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Using enhanced text to facilitate recognition of drug names: Evidence from two experimental studies

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Abstract

Two studies examined the effects of enhanced text on immediate recognition of drug names. Study 1 sampled 102 college students using a between-subjects design, while Study 2 sampled 11 practicing pharmacists and technicians using a within-subjects Latin square design. Both studies utilized a computer-based sequential recognition task where a prime word was shown with various text enhancements, followed by a mask and then a target word. Participants decided whether the target word was the same as the prime word. Stimuli were organized so that 120 trials were matches and 120 trials were mismatches, randomly sequenced for each participant. Results showed an effect of orthographic similarity, where high-similarity name mismatches were missed more often. This effect was independent of the type of text enhancement used and response bias. Case-based enhancements also increased errors of commission (false alarms) significantly. Discussion includes the practical relevance of the data and future directions for research.

Keywords: Pharmacy; Drug names; Enhanced text; Orthographic similarity

1. Introduction

Though there is debate about the accuracy of the data, the Institute of Medicine's reports on medication error (Kohn et al., 2000; Aspden et al., 2006) made it very clear that errors happen far too frequently in health care at all levels. Pharmacy is easily implicated in these errors because of its role in medication delivery. Many studies in the past decade have focused exclusively on the medication-dispensing process as a source of iatrogenic illness in both inpatient and outpatient facilities as well as using laboratory simulations (Calabrese et al., 2001; Dean et al., 2002; Grasha and Schell, 2001; LaPointe and Jollis, 2003; Schell et al., 2006). Though many sources of error have been suggested, one common culprit has been the similar sounds and structures of many drug names (e.g., Lambert et al., 2005). For most of pharmacy's history, pharmacists have had to rely on their own perceptions and memories to make sure that the drug requested for the patient is the one that was selected and filled. Even today, with the slow infusion of automation into pharmacies, there are many facilities that still depend solely on the abilities of the pharmacy staff to detect wrong-drug errors.

Several years ago, the Food and Drug Administration identified a set of "confusable" drug names and instructed manufacturers to use textual enhancements on stock bottle labels to better distinguish certain products from one another. For instance, *glipizide* and *glyburide* are two drugs that were identified as potentially confusable, and so today these drugs are printed in exaggerated text (i.e., "glipiZIDE" and "glyBURIDE"). The obvious intention of the intervention was to make the distinct part of each name more salient perceptually, hopefully triggering further checks on performance and curtailing incorrect product selections. Though credit should be given for the intent of the idea, there have been only a few studies (Filik, et al., 2004, 2005) that have examined these text enhancements for their effects on drug name perception accuracy, and these studies have been mostly supportive of text enhancements. The current study will follow up on these

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findings and examine experimentally the impact of text enhancement on immediate perception and recognition of drug names at low and high levels of visual confusability. A different type of experimental presentation will be utilized to augment the findings reported in previous studies, and we will utilize two samples that vary in drug name familiarity to compare data across this important factor.

Briefly, text enhancements are hypothesized to improve recognition of drug names for various reasons. First, the enhanced letters should be noticed first by the reader. This should lead the reader to utilize those letters first when comparing the drug name on the bottle label to the name on the prescription form, written in regular text. What is unclear is whether the enhanced text will improve the ratio of correct to incorrect comparisons or whether it will be detrimental to it. If the enhanced text functions as intended, then we should see improved immediate recognition of drug names even when comparing the name to another that is orthographically similar. On the other hand, we should see *declines* in correct comparisons if the enhanced text does not function as intended. Interestingly, a case for both possibilities can be made.

Enhanced text as benefit: Signal detection theory suggests that one way to improve target detection is to increase target salience (e.g., Davies and Parasuraman, 1982). Enhanced text should be able to do this well by affecting the size of the letters and the overall shape of the word. If it can do so, then when the actor reads the enhanced name and then compares the memory of that name to a name on a second display, then the salient letters should be the first ones to be compared. If they do not match the comparator name's letters *and* letter sequencing, then the actor should correctly identify that comparison as a mismatch. Essentially, the text enhancements should add additional dimensions of perception beyond those commonly used for reading, and thus provide more information about the names that can be used to distinguish them.

Enhanced text as detriment: However, the above argument rests on some assumptions that may not be valid. The first assumption is that the pharmacist will have unlimited inspection time and/or will devote the proper amount of time to inspection. A second related assumption is that the word will be processed so that every letter will be given equal inspection time and processed in the same way. These assumptions build on one another in that, for the text enhancements to work, the entire drug name must be processed, as the drug name written on a prescription form, for instance, will likely NOT be enhanced. Enhancing certain letters in the drug name will most likely make those letters more salient, but could also *reduce* processing of the unenhanced letters by imposing an artificial dichotomy on the word (important/unimportant letters). The third assumption made is that each additional dimension of perceptual information will additively improve recognition. This assumption fails to account for possible interactions among those dimensions that could offset any gains in perceptual salience—for example, textual enhancements that include size and color adjustments add two perceptual dimensions—so they should be perceived more accurately than text with no enhancements, according to the assumption. This has yet to be directly tested.

Theoretically, these arguments depend on the theory of word perception that one advocates (e.g., Frost, 1998; McClelland and Rumelhart, 1981; Perea and Rosa, 2002). If we process words as letter strings (letter→word perception), which is a more "bottom-up" approach, then the enhanced text should probably be more beneficial than detrimental. By way of contrast, others assert that word recognition is more "top-down" (word→letter perception), and, if so, the enhancements may not help at all but may actually harm drug name comparison accuracy. For example, case enhancements change the overall shape of the letters that are capitalized, eliminating figural information from word perception. In a predominantly "top-down" perspective, this should be problematic because the case enhancements make words look *more* similar, not less, removing information that could help to clarify the semantic path from abstraction and expectation to perception. But, the "bottom-up" theorist would assert that the case enhancement should improve recognition performance, because the letters must be processed singularly and case can be used as additional information to do so more accurately. Of course, it should be noted that the above arguments rest on the assumption that the operator has developed some degree of expertise in reading and interpreting prescriptions, which is likely to be the case even for pharmacy technicians after only a few months of service.

1.1. Error types and practical issues

Checking prescriptions for errors, though complex compared to a simple task like determining the color of a target on a computer screen, conforms to the same theoretical axioms that all signal detection tasks do. That is, two types of errors are possible. First, an *incorrect* prescription can leave the pharmacy without being detected. This would be a "miss" (an error of *omission*) in signal detection terminology (Davies and Parasuraman, 1982; Green and Swets, 1966), because the actor "missed" the presence of the erroneous prescription. Therefore, the appropriate response (stopping the prescription from being dispensed) was omitted. Second, a *correct* prescription could be identified as incorrect. This sort of error is equivalent to a "false alarm" (or an error of *commission*). In this case, the actor triggers the organizational activities necessary when an error is detected, but does so in response to a prescription that is actually correct. In other words, the actor *committed* the wrong behavior because he misperceived the prescription's accuracy.

The most obvious way that text enhancements can improve performance is to decrease the number of misses

(errors of omission). This is the primary outcome that the enhancements are supposed to produce. However, they may also work to affect the number of false-alarm responses. This could happen if the enhancements influence *response bias*. Response bias is an index that denotes the threshold amount of information necessary for a given actor to report a target (in this case, a mismatch between an expected drug name and an observed drug name). If the response bias is conservative, then the actor is hesitant to report a target and requires considerable evidence. If the response bias is liberal, then the actor requires very little evidence to report a target. Clearly, liberal response bias translates into a larger amount of false-alarm responses, whereas a conservative bias will produce relatively few false alarms.

Practically speaking, pharmacists are quite accurate even without the benefit of enhanced text, and many of the errors that do occur are not directly and/or proximally related to misreading drug names (Aspden et al., 2006). Thus, there is some question as to whether the text enhancements can decrease misses substantially given the current base rate. However, we know little about how the enhancements may affect response bias, and this is a practically important point. As the actor becomes more likely to report *perceived* errors (i.e., employs a liberal bias), more errors are likely to be captured by mere chance alone, assuming a constant error rate. Consider the metaphorical example of bird hunting—a shotgun load that spreads wide is desirable for hunting birds because their small profile and quick movement make them difficult to hit. In the same way, if the enhancements can make response biases more liberal, some extra gain in performance may be attained even if the actor's sensitivity to actual mismatches might be unaffected.

For example, we know from the vigilance literature that decrements can occur in some detection tasks over time (Davies and Parasuraman, 1982); a liberal bias might catch some of those targets (in this case, errors) that would have otherwise been missed. But perhaps even more importantly for businesses, it is generally less costly in a number of ways (financially, socially, organizationally) to handle an unnecessary "false alarm" than to recover from a miss. A missed error could injure a consumer; false alarms almost never will, because they remain internal to the pharmacy. Although false alarms may take some time and extra effort to correct, the risk of disastrous consequences is far smaller compared to misses. The reader should understand that the "false alarms" that this study examines are simply momentary cognitive signals indicating to the operator that their initial perception may not have been correct. They are *not* synonymous with audible alarms or other kinds of automated signals. So, given the ubiquitous nature of human error in that total error prevention is not possible (e.g., Reason, 1990; Sharit, 2006), it should be better on average for the pharmacist's perceptual system to be more rather than less likely to identify a potentially problematic prescription.

1.2. The current studies

This research uses a computerized experimental task paradigm to test the basic assertion that text enhancements are beneficial to drug name identification. To simulate the well-established automaticity with which most pharmacists work, we utilized a speeded "go/no-go" type of task where an enhanced drug name was flashed briefly onto the screen, a mask was shown to force short-term memory rehearsal, and then a comparison drug name was presented (without enhancements). Participants were asked to respond "match" or "mismatch" on each trial. While it is probable that most of the drugs in the name list would be unfamiliar to pharmacy-naïve student actors, the task was such that knowledge about the drugs themselves was not required; reading was the only skill necessary. Nevertheless, to account for the possibility that knowledge structures concerning the drugs would enhance memory for the names and, as a result, name identification, the decision was made to sample a second population of pharmacists and technicians on the same task.

To simulate the scarcity of immediate feedback in the pharmacies (especially those without automation), participants were not aware of the accuracy of their comparisons at any time. This put the onus of performance tracking solely on the actor; the computer software simply accepted whatever response was given without telling the actor whether it was correct or not. Even though we were not interested in the ability to be accurate in impressions of one's own performance, this aspect of the task was still needed to simulate an important facet of the pharmacy experience.

Hypotheses were generated by considering how the text enhancements should affect the two types of error that were discussed previously: errors of omission (misses) and errors of commission (false alarms). First, it was expected that participants in the text enhancement conditions would be significantly more accurate in drug name recognition compared to the control condition (H-1). Second, it was expected that the participants in the text enhancement conditions would make significantly more errors of commission (false alarms) in drug name recognition compared to the control condition (H-2). Finally, it was expected that drug name comparisons would be less accurate overall for names high in orthographic similarity versus those names low in orthographic similarity, completing an expected interaction in drug name recognition accuracy between orthographic similarity and text enhancement conditions (H-3).

2. Method—study 1

2.1. Participants

One hundred and two participants from Angelo State University volunteered to participate in the research for extra course credit and completed all study requirements.

The sample was composed of 22 men and 80 women of a mean age of 22.2 years (SD = 5.6).

2.2. Experimental task

Using SuperLab (version 2.04; Cedrus, Inc.), a task was constructed to display and record decision data on the enhanced drug names. The computers were PC-based and employed 43.18 cm (17 in) flat screen monitors at 1024×768 resolutions. The drug names were printed in Arial font and saved as bitmap files so that their size could be controlled by SuperLab more precisely.

The drug names used for the task were taken from a list published by US Pharmacoepia (http://www.usp.org) in 2001 of names that were involved in name confusion errors at the time (the list is available from the author as it is no longer available online). The list of names were ranked according to a mathematically derived measure of orthographic similarity, calculated using a formula popularized by Lambert (Lambert et al., 2001, 2003), and then the bottom and top 40 names on the list were selected for the study, along with the confusable pair name for each one. For example, *prednisone* was a selected name, and so it was paired with its confusable pair name (*prednisolone*) for the study. This technique resulted in a stimulus list of 80 drug names and their confusable pair names. Next, "prime" stimuli were created by writing these 80 drug names using one of three enhancement conditions: no enhancement, color enhancement (red lettering), and case-based enhancement (capital letters in place of lower case letters). These enhancement types were chosen for two reasons. First, color and case enhancements are currently being used in pharmacies. Second, other research (Filik, et al., 2004, 2005) has studied color enhancements in drug name perception. Third, research indicates that color can be useful for perception provided that it is judiciously chosen and cultural rules surrounding the meaning of different colors are observed (Fisher and Tan, 1989; Hughes and Creed, 1994; Wickens and Hollands, 2000). The color "red" is typically associated with "stop" or "warning" signals, and so it was the logical choice for this study. With respect to capitalization, letters that were *dissimilar* to those in the corresponding pair drug name were chosen for enhancement. This is similar to the current "Tall Man" lettering policies in place.

For each "prime" stimulus, two additional "target" stimuli were created: (1) the same drug name, and (2) the confusable pair name, both written in normal text. This technique produced a list of 80 "prime stimulus" drug names within each enhancement category (no enhancement, color enhancement, case-based enhancement) with corresponding "target" stimuli that were either matches (same name) or mismatches (confusable pair name). Finally, as the task progressed, the software selected these name pairs randomly on a per trial basis for presentation to the participants, such that each participant was exposed to 240 trials (120 matches, 120 mismatches). Participants were unaware *a priori* of the set signal probability. Also, they were not exposed to every possible name pair, but the randomization routine insured that each name pair would only be seen once within each block.

Graphical examples of the stimuli used in both studies can be obtained from the author directly.

2.3. Procedure

Participants were randomly assigned to one of three conditions before they arrived for testing: a control group (no text enhancements), a color group (using color enhancements only), and a case group (using capital letter enhancements only). Participants were seated at a computer station and introduced to the task environment. Instructions were given concerning the nature of the task and the response pads required for use. Next, a series of four practice trials were conducted using one name pair ("Norman" and "Norbert") as stimuli. The first two training trials demonstrated a "match," while the second two trials demonstrated a "mismatch." Additionally, the prime words in the four trials were constructed to introduce the capital-letter and color enhancements.

Once training was complete, the first block of name pairs was initiated. The task was organized into six blocks of 40 trials with a 2-min "rest" between blocks. Both high- and low-similarity names were randomized within each block. Each trial in these blocks progressed in the following manner. First, a row of plus signs ("+ + + + + +") appeared on the screen for 3 s to direct attention to the proper area of the screen. Next, the prime drug name appeared for 400 ms and then was immediately covered with a black mask for a period of 3 s. Then the target drug name appeared on the screen in the same position. Once the participant decided if there was a match or a mismatch, he or she pressed the appropriate response key (match = green, mismatch = red) and the next trial began immediately, displaying the row of plus signs again. After each block, a message appeared directing the participant to contact the experimenter. Finally, at no time were participants given feedback regarding the accuracy of their performance; this rule was installed to approximate the paucity of immediate performance feedback available in most pharmacy and other medical settings. Once the six blocks were completed, participants were debriefed on the nature of the study and dismissed.

3. Results and discussion—study 1

Descriptives for the sample are shown in Table 1; the first three rows in each text exaggeration condition are shown in raw numbers of errors. Error detection statistics also include d', a measure of sensory sensitivity to stimuli (in this case, differences between stimuli), and c, a non-parametric measure of response bias. As the value of c increases, the participants are more likely to be liberal in their decisions, or to identify a mismatch where one does

Table 1
Descriptive statistics for error percentage, errors of omission, errors of commission, sensitivity (d'), and response bias (c) within enhancement types (student sample)

Variable	M	SD
Overall (all types) ($N = 102$)		
Total error percentage	6.05	4.12
Omission errors	1.52	1.36
Commission errors	3.32	2.67
Sensitivity (d')	3.46	0.79
Response bias (c)	0.23	0.25
Control (no enhancements) ($n = 37$)		
Total error percentage	5.44	3.65
Omission errors	1.46	1.33
Commission errors	2.89	2.19
Sensitivity (d')	3.52	0.71
Response bias (c)	0.19	0.20
Colored text enhancement ($n = 33$)		
Total error percentage	5.31	3.64
Omission errors	1.49	1.33
Commission errors	2.75	2.34
Sensitivity (d')	3.56	0.75
Response bias (c)	0.19	0.26
Text case enhancement ($n = 32$)		
Total error percentage	7.53	4.79
Omission errors	1.61	1.47
Commission errors	4.41	3.19
Sensitivity (d')	3.30	0.90
Response bias (c)	0.32	0.27

Table 2
Significant multiple comparisons (Tukey's LSD) between enhancement conditions for mean errors of commission

Condition 1	Condition 2	(I–J)	p	95% CI
Case enhanced	Control	1.52	<0.02	(0.28–2.76)
Case enhanced	Color enhanced	1.66	<0.02	(0.38–2.93)

Note: All other possible comparisons were non-significant at $p<0.05$.

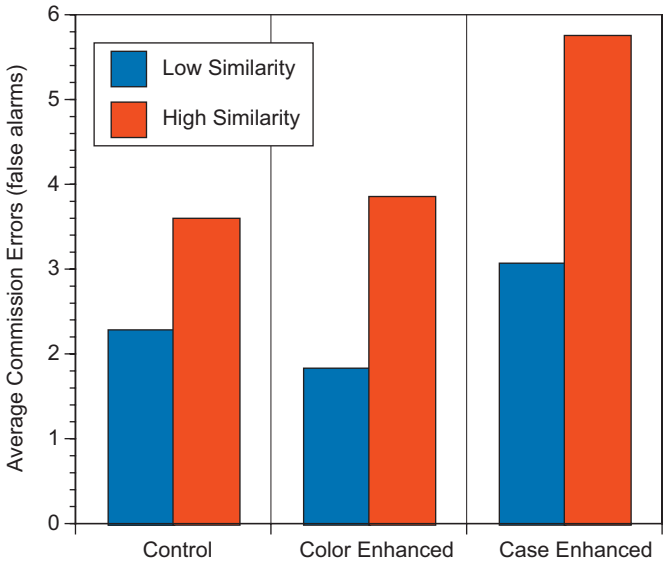

Fig. 1. Average commission errors (false alarms) as a function of text enhancement condition and orthographic similarity of drug names.

not exist ("false alarms"). Participants were fairly accurate at name identification, producing an overall average error rate of just over 6% and a d' statistic of over 3. This suggested considerable sensitivity to the differences in the names. Also, participants committed over twice as many errors of commission (reporting that the names were not the same when they were) as they did errors of omission (reporting that the errors were the same when they were not).

Main effects were analyzed for five dependent measures (error percentage, errors of omission, errors of commission, d' and c) across enhancement type. The results revealed two significant main effects: total error percentage ($F(2, 99) = 3.12$, $p<0.05$) and errors of commission ($F(2, 99) = 4.15$, $p<0.02$). An examination of means in Table 1 shows that the case enhancement led to higher values of both of these dependent measures than in other conditions. Contrast analyses using Tukey's LSD statistic confirmed this observation statistically. The mean number of errors of commission was significantly higher in the case enhancement condition compared to the others (see Table 2). In addition, the control (no enhancement) and color enhancement conditions were not different from one another on any dependent measure of performance. Therefore, H-2 received support, but H-1 did not (see Fig. 1).

A 3 (exaggeration type) × 2 (orthographic similarity) was conducted to examine the differential effects of exaggerations depending on the similarity of the pair names. Results showed a significant main effect of orthographic similarity on sensitivity (d'), where sensitivity was lower for high-similarity names (see Fig. 2). This effect was independent of text exaggeration condition as well. Therefore, H-3 was partially supported in these data (the interaction term was non-significant). Interestingly, there was a significant simple effect within the low-similarity set of drug names, where response bias was more liberal in the case enhancement condition.

The data in this study indicate that the case enhancement only produced a significant increase in errors of commission ("false alarms") over a control condition, where drug names were written normally; it did not improve name recognition accuracy. The color enhancement did not significantly change response patterns in any way. An immediate reaction to these data is that text enhancements of drug names do not improve name recognition. Such a conclusion overlooks the potential importance of the increase in errors of commission. As previously noted, increases in this type of error usually suggests a change in the decision criterion of the actor toward liberal responding. Table 1 shows that the response bias statistic (c) was nearly 70% higher for the case enhancement condition (0.32) as for the other conditions (each at 0.19), suggesting

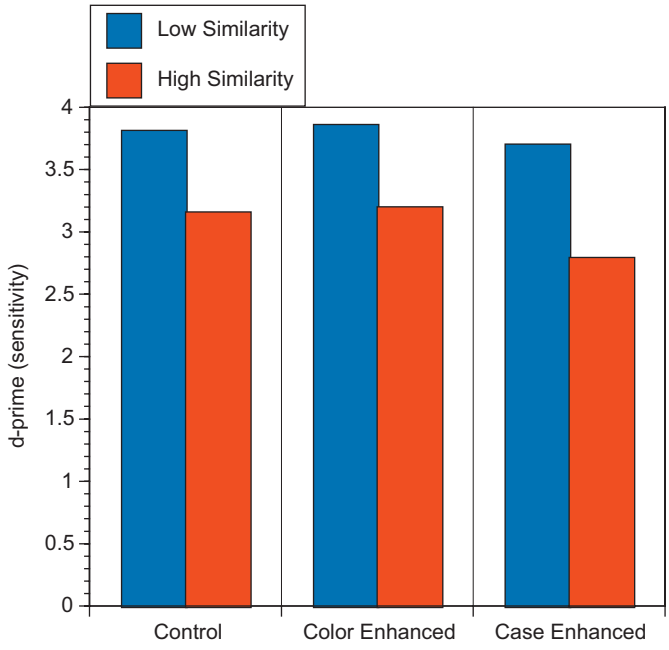

Fig. 2. Perceptual sensitivity (d') as a function of text enhancement condition and orthographic similarity of drug names.

that this shift occurred to some degree. Liberal criterion shifts can reflect an increase in uncertainty regarding the choices the actor must make about the stimuli that she is observing, thus the "safe" option is to report a target and risk more unnecessary alarms.

Carrying this logic further, pharmacists and technicians who work in a well-established automatic processing mode may be prone to what Reason (1990) called "lapses," where inattention and complacency lead to incorrect decisions and actions (of which the actor is usually unaware). Interrupting the automatic processing of the pharmacist with respect to prescription checking might work to encourage greater caution in the evaluation of prescriptions. The probable cost of this switch out of automatic processing mode would only be a small amount of time and work pace, and even that is questionable. One unpublished study in an outpatient pharmacy demonstrated that a "bottle sleeve" intervention, where the front stock bottle was placed under a cover that had to be lifted in order to dispense the medication, actually *decreased* the average time to fill a prescription (Grasha et al., 2000). When one considers that the attention to possible error conditions suggested by an increasingly liberal decision bias is a hallmark of high reliability organizations (Waller and Roberts, 2003), the response profile generated by the case enhancements may not be so problematic.

There is one important methodological limitation in the study above. The participants were not pharmacy-trained and so the drug names may have had no inherent meaning to them. Pharmacists have extensive knowledge structures that are triggered when a drug name is read or perceived, and those structures cannot be simulated in a laboratory study using students. Therefore, a second study was designed to test name recognition in pharmacy-trained personnel. Unfortunately, due to the difficulty of scheduling these individuals around their work responsibilities, a new experimental design had to be constructed and used with this sample. As a function of this new design, additional enhancement categories could be tested as well, including a new "size-based" enhancement where the enhanced portion of the word was increased by 33% relative to the rest of the word. Overall, six enhancement types were used: (1) no enhancement; (2) color enhancement; (3) case-based enhancement; (4) color + case-based enhancement; (5) case-based + size-based enhancement; and (6) all three enhancements combined (color, case and size).

The most important question to be answered in the second study concerned the impact of different enhancement types on recognition performance in a pharmacy-trained sample. In this study, it was expected that sensitivity (d') would be highest with the most significant text enhancement(s) (H-4), and sensitivity would be lowest in the control (no enhancement) condition (H-5). "Significance" with respect to text enhancement is proposed to be a function of the number of different dimensions of enhancement utilized; thus, category 6 above would be the most "significant." These expectations are different because of the increased familiarity of the drug names to the pharmacy sample. That familiarity should make more similar-appearing names more confusable as a function of the word frequency effect (cf., Malmberg et al., 2004; Watkins and Watkins, 1977). So, the enhancements should force the pharmacy-experienced participants into a more data-driven processing strategy, where the benefits of text enhancements should be realized.

4. Method—study 2

4.1. Participants

Eleven practicing pharmacists and technicians from community and long-term care pharmacies participated in this study. The sample was composed of three men and eight women, all of whom had practiced pharmacy in their respective roles for at least 12 months (the maximum tenure was 31 years), although not necessarily at the facility where they were currently employed.

4.2. Method and procedure

The experimental task was divided into six blocks of 80 trials each (a total of 480 trials). Six text enhancement manipulations were used: (1) no enhancement, (2) letter case enhancement, (3) color enhancement, (4) color and letter case enhancement, (5) letter case and size enhancement, and (6) color, letter case and size enhancement (the size enhancement involved increasing the enhanced

letters by 33%). A Latin square technique was used to counterbalance the enhancement conditions within participants.

The same task procedure was used for Study 2 as was used in Study 1 in all respects save two important exceptions. First, the stimulus-exposure time was dropped from 400 to 250 ms. This was done to counteract the expertise of the pharmacists, which should have allowed them to read and recognize the drug names faster. Also, speeding up the task increased objective workload and should have increased the challenge of the task for the more expert performers. Thus, data across the two participant groups should be more comparable at a perceptual and motivational level despite the experiential differences between the samples. Second, the task was composed of 6 blocks of 80 trials instead of 40 trials to provide more opportunity for error, anticipating that experienced personnel would be more accurate than college students as a rule.

5. Results and discussion—study 2

Descriptives for the sample are shown in Table 3. Errors of commission (false alarms) were more likely than errors of omission (misses) on average across the different enhancement types regardless of how the data were organized. The main question to be addressed involved comparisons of accuracy between the various types of text enhancements. While performance was slightly better in the control condition and the case enhancement condition and slightly lower in the color enhancement condition, statistical comparisons between conditions were all non-significant (all p's >0.05). Therefore, neither H-4 nor H-5 received support in these data.

Table 3
Means and standard deviations for name recognition across experimental groups and samples (pharmacist sample)

Variable	*M*	SD
Control—no enhancements		
Errors of omission	0.91	1.45
Errors of commission	2.64	1.91
Letter case enhancement only		
Errors of omission	0.91	1.45
Errors of commission	2.64	2.58
Color enhancement only		
Errors of omission	1.36	1.50
Errors of commission	2.55	1.63
Color/case enhancement		
Errors of omission	1.27	1.10
Errors of commission	1.91	1.14
Case/size enhancement		
Errors of omission	1.18	1.08
Errors of commission	2.36	1.80
Color/case/size enhancement		
Errors of omission	1.00	1.18
Errors of commission	2.18	2.09
Across enhancement types		
Errors of omission	1.11	1.00
Errors of commission	2.38	1.49

Note: $N = 11$.

Thus, among pharmacists and technicians, although there were small absolute differences between enhancement conditions, there was no empirical evidence that name recognition was significantly affected by them. It should be noted that statistical testing of these data could be questioned due to the small sample size and the resulting lack of statistical power. It is possible that Type II errors are being made in this analysis, and future research must increase the sample size to determine this.

6. General discussion

Two studies were conducted to examine the impact of text enhancements on immediate recognition of drug names under controlled conditions. Some evidence was found to suggest that the use of case enhancements (capitalizing confusable segments of certain drug names) increased errors of commission (otherwise called "false alarms"). Also, detection of name mismatches was poorer in all exaggeration conditions when the pair names were more orthographically similar.

It may be disconcerting to think that the text enhancements may encourage the production of false-alarm responses; that is, stopping the filling process for an error that did not really exist. Pharmacists may interpret this finding as troublesome, thinking that all of those unnecessary responses will lower prescription volume and create extra work. This is especially true for those who work in environments where automated warnings sound frequently, and many are bypassed with little thought. In one observation period completed by the author in a hospital pharmacy, over 100 warning signals were generated in a one-hour period by the computer system! The pharmacists reported that the warnings were quite annoying and had little effect on their behavior. For this reason, the increase in false alarms may be seen as a negative result. However, the data in this study, if extrapolated to the total annual prescription volume in the US and spread across all pharmacy-dispensing units, indicate that the text enhancements should result in 1–2 extra false-alarm responses per day, hardly an onerous number. As already stated, given a constant error rate and constant word familiarity, more actual errors should be captured at a more liberal decision criterion. In addition, user-generated alarms can provide useful information that can be used by pharmacists and technicians to improve their error detection ability. Also, increases in false-alarm responses can help to counteract complacency and sensitivity decreases connected to extremely infrequent signals (Davies and Parasuraman, 1982). Policy makers must decide whether the cost of such a criterion shift is worth the benefits.

It should be noted that researchers have done similar sorts of studies on enhanced text (Filik, et al., 2004, 2005). For the most part, the results of these studies were supportive of the use of enhanced text to identify drug names in that name identification was better when using enhanced text compared to normal text. But there are some differences between those studies and the current research. Most of the earlier work was designed so that enhanced drug names were available for comparison using a simultaneous method, where both the enhanced names and the "normal" names were on the screen in an array. In the studies reported here, the task is classifiable as a sequential task, where the prime appears closely followed by the target. The vigilance literature has examined the differences between simultaneous and successive tasks for some time (Wickens and Hollands, 2000), and has found simultaneous tasks to be less resource-demanding and less susceptible to decrements in performance. By examining name recognition in both types of paradigms, it becomes clearer what resources are necessary to process enhanced text, an important question with long-term performance implications. In sum, the current study was intended to be complementary to previous literature rather than contrarian.

The research reported here is subject to some limitations, the most obvious of which is the sample size in Study 2. An additional concern is the presence of ceiling effects on performance, again more of a problem in Study 2 than in Study 1. Finally, the task itself was somewhat artificial and it is unclear if name recognition in a real-world situation would function similarly. Thus, there are still many questions to be asked concerning text enhancements as an error-reduction device.

6.1. Future research and practical implications

An obvious question that arises from this study concerns the real-world impact of increases in false alarms during pharmacy work. Pharmacists and technicians are the ones who will have to handle the ramifications of such an effect, and we need field studies to determine whether the benefits outweigh the costs of a change in decision criterion (or vice versa).

Future research can also inform policy. One critical issue that should be studied is that drug names (and other words as well) are usually composed of interpretable subunits, blocks of letters that carry meaning in themselves. For example, a drug name ending in "-one" is likely to be a steroid and beta blockers will end in "-olol." Experts are likely to read drug names based on this knowledge, and this could affect how text enhancements function with respect to expert operators. In the current research, Study 1 involves pharmacy novices, and so this issue should be irrelevant, but future work with pharmacy-trained samples may want to design, for example, a study that utilizes one enhancement style across different combinations of letters. In this line of thought, consider "glyBURIDE" and "glipiZIDE", two potentially confusable names where the enhancements *include* the part of the name that is similar ("IDE"). Perhaps, "glyBURide" and "gliPIZide" would be better choices, but no empirical work exists to compare the utility of different enhancement combinations. Secondly, these data must be followed with studies in "real-world" simulations where the effects of workload, packaging type, shelf location, and other factors can be examined. Finally, if pharmacies wish to utilize text enhancements, it would seem prudent to empirically revisit the policies in place for handling identified errors. For instance, when a potential error is identified, how is that identification verified? How does that re-checking fit into the facility's workflow patterns? These questions could be pertinent if enhancements are used and if they produce the same increases in errors of commission (false alarms) that were observed in these data, particularly in Study 1.

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