Psychologia, 2016, **59**, 38–49

DOES FINGER POINTING TOWARD DRUG NAMES PREVENT CONFUSION BETWEEN SIMILAR NAMES DURING RAPID SEARCH?

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It is customary for Japanese healthcare workers to use finger pointing toward drugs and prescriptions when they prepare and administer medication to patients, which is believed to be effective to avoid medication errors. The present study investigated whether finger pointing would be effective to avoid confusion errors and anchoring of the gaze on the word pointed to would be a plausible explanation for the potential effects. Sixteen participants observed four drug names with or without pointing with the index finger and determined whether the target drug name was present or not as quickly and accurately as possible (i.e., a choice reaction-time task). The number of similar drug names with the target word was manipulated. The results showed that finger pointing was effective to reduce the error rate when only single similar word existed. Analyses of gaze behavior showed that the fixation duration and number of fixations per drug name increased under finger pointing condition. These results suggest that finger pointing is likely to be effective to fixate a target drug name for a longer time; the effects on error prevention seem to be evident when the error rate itself is relatively high.

Key words: error prevention, word recognition, finger pointing, eye movement

A medication error may occur even when the medication is under the control of the health care professional (U.S. Food and Drug Administration, 2015). Because medication errors can result in severe harm to the patient, developing a technique to prevent medication errors is necessary. De Vries, Ramrattan, Smorenburg, Gouma, and Boermeester (2008) indicate that drug-related adverse events showed the second highest percentage (15.1%) of hospital adverse events, which followed operation-related events (39.6%).

Medication errors can be caused partly by confusion about similar drug names, packages, and labeling (Hoffman & Proulx, 2003; Filik, Purdy, Gale, & Gerrett, 2004; Emmerton & Rizk, 2012). It has been pointed out that the similarities in English drug names are characterized as alphabetical orthographic (look-alike) and phonetic (sound-alike) similarities (Berman, 2004). A similar issue would exist in the case of Japanese drug names (Kawamura, 2003; Suzuki et al., 2005; Nabeta, Imai, Kimura, Ohkura, & Tsuchiya, 2011). Japanese drug names are generally written with Katakana characters. Katakana is phonogram, and the characters normally represent the transcription of foreign-language loan words. Due to such characteristics of Katakana, the reason for confusion between Japanese drug names would be similar to that between English drug names.

In Japan, to avoid medication errors, it has been strongly recommended that health

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care workers use finger pointing toward drugs and prescriptions when they prepare and administer medicine to patients. Finger pointing is generally performed while speaking, or calling, the name of the item being pointed out (finger pointing and calling). The custom of finger pointing and calling was originally used by train drivers to check meters, signals, and any other signs necessary for safely driving a train. Since then, the custom has been highly recommended as a method of avoiding confusion errors for various job fields such as manufacturing, nuclear industries, and health care.

Several studies have shown that finger pointing and calling can play a role in avoiding confusion errors (Kiyomiya, Ikeda, & Tomita, 1965; Haga, Akatsuka, & Shirato, 1996; Watanabe et al., 2005). In one study (Haga et al., 1996), participants performed a choice reaction-time task for color stimuli shown with a “traffic-light-like” background stimulus. Comparisons of accuracy of the task between finger pointing and calling, finger pointing, calling, and control conditions showed that the error rate was lower in finger pointing and calling condition than in the control condition. However, the error rate was also lower than the control in finger pointing only condition. In another study (Shinohara, Morimoto, & Kubota, 2009), participants performed a Posner’s pre-cueing task (Posner, 1980) to investigate the effects of orienting attention. There were four experimental conditions under which participants performed the pre-cueing task: (a) finger pointing and calling, where participants pointed in the direction of the arrow while calling out “right (or left) is OK,” (b) only pointing in the direction of the arrow, (c) only calling out “right (or left) is OK,” and (d) no finger pointing or calling. The results showed that the reaction time (RT) from presenting the target to pressing the key was significantly shorter under finger pointing and calling condition and finger pointing only condition than under the calling only condition. These findings showed the effectiveness of finger pointing and calling to improve speed and accuracy for a reaction-time task. Considering that such improvement was observed not only with finger pointing and calling but also with finger pointing alone in some studies (Shinohara et al., 2009), finger pointing can play a major role in the improvement.

A possible explanation for the role of finger pointing would be that finger pointing toward a target directs the gaze to the target and, as a result, shifts the focus of attention to it. Neggers and Bekkering (2000, 2002) measured the eye movements of participants pointing to two targets consecutively. The analyses of the relationship between the eye movement and pointing behavior showed that the fixation toward the first target occurred before the participants started pointing, and the fixation toward the first target was maintained until pointing toward the first target was terminated. They explained that pointing toward a target will anchor the direction of the gaze toward that target. While the effect of finger pointing on avoiding confusion errors has been demonstrated with several types of figure stimuli, no studies have investigated whether a similar effect would be observed with word stimuli. Moreover, while anchoring of the gaze direction toward the target would be a potential explanation for the effect of finger pointing on avoiding confusion errors, no studies have directly tested this possibility. The purpose of the present study was to clarify these two issues.

In the present study, participants performed the task of pointing their finger toward each drug name while they searched for a target. We focused on investigating the effect of finger pointing, rather than finger pointing and calling, because the potential contribution to a longer fixation toward a target has been found in previous studies by testing finger pointing (Neggers & Bekkering, 2000, 2002).

We investigated whether finger pointing would prevent confusion with similar drug names. We also investigated whether the potential effect of finger pointing would be explained on the basis of anchoring of the gaze on the word pointed to.

METHOD

Participants and ethics statement

Sixteen graduate and undergraduate students (nine females and seven males, mean age = 24.1 ± 5.9 years) participated in this experiment. All participants had normal or corrected-to-normal vision and were right-handed. The experiment protocol was approved by the institutional ethics committee of the Tokyo Metropolitan University (24–41). Participants provided written informed consent to participate in this study. The tenets of the Declaration of Helsinki were followed.

Apparatus

Participants sat on a chair facing a laptop computer (LATITUDE-E5400, Dell, Inc.) with a 14.1-inch LCD display. A chinrest was used to maintain a distance of about 400 mm between the participants' eyes and the display. The experimental stimuli were presented using the stimulus presentation software SuperLab 4.0 (Cedrus, Inc.). Eye movement data were sampled using an eye path tracking system (EMR-9, Nac Image Technology, Inc.). The eye tracker, which was mounted on a hat, was a monocular (left eye) corneal reflection system that measures the eye line of the gaze with respect to the temporal resolution of 30 Hz. Frame-by-frame video-based analyses were performed using analysis software (EMR-dFactory, Nac Image Technology, Inc.) to identify where fixations were located.

Stimuli

The experimental stimuli were 360 registered drug names written in Japanese. All drug names consisted of five letters and were written in the Japanese Katakana style. The visual angle of each name presented on the display was 0.6° × 4.6°. The stimuli consisted of 40 target names and four similar and four dissimilar names for the respective target (see Table 1 for examples). To select similar and dissimilar names to be

Table 1. Example of the index of similarity between drug names.

Drug name of target (in Japanese)	Similarity of distractor	Drug name of distractors (in Japanese)	The index of similarity of a pair of drug name		
			cos1	htco	edit
Reusal (ロイサール)	Similar	Roihil (ロイヒール)	0.80	1.00	1.00
		Roimal (ロイマール)	0.80	1.00	1.00
		Lochol (ローコール)	0.68	0.75	2.00
		Lonmiel (ロイミール)	0.60	0.75	2.00
	Dissimilar	Dormicum (ドルミカム)	0.20	0.00	5.00
		Serenamin (セレナミン)	0.00	0.00	5.00
		Mectect (メクテクト)	0.00	0.00	5.00
		Alajioph (アラジオフ)	0.00	0.00	5.00

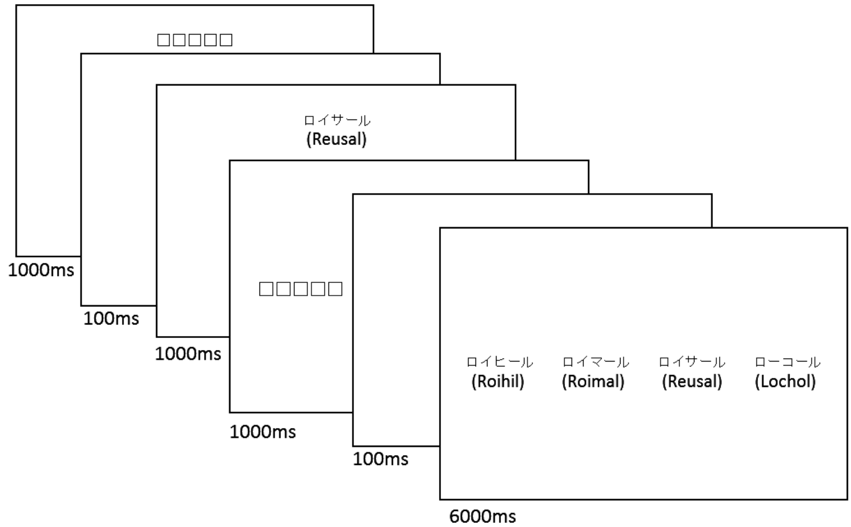

Fig. 1. Sample of stimuli in the experiment.

assigned to each target, we used a database named "Medicine similar name search engine (Japan Pharmaceutical Information Center, 2008)" by Ministry of Health, Labor and Welfare (MHLW). The database was constructed by Tsuchiya, Kawamura, Oh, and Hara (2001), who deliberated on similar names and made a quantitative index, "the index of similarity between drug names." In this index, the similarity drug names were scored based on (a) cos1: the number of same letters used between the names, (b) htco: whether the same letter was used for the beginning and the end of the two names, and (c) edit: the number of manipulations for names (i.e. replacement of letters, insertion or discarding of a letter). To select 40 target drug names, we initially selected candidate drug names for which there were more than four similar drug names. The criteria of "drug names similar to the target name" were (a) more than three letters were the same as those in the target name, (b) more than two same letters in either the beginning or the end of the two letters (four letters in all) were used, and (c) fewer than two manipulations to match the target drug name were necessary. The 40 target drug names were selected randomly out of these candidate names, and subsequently, four similar drug names for each target drug name were randomly selected. Finally, four dissimilar drug names for each target drug name were randomly selected based on the index with the criteria that (a) not a single letter was used in the target name, (b) neither the beginning nor the end of the name was the same as that of the target name, and (c) five manipulations for the name were necessary for the two names (i.e., target and dissimilar names) to become completely the same.

Task and procedure

In this task, the goal of the participants was to observe four drug names, which appeared along a line on the display, with or without pointing with the index finger of the dominant hand, and determine whether the target drug name was present or not as quickly and accurately as possible. Each trial began with a presentation of five squares as a fixation location on the upper center of the display for 1000 ms (Fig. 1). The visual angle of the five squares was the same as the target name. One hundred ms after the squares had disappeared, the target name was presented at the same location for 1000 ms. Then the five squares were presented again on the left side of the center of the screen for 1000 ms as a fixation location. The position of the leftmost drug name corresponded to that of the five squares presented 100 ms prior to the presentation of the drug names. This was followed by presenting four drug names along a line on the center of the screen for 6000 ms. The reason for setting the duration of presenting word stimuli to be 6000 ms was based on our preliminary study. We found that, when using drug names as stimuli, presenting four names along a line for relatively a shorter time (<4000 ms) was not enough for some participants to read all these names. Based on this result, we set the duration to be 6000 ms to ensure that a possible error was not due to the failure to read all of four drug names. Drug names were constituted by including either of one, two, three or neither similar names. Moreover, the target drug name was presented in half of the trials, and the target was not presented in the remaining half the trials but was replaced with a similar drug name.

The participants were asked to quickly look at each of these four names from left to right with or without pointing at it with the index finger of the dominant hand. When finger pointing was requested, the participants were asked to search for the target by pointing at the center of each drug name. When pointing, the location of the finger was just below the center of a drug name to avoid hiding the name with the finger. When finger pointing was not requested, the participants' dominant hand was rested on their thigh. Participants looked for the target name from left to right, and when they found the target, they specified the location of the names by pressing one of four predetermined keys on a keyboard (q, w, e, r; "q" meant the leftmost and "r" meant the rightmost). When they determined that the target was not present, they pressed the space bar, which was assigned as a "no" key.

The participants performed this task for a total of 256 main trials (two finger pointing conditions × two conditions for inclusion of the target name × four conditions for the number of similar names (3, 2, 1, or 0) × repetition for 16 trials). The main trials were divided into two blocks, depending on finger pointing conditions. The order of blocks was counterbalanced, and a five-min rest period was inserted between each block. About a one-minute rest period was also inserted after the participants finished half of the trials within each block (i.e., 64 trials). Prior to each block of the main trials, the participants performed 16 practice trials to familiarize themselves with the task.

Dependent measures and statistical analyses

Task performance and eye movement while performing the task were analyzed. Task performance was measured in terms of the error rate and mean RT. The RT was measured from the onset of the presentation of four drug names to the pressing of one of the predetermined keys. Eye movement while presenting four drug names was measured in terms of the duration of fixation toward each drug name, number of fixations per drug name, number of saccades between drug names, and number of backward saccades between drug names. Frame-by-frame video-based analyses were performed using the analysis software EMR-dFactory to identify where fixations were located. Stabilization of the gaze at one location for a minimum of 66.7 ms (i.e., two video frames) was defined as a fixation. This criterion was selected on the basis of a previous study showing that fixation durations were typically between 60 and 250 ms in reading (Liversedge & Findlay, 2000). Movement of the fixation location more than one letter was defined as a saccade and calculated as the mean number of fixation per name. Movement of the fixation location between drug names was defined as the number of saccades between drug names, and it was defined as the number of backward saccades when the gaze moved from right to left against the instruction. All dependent variables were statistically tested using a three-way (target presence, finger pointing and number of similar drug names) analysis of variance (ANOVA) with repeated measures of all factors. Given that the distribution of the error rate was not normal, we transformed the error rate by means of logarithmic transformation for the statistical analysis. Partial eta-squared values (η_p^2) were calculated as an unbiased estimate of the effect size in an ANOVA. Significant main and interaction effects were analyzed further using Bonferroni-corrected pairwise comparisons.

Results

Task performance

The means and standard deviations of the error rate under each condition are shown in Fig. 2. A three-way ANOVA showed that an interaction between three factors was significant, $F(3, 45) = 3.31$, $p < .05$, $\eta_p^2 = .18$. Post-hoc tests showed that when the target was present and the number of the similar drug names was one, the error rate was significantly lower for the pointing condition than for the no pointing condition. When the target was absence under the pointing condition, the error rate was higher under three and

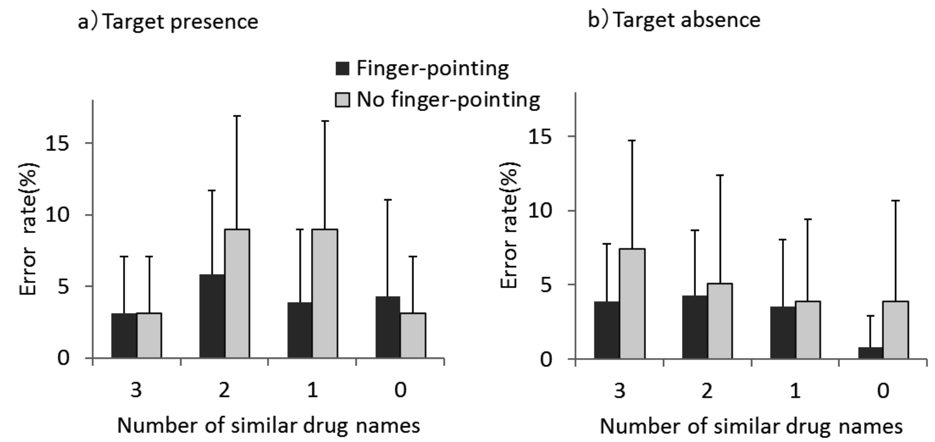

Fig. 2. The error rate with standard deviations under each condition.

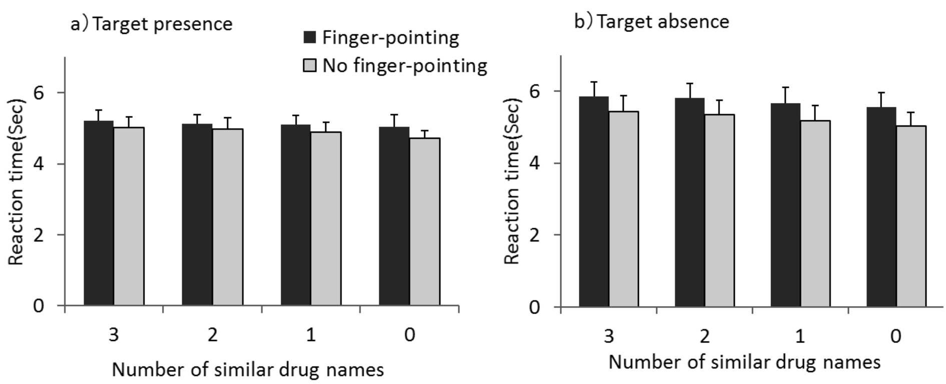

Fig. 3. Mean reaction time with standard deviations under each condition.

two similar drug names than no similar name. When the target was present under the no pointing condition, the error rate was significantly higher with one similar drug names than with three and no similar drug names. For the no pointing condition with three similar drug name condition, the error rate was significantly higher under the target presence condition than target absence condition. However, for the no finger pointing condition with two and one similar drug name condition, the error rate was higher under the target absence condition than target presence condition. For the finger pointing condition with no similar drug name condition, the error rate was significantly higher under the target absence condition than target presence condition.

The means and standard deviations of the RT under each condition are shown in Fig. 3. The three-way ANOVA showed that the main effects of pointing, $F(1, 15) = 25.90$, $p < .001$, $\eta_p^2 = .63$), target presence, $F(1, 15) = 114.66$, $p < .001$, $\eta_p^2 = .88$, and the number of similar drug names, $F(3, 45) = 55.58$, $p < .001$, $\eta_p^2 = .79$, were all significant. Multiple comparisons with Bonferroni correction showed that (a) the RT was significantly longer under the pointing condition than under the no pointing condition, (b) the RT was significantly longer when the target was absent than when the target was present, and (c) the RT became significantly longer as the number of similar drug names increased.

The interaction between finger pointing and target presence was significant, $F(1, 15) = 31.6, p < .001, \eta_p^2 = .68$. Multiple comparisons with Bonferroni correction indicated that for both finger pointing conditions, the RT was significantly longer under the target absence condition than under the target presence condition. For both target conditions, the RT was longer when participants search each drug names with finger pointing than with no finger pointing.

The interaction between finger pointing and number of similar drug names was also significant, $F(3, 45) = 4.6$, $p < .01$, $\eta_p^2 = .23$. For all of similarity conditions, the main effect of finger pointing was significant. The RT was significant longer with finger pointing than without finger pointing under each similarity condition. For both finger pointing conditions, the main effect of number of similarities was significant. Multiple comparisons with Bonferroni correction indicated that for finger pointing condition, all pairs of similarity conditions, except the pair of one and two similarities, was significantly different. The RT was significantly longer when the number of similar drug names increased. For no finger pointing condition, all pairs similarity conditions, except the pair of two and three similarities, was significantly different, showing that the RT was significantly longer when the number of similar drug names increased.

Moreover, the interaction between target and number of similar drug names was significant, $F(3, 45) = 6.9$, $p < .001$, $\eta_p^2 = .32$. For all similar drug names conditions, the main effect of target condition was significant, showing that the RT increased when target was present than when target was absent. For both target conditions, the main effect of similar drug names condition was significant. The RT decreased under no similar drug name condition than under the other similar conditions. When the target was absent, the RT increased as the number of similar drug names increased. Three-way interaction was not significant.

Eye movements

Eye movement data of three participants were excluded from the analysis due to technical difficulties with calibration; as a result, the data sampled from thirteen participants were statistically analyzed. The means and standard deviations of eye movement data under each condition are shown in Table 2.

A three-way ANOVA for the fixation duration showed that the main effect of pointing was significant, $F(1, 12) = 13.4$, $p<.01$, $\eta_p^2 = .53$. Fixation duration was significantly longer for the pointing condition than for the no pointing condition. The main effects of any other factors or interactions were not significant.

For the number of fixations per drug name, a three-way ANOVA showed that a main effect of pointing was significant, $F(1, 12) = 14.82$, $p < .05$, $\eta_p^2 = .55$. The number of fixations significantly increased with pointing. The main effects of any other factors or interactions were not significant.

Table 2. Means (Standard Deviations) of eye movement measures

Factors			Mean fixation duration[a]	N of fixation per name[b]	N of saccades between names[b]	N of regressive saccades between names[b]
Target	Similarity	Finger pointing				
Presence	3	FP[c]	275.62 (44.68)	2.18 (0.26)	2.93 (0.66)	0.42 (0.27)
		NFP	249.92 (49.18)	1.99 (0.23)	3.05 (0.51)	0.57 (0.33)
	2	FP	278.15 (36.45)	2.23 (0.32)	2.72 (0.67)	0.38 (0.31)
		NFP	261.54 (56.40)	1.95 (0.27)	2.95 (0.45)	0.57 (0.30)
	1	FP	289.38 (49.76)	2.21 (0.29)	2.86 (0.69)	0.44 (0.32)
		NFP	262.31 (45.90)	1.91 (0.17)	2.77 (0.65)	0.45 (0.34)
	0	FP	293.31 (43.64)	2.15 (0.30)	2.85 (0.74)	0.43 (0.33)
		NFP	254.38 (44.76)	2.02 (0.24)	2.76 (0.52)	0.46 (0.34)
Absence	3	FP	294.54 (40.92)	2.18 (0.27)	2.80 (0.42)	0.41 (0.23)
		NFP	248.92 (46.72)	1.98 (0.22)	2.92 (0.49)	0.55 (0.30)
	2	FP	272.00 (38.87)	2.15 (0.18)	2.86 (0.47)	0.40 (0.19)
		NFP	243.54 (36.43)	1.91 (0.20)	3.06 (0.64)	0.56 (0.34)
	1	FP	269.46 (43.14)	2.20 (0.26)	2.76 (0.44)	0.35 (0.20)
		NFP	255.23 (38.60)	2.02 (0.26)	2.82 (0.52)	0.51 (0.31)
	0	FP	286.08 (37.20)	2.13 (0.24)	2.84 (0.43)	0.34 (0.27)
		NFP	250.54 (52.71)	1.88 (0.17)	3.12 (0.38)	0.53 (0.27)

[a]A unit is ms. [b]N means number. [c]FP = finger pointing condition, NFP = no finger pointing condition

For the total number of saccades between the drug names, neither the main effects nor interactions were significant. For the number of backward saccades between the names, the main effects of pointing failed to reach significance, $F(1, 12) = 3.79, p = .075, \eta_p^2 = .24$. Finger pointing may reduce backward saccade because it got medium effect size, despite the fact that the main effect of finger pointing condition was marginally significant.

Discussion

The main purpose of this study was to examine whether finger pointing toward drug names would prevent confusion between similar names. The results of the choice reaction-time task using the stimuli of drug names partly showed the effectiveness of finger pointing: the error rate was significantly lower for finger pointing condition when the target was present and the number of similar drug names was one. Another purpose of the present study was to examine whether the effectiveness of finger pointing would be explained in line with anchoring of the gaze on the word pointed to. Analyses of gaze behavior showed that, under finger pointing condition, the fixation duration became significantly longer. The number of fixations for each drug name was higher in finger pointing condition than in the no finger pointing condition. In addition, the frequency of backward saccades, which was used as an index of rereading a name, decreased in finger pointing condition, though it was marginally significant (p = .075). The results suggest that when a drug name was pointed to with the finger, the individual's gaze was anchored to that drug name. This will lead to watching the name more carefully and, consequently, preventing confusion between similar drug names.

Finger pointing can help prevent confusion between similar drug names

The potential effects of finger pointing on avoiding confusion between similar stimuli have already been demonstrated by previous studies (Haga et al., 1996; Shinohara et al., 2009) in which figure stimuli were used. This is the first study to demonstrate that finger pointing is also effective in preventing confusion between similar drug names. This suggests that finger pointing would be effective in finding the differences between words that were characterized as having alphabetical orthographic (look-alike) and phonetic (sound-alike) similarities (Berman, 2004).

A reason the effect of finger pointing was observed only in one condition could be that the error rate itself was very low in other conditions (i.e., when the number of similar drug names was three or zero), regardless of whether finger pointing was used. When no similar drug name was included, the target drug name stood out; as a result, finding the target was very easy. In contrast, when three similar names were included, the RT became significantly longer. This implies that, even without finger pointing, participants would carefully watch each word under such demanding conditions. If this explanation is the case, then one would expect a longer duration and/or a larger number of fixation when three similar names were included. However, we did not found such results. One possible explanation for the failure of obtaining such results was that the eye movement was strongly affected with the location of the target drug name. A one-way (target location) ANOVA showed a significant main effect on each of fixation duration and number of fixation, $F(1, 12) = 148.73, p < .001$, $\eta_p^2 = .925$, and $F(1, 12) = 115.94, p < .001, \eta_p^2 = .906$, respectively. Multiple comparison with Bonferroni correction showed a significantly longer duration and a significantly larger number of fixation when the target drug name was presented at the leftmost position than at the other positions. We believe such strong effect may have hindered the expected findings regarding the eye movement data when three similar names were included.

Finger pointing and anchoring the gaze

Our data analysis showed that eye movement, fixation duration and number of fixations per drug name increased with finger pointing. These results suggest that finger pointing could lead to an individual's anchoring his or her gaze toward the target pointed to and thus watching it carefully. Moreover, our data showed that the number of fixations for each drug name was higher in finger pointing condition than in the no finger pointing condition. This suggests that when participants looked at each word while pointing toward it, their eyes would move finely on each drug name. The fine eye movement would be beneficial for this task, considering that the target drug name and similar drug names consisted of many of the same letters.

Since the fixation toward each drug name would involve information processing of its letters in the fovea (i.e., high-resolution processing), finger pointing facilitates the involvement of overt attention toward the target pointed to (Carrasco, 2011). However, according to prior research, finger pointing might also facilitate covert attention. For example, Shinohara et al. (2009) reported that the RT for cueing orientation increased when the participants pointed their finger to a cue stimulus in contrast to when they did nothing. Reed, Grubb, and Steele (2006) tested the relation between hand location and spatial attention using a visual covert-orienting paradigm. The results showed that hand reaching to the near target location increased search efficiency in comparison to reaching to the farther location. Moreover, Chanceaux and Grainger (2012) indicated that parafoveal vision played an important role in visual word recognition. Finger pointing to the object attracts overt and covert attention and facilitates the recognition process in not only foveal but also parafoveal vision. Considering these findings in previous studies, both overt and covert attention would be involved in the effect of finger pointing.

In conclusion, finger pointing to a drug name has a limited error prevention effect, and finger pointing leads to a decrease in error when the error rate was high due to misidentification in the particular situation where similar and dissimilar drug names were mixed with the target name. A possible contributor to this result is anchoring of the gaze on each drug name. Because we did not measure the duration of finger pointing, we could not address whether there would be a linear relationship between gaze duration and pointing duration. Future studies addressing this issue is necessary to show further evidence the role of finger pointing in anchoring the gaze toward to a target.

Notably, participants of the present study were university students. Therefore, they were unfamiliar with drug names. Lambert, Chang, and Lin (2001) showed that pharmacists distinguished more accurately between target and similar drug names than did university students. Health care workers, who generally handle drugs on a daily basis, will recognize drug names as meaningful words and process them more easily and accurately. Future studies should test health care workers to investigate whether those who are very familiar with drug names would also receive a benefit from finger pointing.

Future studies should also test whether the effect of finger pointing would be changeable depending on the time pressure for searching the target. In our study, the duration of presenting word stimuli was set to be 6000 ms. This was long enough to carefully look at each drug names. There is a possibility that the effect of finger pointing on error prevention was limited because, with the help of this longer duration of presentation, participants could look at each words carefully even without finger pointing. To address the validity of this possibility, future studies should test the effect of finger pointing under time pressure.

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(Manuscript received 31 March, 2016; Revision accepted 12 September, 2016)