedure.** The procedure was the same as that used in Experiment 2, except that the subjects were given either a free-recall test or a recognition test (not both), and both number of repetitions (i.e., five times per item) and rehearsal duration were controlled (an experimenter gave an oral signal, "hai [next]," every 4 sec, at which point the subjects turned to the next item).

**Design.** A 2 (retrieval by free recall or by recognition) × 2 (rehearsal by writing or by reading) × 4 (words, pseudowords, nonwords, or graphic designs) experimental design was applied. Only the first factor was between subjects.

### Results and Discussion

Figure 7 shows graphically the number of correct responses by recall and by recognition. A difference between the two strategies was seen only for the free recall of graphic designs.

The results suggested that the repeated-writing effect is accounted for—at least to some extent—by the degree of match between encoded and retrieved visual-motor information.

## EXPERIMENT 4

Experiment 4 was conducted to replicate the results obtained in the previous experiments as well as to assess the applicability of the repeated-writing strategy to learning a foreign language. Although the graphic materials used in Experiments 1, 2, and 3 were designed to be unfamiliar to the subjects, they might have borne some resemblance to Chinese characters (Experiment 1) or to the English alphabet (Experiments 2 and 3). If the repeated-writing effect is accounted for by the encoding specificity of visuomotor information rather than by the cultural background associated with a particular language, repeated writing must facilitate the recall of even less familiar items, such as characters comprising the Arabic alphabet, which is rarely seen in Japan. In Experiment 4, therefore, we studied the effect of repeated-writing on learning the Arabic alphabet. Foreign letters are typically learned by each letter being presented, along with its pronunciation, and then by the letter being written down while it is named or pronounced. We simulated such a process in this experiment.

### Method

**Subjects.** The subjects were 80 Japanese undergraduates at Chiba University, none of whom had any experience with the Arabic language. The subjects were assigned to either the writing ($n = 40$) or the reading condition ($n = 40$). Half of the subjects in each condition were given a free-recall test, while the other half were given a recognition test.

**Materials.** The 28 letters of the Arabic alphabet and their pronunciation in Japanese (Katakana) were used (see Appendix C).

**Procedure.** The subjects were tested in a group. As in the previous experiments, they were each given a booklet, consisting in this experiment, of instructions, five pages of the Arabic alphabet, together with its pronunciation, arranged in Arabic alphabetical order,[7] an intervening task (the same subtraction task used in Experiments 2 and 3), and either a free-recall or a recognition test.

The instructions were as follows: "Learn the Arabic alphabet so you will be able to write down your name in Arabic![8] Learn the letters *by writing* [*by reading and putting a circle around the letter* for the reading condition]. Also try to remember the pronunciation shown under each letter" (translation of the Japanese version given to subjects). The subjects in the writing condition were instructed to write only letters. As far as the pronunciation of the letters was concerned, no further specific instruction was given, nor was any extra emphasis put on them. As in Experiment 3, an experimenter gave the oral signal "hai[next]" (but in this case, every 3 sec), at which point the subjects turned to the next letter. They were prohibited from using other strategies.

After the learning session, the subjects were given an intervening task, followed by either a free-recall test or a recognition test of the Arabic letters. Both groups of subjects were also instructed to write down (i.e., recall) the pronunciation of recalled or recognized letters.

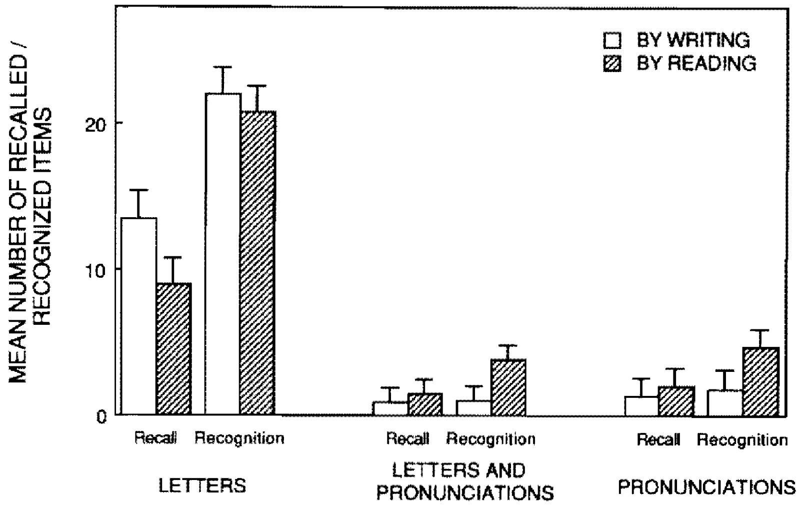



**Figure 8. Results from Experiment 4: Correct recall and recognition of Arabic letters, letters with their pronunciations, and pronunciations only, in both the writing and the reading conditions. Error bars indicate one standard error of the mean.[9]**

**Design.** A 2 (rehearsal by writing or reading) × 2 (retrieval by free recall or recognition) between-subjects experimental design was applied.

### Results and Discussion

Figure 8 shows graphically the number of letters recalled or recognized correctly (left), the number of letters recalled or recognized, together with that correct pronunciation (middle), and the number of pronunciations recalled correctly (right). Repeated writing facilitated the recall, but not the recognition, of letters. Interestingly, both the number of letters retrieved with their correct pronunciation and the number of correct pronunciations were greater for the reading condition than for the writing condition, suggesting another encoding–retrieval interaction—namely, that the pronunciations that might be encoded in phonetic codes were retrieved better by recognition than by recall.

In general, the results of the previous experiments were confirmed and the advantage, as well as the limitation, of the repeated-writing strategy was suggested; that is, it facilitates the recall of a letter's shape but not the pronunciation of the letter.

## GENERAL DISCUSSION

The main findings in this study were that (1) rehearsal by writing facilitated memory for intra-item information concerning graphic designs, (2) the effect occurred irrespective of subjects' cultural backgrounds, and (3) the effect occurred for free recall but not for recognition. It seems to be accounted for by the encoding specificity of visual-motor information.

It has been demonstrated that visual rehearsal facilitates memory for pictures and other nonverbal stimuli (Levin et al., 1977; Levin et al., 1975; Tversky & Sherman, 1975; Watkins & Graefe, 1981; Watkins, Peynircioğlu, & Brems, 1984; Weaver, 1974; Weaver & Stanny, 1978). Although definitions of visual rehearsal are diverse, they seem to fall into two categories, the first of which is Type 1 maintenance rehearsal (i.e., "to maintain an image [of to-be-remembered item] and to scan the image with mind's eye" [Watkins et al., 1984]). The second is Type 2 elaborative rehearsal (i.e., "to find categories or relations between materials" [Tversky & Sherman, 1975]). Given such a dichotomy, repeated writing is closer to Type 1 than to Type 2 visual rehearsal, since it is a rote repetition of writing action. Moreover, rehearsal by writing seems also to share some features with the usual Type 1 rehearsal, in that it enhances surface information rather than deep semantic information and it facilitates intra-item processing rather than inter-item processing (Bradley & Glenberg, 1983; Glenberg & Bradley, 1979).

It may be argued that Type 1 rehearsal does not lead to long-term memory of the to-be-remembered item (Craik & Watkins, 1973; Woodward, Bjork, & Jongeward, 1973). However, it is known that even mere repetition facilitates long-term memory if enough effort is put into the rehearsal (Dark & Loftus, 1976; Darley & Glass, 1975; Glenberg, Smith, & Green, 1977; Kamiya, 1982). That being the case, the strategy may well be applied to learning visual-motor stimuli, such as foreign letters and characters, and possibly map routes. Further research is necessary to determine the links between repeated writing, Type 1 visual rehearsal, and the usual Type 1 rehearsal, as well as to be able to utilize the strategy for practical purposes.

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## NOTES

1. Japanese uses Chinese characters (Kanji), Hiragana and Katakana. Hiragana and Katakana are syllabaries.

2. Although in the case of graphic designs it would be more accurate to use "draw" instead of "write," we used "write" throughout this paper as well as in the booklet instructions because our purpose was to study the effect of *writing*. In fact, since the graphic designs used here were the same size as the other characters, they had the appearance of foreign logographic characters, and no one had any difficulty understanding the instruction.

3. A within-subjects error bar shows a 95% confidence interval (CI) (Loftus & Masson, 1993):

$$CI = \sqrt{MSI/n}\ [\text{criterion } t(df)].$$

Two sample means, $M_i$ and $M_j$, are significantly different if, and only if,

$$|M_i - M_j| / \sqrt{2} > CI$$

4. See previous note.

5. The items were divided into four sets, A1, A2, B1, and B2, each of which was made up of 20 items—5 of each of the four types. For half of the subjects, A1 and A2 were used as targets and B1 and B2 were used as distractors; of this group, half learned A1 by writing and A2 by reading, while the other half learned A2 by writing and A1 by reading. For remaining subjects, B1 and B2 were used as targets and A1 and A2 were used as distractors; half of this group learned B1 by writing and B2 by reading, while the other half learned B2 by writing and B1 by reading.

6. Although the American subjects finished this task within a minute, the Japanese subjects were found to take much longer to complete it. For the Japanese subjects, therefore, the intervening task was changed to one involving subtraction, whereby, starting at 100, they were to keep subtracting 6 until they reached less than 0 (i.e., 100, 94, 88, and so on); this task took them almost the same amount of time to complete as it took the American subjects to write the English alphabet backward.

7. Although the Arabic alphabet is usually arranged from right to left, it was arranged from left to right in this experiment.

8. None of the subjects knew which letters would compose her or his name. After the testing was completed, the subjects were all provided with a sheet showing them how to combine letters to spell their name in Arabic.

9. Because the rehearsal condition in Experiment 4 was between subjects, the CI is based on the pooled estimate of the within-condition variance—that is, on MSW (the pooled estimate of the within-condition variance):

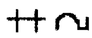
$$CI = \sqrt{MSW/n}\ [\text{criterion } t(df)].$$

The error bar shows a 95% confidence interval.

## APPENDIX A
### Materials Used in Experiment 1

| Chinese Characters | Words | Nonwords | Graphic Designs |
|---|---|---|---|
| 委員[i-in]: committeeman | あみ[a-mi]: net | エウ[e-u] |  |
| 運命[un-mei]: destiny | いと[i-to]: thread | ケク[ke-ku] |  |
| 価格[ka-kaku]: price | うた[u-ta]: song | スセ[su-se] |  |
| 過労[ka-rou]: fatigue | かお[ka-o]: face | セホ[se-ho] |  |
| 企業[ki-gyo]: company | さと[sa-to]: country | ツオ[tu-o] |  |
| 検査[ken-sa]: test | しき[shi-ki]: seasons | トヌ[to-nu] |  |
| 賛成[san-sei]: affirmation | そら[so-ra]: sky | ナテ[na-te] |  |
| 宗教[shu-kyo]: religion | たに[ta-ni]: valley | ニメ[ni-me] |  |
| 勝負[sho-bu]: match | とら[to-ra]: tiger | ネヒ[ne-hi] |  |
| 設計[se-kkei]: design | にわ[ni-wa]: garden | ムモ[mu-mo] |  |
| 世論[se-ron]: world opinion | はね[ha-ne]: feather | ユロ[yu-ro] |  |
| 停車[tei-sha]: stopping a car | ふく[hu-ku]: clothes | ラエ[ra-e] |  |
| 電波[den-pa]: electric wave | へや[he-ya]: room | ロテ[ro-te] |  |
| 秘密[hi-mitsu]: secret | まゆ[ma-yu]: cocoon | ヌソ[nu-so] |  |
| 貿易[bo-eki]: trade | みせ[mi-se]: shop | ハユ[ha-yu] |  |
| 報告[ho-koku]: report | もり[mo-ri]: woods | メミ[me-mi] |  |
| 目標[moku-hyo]: goal | やま[ya-ma]: hill | ルヤ[ru-ya] |  |
| 利益[ri-eki]: gain | ゆめ[yu-me]: dream | ロヘ[ro-he] |  |
| 留学[ryu-gaku]: studying abroad | わた[wa-ta]: cotton | ワソ[wa-so] |  |
| 礼儀[rei-gi]: manner | なす[na-su]: eggplant | ヘヨ[he-yo] |  |

## APPENDIX B
### Materials Used in Experiments 2 and 3

| Words | Pseudowords | Nonwords | Graphic Designs |
|---|---|---|---|
| ant | zok | bgq |  |
| lie | lom | mzs |  |
| cow | ces | dgx |  |
| nod | ozi | qdm |  |

**APPENDIX B (Continued)**

| Words | Pseudowords | Nonwords | Graphic Designs |
|---|---|---|---|
| egg | faw | frz |  |
| set | tul | rdg |  |
| van | ver | yht |  |
| jar | kif | kjl |  |
| gun | gik | wbp |  |
| pea | poy | trv |  |
| hat | sei | gnl |  |
| key | wom | jzp |  |
| red | rul | pzf |  |
| way | jid | vft |  |
| tar | hol | stc |  |
| oak | nok | ltk |  |
| bag | azt | cwh |  |
| far | ege | zgd |  |
| dog | dez | gtz |  |
| man | mor | ndx |  |

**APPENDIX C**
**Materials Used in Experiment 4**

| Letter | Pronunciation in Japanese | Phonetic Pronunciation | Letter | Pronunciation in Japanese | Phonetic Pronunciation |
|---|---|---|---|---|---|
| أ | アルフ | [a-ru-hu] | ض | ドォーダ | [doo-da] |
| ب | ベ | [be] | ط | タ | [ta] |
| ت | テ | [te] | ظ | ザ | [za] |
| ث | ゼ | [ze] | ع | アイエンヌ | [a-i-e-n-nu] |
| ج | ジム | [ji-mu] | غ | リエンヌ | [ri-e-n-nu] |
| ح | ハ | [ha] | ف | フエ | [hue] |
| خ | ツハ | [tt-ha] | ق | カーフ | [ka-hu] |
| د | ダーラ | [da-ra] | ك | ケーフ | [ke-hu] |

**APPENDIX C (Continued)**

| Letter | Pronunciation in Japanese | Phonetic Pronunciation | Letter | Pronunciation in Japanese | Phonetic Pronunciation |
|---|---|---|---|---|---|
| ذ | ザーラ | [za-ra] | ل | レーム | [re-mu] |
| ر | ラ | [ra] | م | ミーム | [mi-mu] |
| ز | ザール | [za-ru] | ن | ヌーヌ | [nu-nu] |
| س | スィーン | [sui-n] | و | ワォワ | [wao-wa] |
| ش | シーン | [shi-n] | ه | へ | [he] |
| ص | サーダ | [sa-da] | ي | イェ | [ie] |

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