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Combination of Tall-man Lettering and Symbol Prefixing to Improve Drug Identification by Pharmacists

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ABSTRACT

Similar drug names can confuse pharmacists and lead to dispensing errors. A well-accepted solution to the problem is tall-man lettering, a typographic alteration to drug names. However, studies of its effectiveness have yielded mixed results. Furthermore, the potential of orthographic alterations to drug names has not been explored. Therefore, this study aims to examine the usefulness of the combination of tall-man lettering and a simple but new orthographic alteration, symbol prefixing. Twenty-six outpatient pharmacists were recruited to participate in an experiment on drug identification. The results showed that first, the accuracy of drug identification increased with tall-man lettering. Next, the response time and the number of eye fixations for the identification decreased with tall-man lettering and symbol prefixing. Finally, the number of eye fixations decreased with symbol prefixing when there was no tall-man lettering. The findings support that tall-man lettering and symbol prefixing are effective techniques for helping pharmacists identify drugs. Further research could assess the impacts of different types of typographic and orthographic alterations for alleviating the problem of drug name confusion and ultimately minimizing medication errors and ensuring patient safety.

Keywords: Confusing drug names, Typography, Orthographic similarity

INTRODUCTION

Confusion between similar drug names has been identified as a primary problem for medication safety as it often leads to medication errors (World Health Organization, 2017). Specifically, the confusion was the main source of wrong drug dispensing errors in pharmacies (Reiner et al., 2020; Tseng et al., 2018).

Drug names are confusing because they are spelled and/or pronounced similarly, the so-called look-alike-sound-alike (LASA) drug names (Institute for Safe Medication Practices, ISMP, 2019). A predominant solution to this problem is tall-man lettering, which capitalizes the letters that are not shared between confusing drug names to emphasize their difference. For example, a pair of confusing drug names such as “Nexavar” and “Nexium” would be written as “NexAVAR” and “NexIUM,” respectively (ISMP, 2019).

Table 1. Experimental studies of tall-man lettering with pharmacists as participants.

Reference	Participant	Task	Effect of TML
Filik et al. (2010)	127 healthcare professionals (77 with a pharmacy background)	Whether TDN appears on the list	Accuracy in verifying the absence of TDN increased
Darker et al. (2011)	144 healthcare professionals (36 pharmacists; 45 pharmacy technicians)	Which of the two is TDN	Accuracy in identifying TDN increased
Or and Wang (2014)	40 student pharmacists	Whether the two drug names are identical	Accuracy in the verification increased
DeHenau et al. (2016)	40 healthcare professionals (some with a pharmacy background)	Detect the change of 16 drug labels	Accuracy increased and response time decreased
Schell (2009)	11 practicing pharmacists and technicians	Whether the drug name is TDN	Not significant
Irwin et al. (2013)	26 pharmacists and 2 pharmacy technicians	Whether TDN appears on one of 20 drug labels	Not significant

TDN: target drug name; TML: tall-man lettering

Experimental studies that recruited pharmacists as participants were reviewed and summarized in Table 1, while studies without experiments (e.g., Gabriele, 2006; Zhong et al., 2016) or non-pharmacist participants (e.g., Filik et al., 2004; 2006; Liu et al., 2019; Wang and Or, 2020) were excluded.

Filik et al. (2010) recruited 127 healthcare professionals, of whom 77 had a pharmacy background. For each trial, a target drug name was first displayed on the computer screen, then replaced by a list of five drug names. The target drug name was present or absent from the list. When the target drug name was absent from the list, its corresponding confusing name would be on the list instead. Participants were asked to verify whether the target name appeared on the list. The results showed that tall-man lettering, compared to lowercase lettering, increased the accuracy in verifying the absence of target drug names.

Another study by this research group recruited 144 healthcare professionals that included 36 pharmacists and 45 pharmacy technicians as participants (Darker et al., 2011). For each trial, a target drug name was first displayed on a computer screen, then replaced by two drug names, one of which was the target and the other its corresponding confusing name. Participants were asked to select the target drug name from the two alternatives. It was found that tall-man lettering, compared to lowercase lettering, increased the accuracy in identifying the target drug names from their distractors.

Or and Wang (2014) recruited 40 student pharmacists to participate in an experiment to verify whether pairs of drug names displayed on the screen were identical or different. The results showed that, compared to lowercase lettering, tall-man lettering increased the accuracy of the verification.

Finally, DeHenau et al. (2016) recruited 40 healthcare professionals, some of them having a pharmacy background. For each trial, 16 drug labels arranged as a 4-by-4 square array were displayed on the screen in tall-man lettering or lowercase format and one of the 16 labels was designed as the target drug name. The screen was then changed to the next page with all labels being the same except that the target drug name switched to its corresponding confusing name. Participants were asked to detect the change as soon as possible. The results showed that tall-man lettering, compared to lowercase lettering, increased the correct rate of change detection and reduced the detection response time.

However, Schell (2009) recruited 11 practicing pharmacists and technicians to participate in an experiment to determine whether the drug name displayed on the screen was the target name displayed on the previous page. There was a 3-second black mask between the two display pages. The results showed that the effect of tall-man lettering was not significant and the author argued that such results could be due to the insufficient statistical power caused by the small sample size.

Irwin et al. (2013) recruited 26 pharmacists and two pharmacy technicians to participate in an experiment to find the target drug name among 20 alternatives displayed as labels on boxes arranged as a 4-by-5 rectangle array. The results showed that tall-man lettering did not affect accuracy and response time. These results contradicted an earlier similar study (Filik et al., 2004), and the authors argued that the non-significant effect of tall-man lettering in their study could be attributable to the unfamiliarity of the participants with tall-man lettering.

In summary, tall-man lettering appears to improve the accuracy and efficiency of identifying confusing drug names by pharmacists who are familiar with tall-man lettering. However, this conclusion requires more research to be strengthened.

The chances of wrong drug errors were positively correlated with the degrees of similarity between drug names (Lambert et al., 1999). An online software tool that applied string-matching algorithms is available to measure the similarity between any two drug names (US Food and Drug Administration, US FDA, 2021). However, these algorithms suggest that tall-man lettering does not affect the degree of similarity between confusing drug names since it does not change any letter or sequence of letters in the names. Therefore, in addition to tall-man lettering, we proposed an orthographic alternation, symbol prefixing, by simply adding a symbol before the initial letter of a drug name to make it less similar to its corresponding confusing drug name. Note that the symbol was prefixed but not suffixed since the initial eye fixation typically lands around the first quarter of a word (Dunn-Rankin, 1978; Rayner, 1979), and readers pay more attention to the information from the right of the fixation than from the left (McConkie and Rayner, 1976). Since about three-quarters of the confusing drug names listed by ISMP have the same initial letters (ISMP, 2019), a prefixed symbol on one of a pair of confusing drug names should be able to facilitate differentiation between each other.

Overall, this study aims to investigate the effectiveness of tall-man lettering and symbol prefixing for pharmacists to identify drugs.

METHODS

A 2×2 repeated-measures factorial experiment was designed. The first independent variable was whether a pair of confusing drug names were altered with tall-man lettering (TML), and the second independent variable was whether one of the names was altered with hash symbol prefixing (HSP). To take the two confusing drug names, "Daivonex" and "Daivobet", as an example, the four conditions of the experiment are presented in Table 2. Note that the name without TML was in lowercase format with a capital initial letter, and one of the two names was randomly chosen as the target name to prefix with the hash symbol (#). In this example, "Daivonex" was the target name.

Table 2. An example of the experimental design.

		TML	
		No (lowercase)	**Yes**
HSP	No	Daivonex Daivobet	DaivoNEX DaivoBET
	Yes	#Daivonex Daivobet	#DaivoNEX DaivoBET

TML: tall-man lettering; HSP: hash symbol prefixing

Three dependent variables were error rate, response time, and the number of eye fixations. The experimental task was to select the target drug name from two alternatives, similar to the task of Darker et al. (2011). The error rate was defined as the number of trials for which a participant selected the wrong drug names divided by the total number of trials. The response time was the time that participants took to select the target drug name. An eye fixation was defined as the fixation with more than 200 milliseconds during the selection. Note that the number of eye fixations was found to be positively correlated with task difficulty (Lin et al., 2019) and negatively correlated with the efficiency of performing tasks (Goldberg and Kotval, 1999).

Participants

Twenty-six outpatient pharmacists (18 women and eight men) from a regional hospital participated in data collection. Their ages averaged 29.9 years with a standard deviation of 4.9 and ranged from 22 to 40 years, and their pharmacy work experiences averaged 5.6 years with a standard deviation of 3.9 and ranged from half to 18 years.

Materials and Apparatus

Forty-eight pairs of confusing drug names that have been used in the hospital were selected as materials in the experiment. Each pair of confusing drug names was randomly assigned as the target and the distractor. The average length of these names was 7.2 letters with a standard deviation of 1.4 and ranged from four to 11 letters. Most (77%) of these drug names were six, seven, and eight letters long. Since there were four experimental conditions for each of the 48 drug pairs, the participants would perform 192 trials.

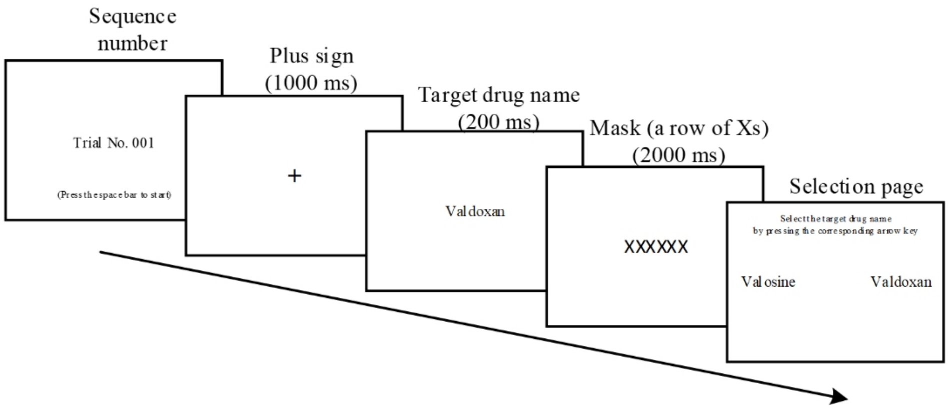

Figure 1: Illustration of the page sequence of each trial.

A self-developed data collection software tool built in PsychoPy (Peirce & MacAskill, 2018) was run on a 15-inch notebook computer. As shown in Figure 1, five pages would be presented sequentially on the computer screen in each trial. The first page displayed the trial sequence number at the center of the page and a "Press the space bar to start" instruction at the bottom. When the participant pressed the space bar on the keyboard, the screen turned to the second page. A plus sign was displayed at the center and participants were asked to keep their eyes on the plus sign. After a thousand milliseconds (ms), the second page was replaced by the third page. The target drug name was displayed at the center for 200 ms., then the screen changed to the fourth page. A row of six Xs was displayed at the center as a mask pattern for 2000 ms to roughly simulate the latency for pharmacists from reading a drug name on a drug bag to the beginning of reading the labels of drug names on medication cabinets.

Finally, the fifth page appeared after the mask pattern. The target drug name was randomly displayed on the left or right side of the page, whereas its distractor was on the opposite side. At the top of the page, the instruction "Select the target drug name by pressing the corresponding arrow key" was displayed. Participants selected a drug name they thought was the target drug name by pressing the corresponding left or right arrow key on the keyboard. Once the arrow key was pressed, the screen turned to the first page of the next trial. Note that the text formats of the target drug names on the target drug name page were identical to those shown on the selection page.

Prior to the first trial, a practical version was provided to familiarize participants with the user interface of the data collection tool. Three extra pairs of confusing drug names without tall-man letters and a prefixed hash symbol were used for the practice.

While the data on the error rate and response time of the participants were collected using the self-developed software tool, the data on the number of eye fixations were collected using the Tobii Pro Glasses 2, a wearable eye-tracking system.

Procedures

After signing a consent form, the participant was asked to sit in front of a 15-inch screen of a notebook computer. The distance between the participant and the screen was about 50 centimeters. The participant was then instructed to practice with the practice version of the data collection tool until he or she felt ready to start the experiment. The sequence of 192 trials was randomized for each participant. The duration of the experiment for each participant was about 15 minutes. The study protocol was approved by the local research ethics committee (National Taiwan University, approval No 201806ES078).

RESULTS

The effects of tall-man lettering and hash symbol prefixing on the error rate, the response time, and the number of eye fixations are presented below.

Error Rate

The Wilcoxon signed-ranks test was applied since the data violated the normality assumption. The main effect of TML on the error rate was significant, $Z = -3.36$, $p = 0.001$, indicating that the error rate decreased significantly when the drug names were altered with TML (M =0.7%, SD = 0.9%) than when they remained lowercase (M = 2.1%, SD = 1.8%). However, the main effect of HSP on the error rate was not significant, $Z = -0.55$, $p = 0.585$, and the interaction effect was not significant, as shown in the profile plots in Figure 2.

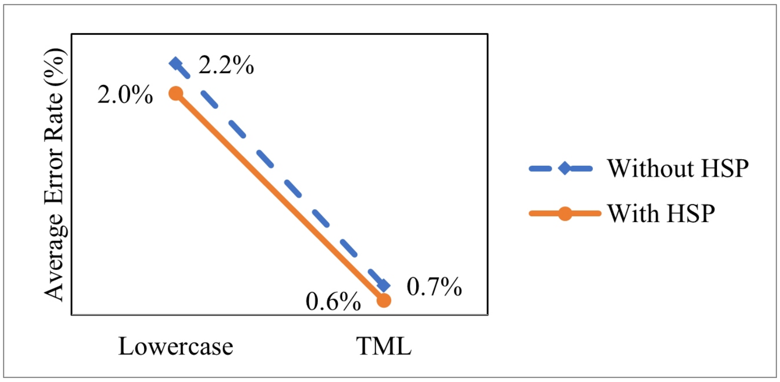

Figure 2: Profile plots of the error rate (TML: tall-man lettering; HSP: hash symbol prefixing).

Response Time

The two-way repeated measures ANOVA was used since the data met the normality assumption. The main effect of TML on the response time was significant, $F(1, 25) = 19.48$, $p < 0.001$, $\eta_p^2 = 0.44$, indicating that the response time decreased significantly when the drug names were altered with TML ($M = 0.92$, $SD = 0.13$) than when they remained lowercase ($M = 1.00$, $SD = 0.16$).

The main effect of HSP on response time was significant, $F(1, 25) = 4.48$, $p = 0.044$, $\eta_p^2 = 0.15$, indicating that the response time decreased significantly when the target drug names were prefixed with a hash symbol ($M = 0.94$, $SD = 0.15$) compared to when the names without the prefixed symbol ($M = 0.98$, $SD = 0.14$). However, the interaction effect was not significant, $F(1, 25) = 0.44$, $p = 0.515$. The profile plots are shown in Figure 3.

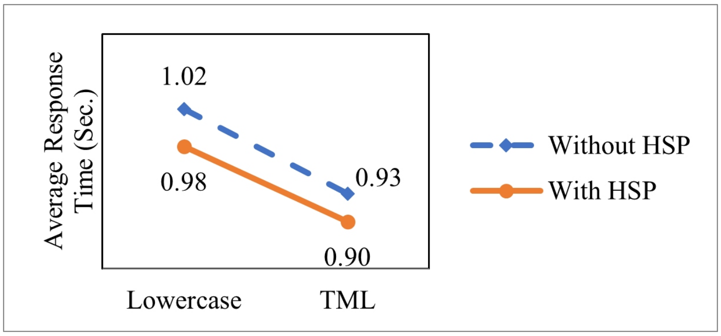

Figure 3: Profile plots of the response time (TML: tall-man lettering; HSP: hash symbol prefixing).

Number of Eye Fixations

The two-way repeated measures ANOVA was applied since the data met the normality assumption. The main effect of TML on the number of eye fixations was significant, $F(1, 25) = 259.71$, $p < 0.001$, $\eta_p^2 = 0.91$, indicating that the number of eye fixations decreased significantly when the drug names were altered with TML ($M = 2.0$, $SD = 0.1$) than when they remained lowercase ($M = 2.3$, $SD = 0.1$).

The main effect of HSP on the number of eye fixations was significant, $F(1, 25) = 38.48$, $p < 0.001$, $\eta_p^2 = 0.61$, indicating that the number of eye fixations decreased significantly when the target drug names were prefixed with a hash symbol ($M = 2.0$, $SD = 0.1$) compared to when the names without the prefixed symbol ($M = 2.2$, $SD = 0.1$).

The interaction effect was also significant, $F(1, 25) = 29.34$, $p < 0.001$, $\eta_p^2 = 0.54$. To decompose this interaction, a simple-effects analysis showed that the simple effect of HSP on the number of eye fixations was significant when the drug names remained lowercase, $F(1, 25) = 42.13$, $p < 0.001$, $\eta_p^2 = 0.63$, indicating that, as the drug names were not altered with TML, the number of eye fixations decreased significantly when the target drug names were prefixed with a hash symbol ($M = 2.1$, $SD = 0.2$) compared to when the names without the prefixed symbol ($M = 2.4$, $SD = 0.2$). In contrast, the simple effect of HSP on the number of eye fixations was not significant when the drug names were altered with TML, $F(1, 25) = 0.35$, $p = 0.559$. The profile plots are shown in Figure 4.

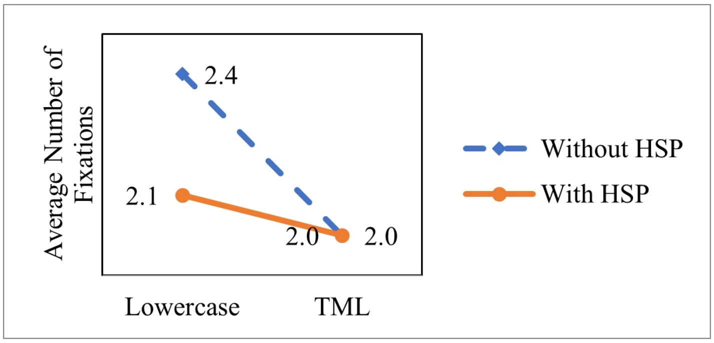

Figure 4: Profile plots of the number of eye fixations (TML: tall-man lettering; HSP: hash symbol prefixing).

DISCUSSION

The findings provide evidence that confusing drug names differentiated by both tall-man lettering and symbol prefixing could facilitate the dispensing work of pharmacists. With tall-man lettering alone, the error rate, response time, and the number of eye fixations for drug name identification could be reduced by 67%, 8%, and 13%, respectively. Furthermore, with symbol prefixing alone, the response time and the number of eye fixations could be reduced by 4% and 6%, respectively. Finally, when there was no tall-man lettering, having symbol prefixing could reduce the number of eye fixations by 11%. In summary, tall-man lettering and symbol prefixing could complement each other well in helping pharmacists identify confusing drug names.

To our knowledge, this study was the first attempt to propose an orthographic alteration method, symbol prefixing, with the popular typographic alteration method, tall-man lettering, to improve the identification of confusing drug names.

Although the orthographic alteration method proposed in this study has not been found in previous research. Its impact needs more research. Several possible explanations exist for the non-significant effect of symbol prefixing on the identification error rate. While it could be due to the moderate sample size that limited statistical power (Irwin et al., 2013), it could be attributable to the relatively low error rate that led to a floor effect (Wang and Or, 2020). Another explanation is that symbol prefixing was relatively new to pharmacists who were familiar with the purpose and application of tall-man lettering (Filik et al., 2004). Future work may focus on the effect of pharmacists' familiarity with various text enhancement modifications on their drug identification performance.

Moreover, the orthographic alteration method applied in this study might come with the caveat that a prefixed symbol could be used as a shortcut to identify drugs. That is, pharmacists could identify drugs only by their prefixed symbols without looking at drug names. This side effect has been found when using color as a cue to identify drugs and has led to errors (Filik et al., 2005). Further studies on this issue are recommended.

In practice, drug names or brand names are usually displayed with additional information on medication lists, drug cabinet labels, and/or drug packages, such as their generic names, names in the second language, dosage strengths, and/or dosage forms. These various orthographic sources can influence the identification of drugs. It is worth investigating the effects of these different types of information on the impact of differentiating confusing drug names.

In addition to tall-man letters, other typographic attributes have been studied to understand their effects on the differentiation of confusing drug names, such as boldface letters (Gabriele, 2006; Liu et al., 2019; Or and Chan, 2014; Or and Wang, 2014; Wang and Or, 2020), colored (e.g., red) letters (Filik et al., 2005; 2006; Or and Chan, 2014; Or and Wang, 2014; Schell, 2009; Wang and Or, 2020), white letters on a black rectangle (Gabriele, 2006; Liu et al., 2019; Or and Wang, 2014; Wang and Or, 2020), reverse tall-man letters (Wang and Or, 2020) and enlarged letters (Or and Chan, 2014). However, the findings of previous research were not conclusive. More systematic studies seem necessary to justify the effectiveness of these attributes individually and collectively.

CONCLUSION

This study has shown that the combination of tall-man lettering and symbol prefixing could reduce confusion between drug names and help pharmacists identify drugs. While the findings strengthen the idea that tall-man lettering is an effective technique for differentiating drug names, this study has demonstrated, for the first time, that symbol prefixing is also a useful method for the differentiation of drug names.

Since confusion between drug names is one of the main causes of medication errors and therefore affects patient safety, continued efforts are needed to explore and examine any approach that can solve the problem. A natural progression of this work is to investigate possible typographic and orthographic alterations to drug names for mitigating the confusion and ultimately improving patient safety.

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