The Effect of Visual Feedback on Writing Slips

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Abstract

People sometimes mistakenly write words or characters that differ from what they plan to write. This error is called writing slips (slips of the pen). Slip refers unintentional and substitutional error in action sequences. Writing slips can be experimentally induced by Rapid Repeated Writing (RRW), which one writes the same character repeatedly as fast as possible. Previous studies proposed a hypothesis that RRW activates motor representations of characters that are not intended to write, and writing slips occur. However, those studies have not investigated what kind of factors affect the occurrence of writing slips. The present study investigated the effect of visual feedback on writing slips. In the experiment, 20 participants were divided into two groups (visual feedback group or no visual feedback group) and did RRW for eight Hiragana characters (the Japanese phonetic letters). The results of the present study showed that there was no significant effect of visual feedback on the occurrence rate of writing slips, whereas it differed the type of slipped characters that frequently observed. In visual feedback group, the writing slip from お to あ was most frequent. This result was in line with a previous study, where this writing slip was reported to be the most popular. In contrast, the most frequent writing slip was from す to よ in the no visual feedback group. The present study reported for the first time that visual feedback affected the type of writing slips. Based on these results, we discussed the possible mechanisms of writing slips.

Keywords

Action slip, Slips of the pen, Human motor control, Writing movement, Attention

1. Introduction

When people are in a hurry or get tired, they sometimes mistakenly write words or characters that differ from what they plan to write. This error is called writing slips (slips of the pen). Slip refers unintentional and substitutional error in action sequences [1] - [3]. When we pour water in a glass to water flowers and find we drink it, or when we approach a trash can to throw away an empty bin held in the right hand and find we throw away a smartphone held in the left hand, that is an action slip. According to an activation-trigger-schema system (ATS) proposed by Norman [2], an action slip in the former case is induced when an action sequence for pouring water in a glass activates the scheme for drinking water, which is executed more frequently than that for watering flowers.

Writing slips can be experimentally induced by Rapid Repeated Writing (RRW), which one writes the same character repeatedly as fast as possible [4]. Figure 1 shows the examples of writing slips. The slipped characters are underlined. Example 1 and 2 show the aimed character お changes into the slipped characters す, み, and む. Example 3 shows the aimed character す changes into a slipped character よ. Usually people do not notice the occurrence of writing slips, but sometimes they find it and try to correct it. Writing slips induced by RRW are observed not only among the Japanese [4] - [6] but also among the Korean [7]. In line with a mechanism of ATS [2], previous studies [8], [9] proposed a hypothesis that RRW activates motor representations of characters that are not intended to write, and writing slips appear. However, those studies have not investigated what kind of factors affect the occurrence of writing slips. In the present study, we focused on the importance of visual feedback of writing trajectory, and investigated its effect on writing slips.

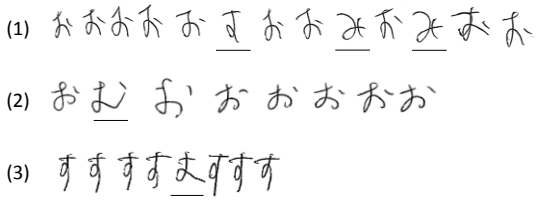

Figure 1 Examples of slips of the pen

In order to reveal the mechanism of writing slips, it is necessary to take visual components of writing movement into account. Visual feedback is helpful for execution of planned movement [10] - [12]. Without any visual feedback, it is difficult to write beautiful letters or write

sentences along ruled lines. A fMRI study revealed that some brain areas, related to control of writing movement and locate nearby Exner's area [13], are activated even when people get visual inputs of letters [14]. Based on these suggestions, we hypothesized that visual feedback of writing movement affects the occurrence of writing slips.

The present study aimed to reveal the effect of visual feedback of writing movement on the occurrence of writing slips. Though visual input plays an important role for execution of writing movement, the effect of its feedback on writing slip still remains unclear. In the present study, the participants performed RRW for eight Hiragana characters (the Japanese phonetic letters). There were two groups for visual feedback of writing movement; the visual feedback group and the no visual feedback group. We hypothesized that the visual feedback during RRW inhibits writing slips, and investigated the occurrence of writing slips between those characters. It was predicted that the occurrence rate of writing slips would be lower in the visual feedback group than in the no visual feedback group.

2. Methods

In the present study, we investigated the effect of visual feedback of writing movement on the occurrence of writing slips induced by RRW. 20 healthy university students (10 females, 10 males, mean age 22.5 years) participated in the experiment. All the participants were the right-handed Japanese, and they usually read and write Hiragana (the Japanese phonetic letters) and Kanji (the Japanese logographic letters) characters with any difficulties. Eight participants (four females, four males) were in the visual feedback group and the others were in the no visual feedback group.

Hiragana characters are the Japanese phonetic letters and there are 50 characters in total. All of Hiragana characters consist of 1 – 4 strokes. In the experiment, we use eight Hiragana characters as the aimed characters. Those were あ (a) , お (o), す (su) , な (na) , ま (ma), み (mi), む (mu), よ (yo), which [6] reported occurrences of writing slips. One of them consists of four strokes, other four characters consist of three strokes, and the other characters consist of two strokes.

The participants performed RRW for each Hiragana character and wrote them from left to right. They started writing according to a verbal cue of the experimenter and kept writing the aimed character as fast and many as possible until the time limit. The participants were instructed not to mind even if their handwriting become messy. One trial took two minutes, and the participants performed RRW once for each of Hiragana characters. The order of trials was randomized. Nihei [4] reported that the occurrence rate of writing slips increased when the participants wrote a different character that was similar to the aimed character repeatedly in advance of RRW. The result suggests that the activation of representation of characters facilitates the occurrence of writing slips. Thus, in the experiment, we set one-minute interval between trials to reduce the activation of each aimed character.

The participants were divided into two groups according to the visual feedback of writing trajectory. The participants of the visual feedback group sat in front of a desk and did RRW using a ball-point pen and pieces of paper. They were instructed to write characters within a radius of 1 cm, in order not to write them too small. The participants of the no visual feedback group sat in front of a pen tablet (WACOM) on a desk, and did RRW using a stylus. They were instructed to write characters along ruled lines (2 cm width). Since they could not see writing trajectories during main trials, we showed them the trajectory to check the size of characters in a few test trials. The participants in the no visual feedback group could see their right hand movement. This was because it would be too difficult to perform the task that requires them to write characters within the frame of the pen tablet without any visual information.

We compared the occurrence rate and type of writing slips between the visual feedback group and the no visual feedback group two groups. The number of characters that clearly differed in their shape from the aimed character was counted as writing slips, and we did not include uncompleted or corrected characters. We had unpaired t-test to investigate the difference in the occurrence rate of writing slips between the groups.

3. Results

As a result of the experiment, the visual feedback of wiring trajectory did not significantly affect the occurrence rate of writing slips. On the other hand, it changed pairs of characters whose writing slips were induced most frequently. The average of the total number of written characters in all participants in a certain character in the visual feedback group was 1227.1±249.7, and that in the no visual feedback group was 1667.0±212.2. The number and occurrence rate of writing slips in the two group were 2.4±2.3 (0.2±0.2%) and 2.5±6.7 (0.27±0.7%). An unpaired t-test revealed that there was no significant difference in the occurrence rate of writing slips between the groups. Figure 2 shows the average occurrence rate of writing slips in the two groups.

In contrast, pairs of characters that induced writing slips most frequently were different between the groups. Table 1 shows the types of writing slips, the total number of written characters (the sum of the number of characters written by all the participants), the number of writing slips, and the occurrence rate of writing slips. It was distinctive that the occurrence rate of writing slips from お to あ, which did not occur in the visual feedback condition at all, was around 2% (26 slipped characters in 1449 written

characters). This type of writing slips was reported to be the most popular in previous studies [6].

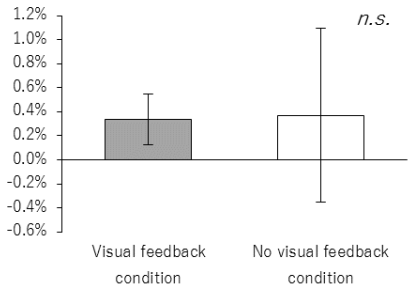

Figure 2 The average occurrence rate of writing slips

Table 1 The number and occurrence rate of writing slips

Visual feedback condition			
Aimed character	Slipped character	the number of slips / written characters	occurrence rate
あ	な	4 / 1067	0.37%
お	み	3 / 1063	0.56%
	む	2 / 1063	
	す	1 / 1063	
す	よ	9 / 1547	0.65%
	お	1 / 1547	
な	お	2 / 930	0.32%
	よ	1 / 930	
ま	あ	1 / 1221	0.08%
み	す	2 / 1671	0.24%
	む	1 / 1671	
	よ	1 / 1671	
む	―	0 / 1002	0%
よ	す	6 / 1316	0.46%
Average(SD)			0.34% (0.2%)
No visual feedback condition			
Aimed character	Slipped character	the number of slips / written characters	occurrence rate
あ	お	1 / 1591	0.19%
	す	1 / 1591	
	よ	1 / 1591	
お	あ	26 / 1449	2.28%
	す	5 / 1449	
	む	2 / 1449	
す	よ	3 / 1998	0.15%
な	あ	1 / 1393	0.07%
ま	―	0 / 1718	0%
み	お	2 / 1711	0.12%
む	―	0 / 1506	0%
よ	す	2 / 1970	0.15%
	み	1 / 1970	
Average(SD)			0.37% (0.7%)

4. Discussion

The present study aimed to reveal the effect of visual feedback of writing trajectory on writing slips. We compared the occurrence rate and type of writing slips between the visual feedback group and the no visual feedback group. The result showed that there was no significant effect of visual feedback on the occurrence rate of writing slips, whereas the type of writing slips differed between the two groups. In the no visual feedback group, the writing slips from お to あ was most frequently observed. Writing slips between this pairs of characters were reported as the most frequent type of writing slips [6], whose participants did RRW with visual feedback of writing movement. On the other hand, in the present study, the most frequent type in the no visual feedback group was that from す to よ. The present study cannot provide the answer why writing slips from お to あ did not appear under the visual feedback condition. However, the present study revealed for the first time that the visual feedback of writing movement varied the types of writing slips. In this section, we discuss the mechanism of writing slips.

The result of the present study could be explained by two assumptions; the decrease of attention resources and the activation of unplanned character representation. A previous study suggests that errors in movement increase when people pay attention to their movement itself during they execute the motor skill [15]. It is also known that the secondary task or time pressure during a motor task reduce attention resources for the task itself, and error in the task increases [16], [17]. Writing Hiragana characters is an automatic movement for all of the participants in the present study. Since RRW requires the participants to write characters rapidly, they have to spare their attention resources to write characters in high speed. As a result, attention resources for writing intended characters relatively decrease, and the possibility of writing unintended character increases. When people write the same character repeatedly, not only the representation of the character but also that of other characters which is linked to the aimed character is activated [8], [9]. Based on this assumption, when a representation of a character is activated because of a triggering factor, writing movement would be carried out regardless of intention and writing slips occur.

The results of the present study suggest that visual feedback of writing movement does not have an effect on the decrease of attention resources, which is related to the occurrence of writing slips. In the present study, there was no significant difference in the occurrence rate of writing slips between the two groups. Writing slips could be triggered by the decrease of attention resources regardless of the magnitude of the activation of unplanned character representation. The absence of difference under two conditions suggests that visual feedback of writing movement does not relate to the decrease of attention resources.

Visual feedback of writing movement could affect the activation pattern of representation of characters. Previous studies [8], [9] insists that writing a character activates other characters' representation, which is linked to the original character. In addition, a fMRI study reported that a brain area for writing a character activated when he or she just observed the character [14]. These studies suggest the possibility for two distinct route for the activation of character representation; writing movement (motor command and kinematic feedback) and visual feedback [18]. In the present study, the type of occurred writing slips was different between two visual feedback groups.

This result suggests that visual feedback activates the character representation that was not intended to write. It is likely that the character representation is activated by writing movement related to the similarity in kinematic components, and visual feedback related to the similarity in visual features. However, no previous studies reported that kind of similarity, and the present study did not investigate it neither. It is unclear how visual feedback affective activation of character representations that shares some features. In order to reveal how vision and movement affect the type of writing slip, it is necessary to investigate the features in their shape and kinematic components.

In order to reveal the mechanism of writing slips, it is necessary to take the effect of individual differences on writing slips into account. Recently, Nihei [9] reported that ADHD tendency would affect the occurrence of writing slip, and hyper activity and the decrease of the ability to control attention would facilitate the occurrence of writing slips. Kane and Engle [19] revealed that individual differences in the capacity of working memory would differ the performance of cognitive tasks that requires execution attention. Moreover, in the view of the activation of character representation, it is important to take the difference in vocabulary network [20]. Due to the lack of the participant, the factor of individual differences was not controlled enough in the present study, and it might lead to the different result from a previous study [6] in the most frequent type of writing slips.

Conclusions

The present study investigated the effect of visual feedback on writing slips. The results showed that there was no significant effect of visual feedback on the occurrence rate of writing slips. In contrast, different types of writing slips were observed depending on the visual feedback of writing trajectory. The present study reported for the first time that visual feedback affected the pattern of frequency of writing slips.

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