

EFFECTS OF PRE-ACTIVATION OF MOTOR MEMORY FOR KANJI AND KANA ON SLIPS OF THE PEN: AN EXPERIMENTAL VERIFICATION OF THE RECENCY HYPOTHESIS FOR SLIPS¹

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The 'recency' hypothesis for action slips was verified by an experiment involving pen slips with kanji (Chinese originated characters) and kana (Japanese phonograms). In this hypothesis, it is assumed that when an intended action has something in common with another action that has been recently used, the former action may well appear as a slip while the intended action is being performed. Two hundred and twenty undergraduates were asked to write certain characters using the rapid repeated writing (RRW) technique. The character chosen used elements that had appeared in other characters practiced a short time previously. Errors in which the former characters were written instead of the intended character increased as a function of the number of times they had previously been used.

Key words: slips of the pen, motor memory, activation, priming, kanji, kana, rapid repeated writing (RRW).

INTRODUCTION

A slip is a form of human error defined as the performance of an action that was not intended (Norman, 1981). Theories concerning action slips share the assumption that when the intended action has something in common with another action performed recently or frequently, the former action is likely to appear instead of the intended one in the form of a slip. This type of slips is called a 'capture slip' (Norman, 1981; Reason, 1984). Capture slips may be represented by this example reported by Norman (1981);

I was using a copying machine, and I was counting the pages. I found myself counting "1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Jack, Queen, King." (I have been playing cards recently.)

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The capture slip occupies an important position among slip types. Reason (1984) claimed that a large proportion of absentminded slips (40% in one study) involve capture slips. Those slips predicted by the hypothesis that result from a recently performed action might be called 'recency slips' and this part of the hypothesis the 'recency hypothesis.

This particular kind of capture slip can be explained by Norman's ATS (activation-trigger-schema system) model (Norman, 1981). With well learned actions, memory units are formed and used for producing and controlling action sequences. These units are called schema or schemata. A schema activated for a given action may well form part of another, distinct action, which can also be activated concomitantly. This effect will be enhanced when the unintended but linked action has been performed recently, because of the remaining activation by the recent use of the schema.

One way of verifying the recency hypothesis is to collect spontaneous slips and to try to see if they have any connection with recently performed actions. This was actually done by Reason (1984), who found a certain amount of evidences to confirm the theory. However, "whenever possible, the study of spontaneous errors should be supplemented by experimental evidence" (Baars, 1980). The present study is aimed at an experimental verification of the recency hypothesis in the domain of pen slips.

Nihei (1986a, b) found a method for experimentally inducing pen slips called rapid repeated writing (RRW). Subjects write a given character, either a kanji (Chinese originated character) or a kana (Japanese phonogram) rapidly and repeatedly. This simple method produces frequent errors, in which unintended substitutions are made. For example, RRW of kana お (/o/) can be expected to cause slips in the writing of other characters among about 50% of Ss by the 50th repetition. Moreover,

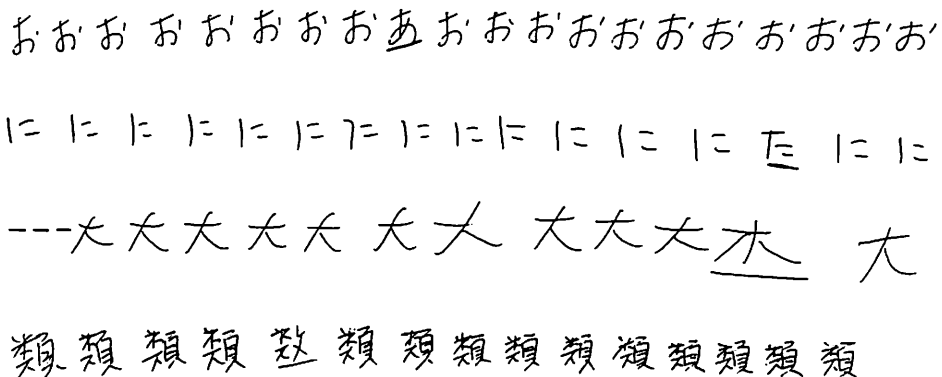


Fig. 1. Examples of slips of the pen induced by the Rapid Repeated Writing (RRW).

In RRW, subjects wrote a designated character rapidly and repeatedly. (a) The subject wrote a kana あ (/a/) unintentionally instead of the target character お (/o/) at the ninth writing, (b) kana た (/ta/) instead of kana に (/ni/), (c) kanji 木 (/ki/) instead of kanji 大 (dai/), and (d) kanji 数 (/sū/) instead of kanji 類 (/rui/).

characters that appear as slips have, without exception, elements in common with the target characters (See examples in Fig 1). RRW is, then, an effective method for inducing capture slips experimentally. It was clear that RRW might lead to the verification of the recency hypothesis of capture slips. Ss would be asked to write, immediately before the RRW of the target character, another character that has movement sequences in common with it, thus heightening the activation of the schema for the non-target character and increasing its appearance as a slip. If this prediction were fulfilled, experimental support for the recency hypothesis could be claimed.

METHOD

The procedure used in the present method is a variant of the response-priming procedure used in the domain of speech production by Meyer & Gordon (1985). Immediately before the RRW of the target character, subjects were asked to write another character that, according to the theory, is likely to appear as a slip, or unintentional substitution. Pre-writing should pre-activate the motor memory of the non-target character linked in some way with the target character that will be produced in RRW, and thus will in all likelihood result in an increased frequency of substitutions.

The independent variable of the present experiment was the number of times a non-target character was written prior to the RRW. It was assumed that an increased number of writings would result in an increase in the amount of substitutions, or slips.

Subjects: Two hundred and twenty undergraduates served as subjects.

Materials: Two characters, one kanji and one kana, were used in RRW. They were already known, from previous studies, to be fertile in inducing pen slips in RRW. The kanji was 栄 (/ei/), and the kana was お (/o/). The characters used in the advance writing (pre-writing) prior to RRW were 学 (/gaku/) for 栄 (/ei/), and あ

お	—	お	お	栄	𠄎	𠄎	栄
	1	2	3		1	2	3
あ	—	十	あ	学	𠄎	𠄎	学
	1	2	3		1	2	3

Fig. 2. Sequences in writing the characters お (/o/), あ (/a/), 栄 (/ei/), 学 (/gaku/).

お and あ share a common beginning and similar strokes. 栄 and 学 share common parts from the beginning to halfway.

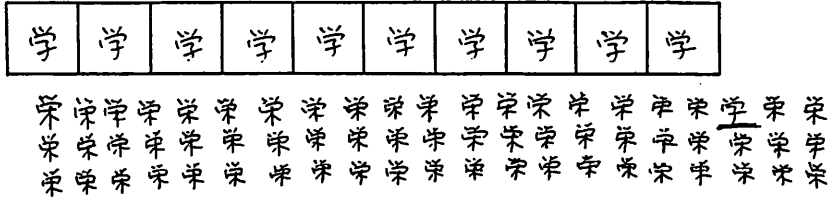


Fig. 3. Procedure of the pre-writing and the rapid repeated writing (RRW).

Ss had written 学 (/gaku/) ten times in the frames at their normal writing speed (pre-writing). Then, immediately after the pre-writing, they wrote the designated character 荣 (/ei/) repeatedly as fast as possible (RRW). This subject wrote 学 (/gaku/) unintentionally at the 19th writing in the RRW of 荣 (/ei/).

(/a/) for お (/o/). As shown in Fig. 2, two pairs have certain production movements in common. 荣 (/ei/) has neither semantic relation with nor phonetic similarity to 学 (/gaku/). (荣 means to prosper, and 学 means to learn).

Procedure: Subjects wrote characters on paper of B4 size with a ball-point pen. They were instructed to write repeatedly a designated character as fast as possible immediately after writing at normal speed the non-target character in the frames (20 mm×20 mm) printed on the upper part of the paper. They were also asked to underline wherever they made an error, or wherever they stopped themselves during the commission of such an error. After the session, the subjects were asked to explain in detail the errors they had produced.

There were three pre-writing conditions: Pre-1, in which the non-target character was written once only, Pre-10, in which it was written ten times, and Pre-20. In addition, control subjects undertook RRW of the target-character without pre-writing the non-target character. Different groups of subjects were used for each condition.

RRW sessions lasted two minutes for お (/o/), and three minutes for 荣 (/ei/). The RRWs were done in groups. The mean times for pre-writing for the three conditions were estimated by a preliminary experiment, and were added to the duration of the RRW sessions as appropriate. For the four conditions of お (/o/) there were four groups of 30 different students, and for 荣 (/ei/) four groups of 25 different students.

RESULTS

RRW characters 1-50 are included in the present analysis. Characters identified by the subjects themselves as being non-target characters were counted as slips.

1) RRW of kana お (/o/).

In the RRW of お (/o/), the characters appearing as slips by the 50th writing were kana あ (/a/), む (/mu/), す (/su/), よ (/yo), み (/mi/), か (/ka/), and め (/me/). All of these characters have strokes that involve movements similar to those used for お (/o/).

The character most frequently appearing as a slip was あ (/a/). In the control group, it appeared as 57.1% of the total errors, in Pre-1, as 62.2%, in Pre-10 as 79.7%, and in Pre-20 as 88.2%. Thus the extent of convergence to あ (/a/) slips was increased as a function of the number of the pre-writing of あ (/a/), $\chi^2=14.2$, $df=3$, $p<0.01$.

The proportion of subjects who made at least one あ (/a/) slip was 30.0% for the control group, 36.7% for Pre-1, 53.3% for Pre-10, and 66.7% for Pre-20. The proportion increased as a function of the number of pre-writing, $\chi^2=10.4$, $df=3$, $p<0.05$. Fig. 4 shows the cumulative percentage of the subjects who made at least one あ (/a/) slip as a function of the number of RRW repetitions for each condition.

The mean number of あ (/a/) slips by the 50th repetition was 0.40 (SD 0.71) for the control, 0.77 (SD 1.33) for the Pre-1, 1.97 (SD 2.60) for the Pre-10 condition, and 2.00 (SD 2.32) for the Pre-20 condition. The mean number of the slips differed significantly across the pre-writing conditions, $F(3,116)=4.76$, $p<0.01$. Tukey tests indicated that there were significant differences between the control condition and the Pre-10 condition ($p<0.05$), and between the control condition and the Pre-20 condition ($p<0.05$). The difference between the control and the Pre-1 conditions was not statistically significant.

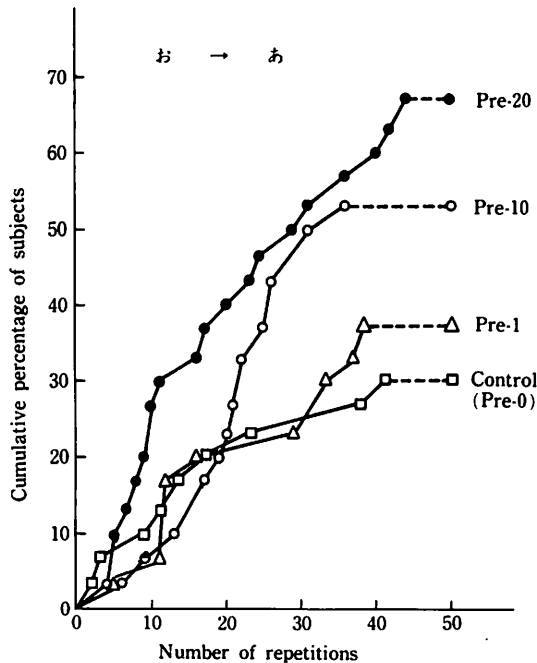


Fig. 4. Cumulative percentage of subjects, who started to make slips of the pen of writing あ (/a/) in RRW of お (/o/), as a function of the number of RRW repetition for each pre-writing condition.

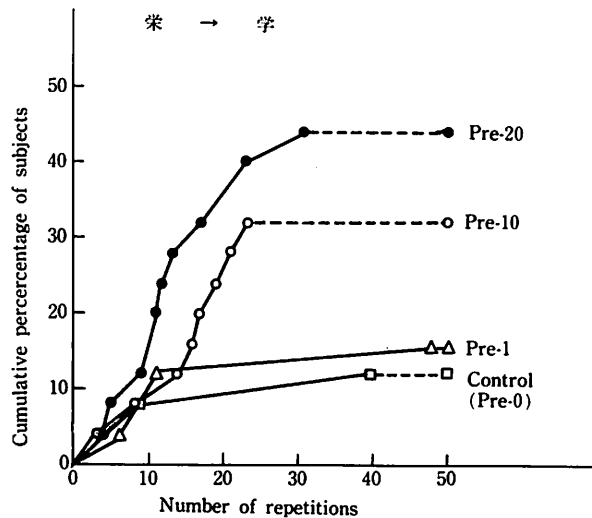


Fig. 5. Cumulative percentage of subjects, who started to make slips of writing 学 (/gaku/) in the RRW of 荣 (/ei/), as a function of the number of RRW repetition for each pre-writing condition.

2) RRW of Kanji 荣 (/ei/).

The character most frequently appearing as a slip instead of the target kanji 荣 (/ei/) was the kanji 学 (/gaku/) in all four conditions. Other slips were the whole character 单 (/tan/), or parts of other kanji such as 業 (/gyō/), or 受 (/ju/). All of these characters have writing movements in common with 荣 (/ei/).

学 (/gaku/) was written instead of the target 荣 (/ei/) more frequently when the number of pre-writings was increased. For the control condition, it represented 42.1% of the total errors, for Pre-1, 50.0%, for Pre-10, 64.7%, and 80.8% for Pre-20, $\chi^2=8.01$, $df=3$, $p<0.05$. Fig. 5 shows the cumulative percentage of subjects who made at least one 学 (/gaku/) slip as a function of the number of repetitions. The proportion of the subjects who made the 学 (/gaku/) slip by the 50th repetition was 12% for the control, 16% for the Pre-1, 25% for the Pre-10, and 44% for the Pre-20 condition. The proportion differed significantly across the four conditions, $\chi^2=8.52$, $df=3$, $p<0.05$.

The mean number of 学 (/gaku/) slips was 0.32 (SD 0.97) for the control condition, 0.32 (SD 0.79) for the Pre-1, 0.44 (SD 0.70) for the Pre-10, 0.82 for the Pre-20 condition. However, the increase in the mean number of slips was not statistically significant ($F(3, 96)=1.55$).

DISCUSSION

This results obtained in this experiment supported the recency hypothesis for action slips (Norman, 1981; Reason, 1984). When an intended action has something

in common with another action that has been recently used, the former action may well appear as a slip while the intended action is being performed.

With both kana and kanji characters, pre-writing of a movement-linked non-target character enhanced the production of RRW slips. Similar results have been obtained with characters other than the two used in this study (Nihei, 1984).

The slips occurred in the present experiment can be explained as the result of the summation of activations from different sources. One source of activation of the unintentional motor memory is slightly prior use of it (here, pre-writing). Another is the 'spreading activation' from a linked motor memory in RRW. The summation of these activations leads to a heightened level of activation in the unintentional motor memory, which in turn brings about the conversion of motor-memory triggering into pen slip. The increase in the number of slips with the increase in the number of pre-writings tends to confirm the validity of this reasoning.

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