ORIGINAL RESEARCH ARTICLE

Drug Saf 2010; 33 (8): 677-687
0114-5916/10/0008-0677/$49.95/0

The Influence of Tall Man Lettering on Drug Name Confusion

A Laboratory-Based Investigation in the UK Using Younger and Older Adults and Healthcare Practitioners

Ruth Filik,[1] *Jessica Price,*[2] *Iain Darker,*[3] *David Gerrett,*[4] *Kevin Purdy*[3] and *Alastair Gale*[3]

1 School of Psychology, University of Nottingham, Nottingham, UK
2 Bioengineering Unit, University of Strathclyde, Glasgow, UK
3 Applied Vision Research Centre, University of Loughborough, Loughborough, UK
4 National Patient Safety Agency, London, UK

Abstract

Background: Medication errors commonly involve confusion between drugs with similar names. One possible method of reducing error is to emphasize differences between the names using 'Tall Man' (uppercase) letters (e.g. cefTAZidime vs cefUROxime). Previous studies investigating this issue have been conducted mainly on university students, and results have been mixed.

Objective: To investigate the influence of Tall Man lettering on drug name confusion in other key participant groups.

Study Design: Two separate experiments were conducted. In Experiment 1 (conducted at the University of Glasgow, Scotland, between January 2008 and May 2008), younger and older adults performed a same/different judgement task. In Experiment 2 (conducted at various sites in England between December 2008 and February 2009), healthcare practitioners performed a task based on electronic prescribing.

Results: In Experiment 1, both younger and older adults made fewer name confusion errors when names contained Tall Man letters. Response times suggested that Tall Man lettering drew participants' attention to those letters, but that readers did not solely rely on these letters in making their response. In Experiment 2, healthcare practitioners made fewer name confusion errors when the names contained Tall Man letters.

Conclusions: Overall, results showed that Tall Man lettering reduced drug name confusion errors in a series of laboratory-based tasks, in both younger and older adults, and healthcare practitioners. Thus, the current findings offer some support for the use of Tall Man letters as a possible systems change that could be made by both pharmacies and manufacturers in an effort to reduce error caused by drug name confusion.

Background

Figures suggest that confusion caused by drug names that look or sound alike accounts for up to 25%[1] of reported medication errors. In addition, one observational study that measured dispensing accuracy reported a rate of 'wrong drug' errors of 0.13%,[2] which, when multiplied by the large number of prescriptions made out each year (805 million in the year ending June 2009 in the UK[3]), results in a considerable number of errors. Similarity between different drug names can occur for a number of reasons. Brand (proprietary) names may be similar to each other so that the value invested in one trademark can be transferred to another, whereas generic (non-proprietary) names that share a mechanism of action or chemical constituent often have the same prefix or suffix. To give an indication of the scale of the problem, the UK National Pharmacy Association published a list of 294 look-alike or sound-alike drug names for which confusions had caused actual harm or 'near misses' in community pharmacy dispensing.[4] Strategies for reducing errors must consider both preventing the approval of new names that may be confused with existing names[5] and dealing with existing confusable names.

In this article we are principally concerned with reducing errors relating to existing confusable names. Specifically, we assess the use of 'Tall Man' (uppercase) letters to emphasize the differences between similar names. For instance, it has been suggested that it is easier to differentiate 'DOBUTamine' and 'DOPamine' than 'dobutamine' and 'dopamine'.[6] In 2001, The US FDA Name Differentiation Project implemented this idea. Following FDA recommendations, the Office of Generic Drugs requested that manufacturers voluntarily produce labelling that visually differentiated 16 look-alike name pairs using Tall Man letters.[7,8]

Since then, a number of scientific studies have been carried out in an attempt to objectively assess the effectiveness of Tall Man lettering. In one study, participants' eye movements were recorded while they searched for a target product amongst an array of packs presented on a computer screen.[9] The task was to indicate whether the target was present in the array. In fact, the target was never present, but was always replaced by a 'distractor' drug with a similar name (e.g. the target was chlorpromazine, but chlorpropamide was present in the array). The study design was balanced with 'filler' trials where the target *was* present. Names on the packs were either in lowercase or contained Tall Man lettering. Participants made fewer name confusion errors when the names included Tall Man letters. In addition, the eye movement data showed that participants spent less time looking at a distractor pack when the name contained Tall Man lettering, indicating less difficulty with the task in this case.[9] These results were supported by another study showing that Tall Man lettering made similar names easier to distinguish in a same/different judgement task when participants were aware of the purpose of the Tall Man letters, and improved recognition memory by increasing attention.[10] However, an acknowledged limitation of this research was the use of non-healthcare professionals (i.e. university students) as participants.

More recently, this issue was investigated in two computer-based sequential recognition experiments.[11] Participants were shown a 'prime' drug name, followed by a target name, and the task was to indicate whether the target name was the same as the prime name. In Experiment 1, names were either presented in lowercase, with sections featuring 'colour enhancement' (red lettering) or 'case enhancement' (uppercase letters in place of lowercase letters). Participants in this experiment were college students. Results showed that neither colour nor case reduced confusion between similar names (i.e. did not alter the likelihood of reporting that two names were the same when they were in fact different). In addition, presenting portions of the name in uppercase letters actually significantly increased the number of false alarms (i.e. indicating that the two names were different when they were in fact the same). However, it was argued that this may be a positive outcome as an increased tendency to report errors may lead to more actual errors being caught. Experiment 2 included six text enhancement types; no enhancement, colour enhancement, case-based enhancement, colour- and case-based enhancement, case- and size-based enhancement (where the enhanced portion of the word was increased by 33% relative to the rest of the word) and all three enhancements combined (colour, case and size). Participants were practicing pharmacists and technicians from community and long-term-care pharmacies. Results showed that none of these enhancements had a significant effect on accuracy. However, the author noted that this may be due to a lack of statistical power (n = 11) and that future research must increase the sample size.[11]

In another study, Tall Man lettering, bold text, and reverse print (i.e. white text on a black background) were examined using a sample of 11 acute-care nurses.[12] It was suggested that, from the results of a word recognition/memory task, the manipulation of reversing font and background colours seemed to be most effective, followed by Tall Man lettering, followed by bold type. Subjective judgements suggested that the nurses considered that the reversal and bold-type manipulations, followed by Tall Man lettering, made the names less confusable; however, no statistical analyses were presented and the author admitted that a larger scale study is required in order to be conclusive.

It is clear from this that studies that included healthcare practitioners as participants used sample sizes that may be too small to lead to conclusive results. Thus, while some preliminary research conducted on university students seems quite positive, it remains to be seen whether these effects generalize to other key participant groups. The aim of the current research is to fill this gap, specifically, to investigate the effect of Tall Man letters on name confusion in older adult participants, a portion of the population who may have to recognize a large number of drug names when handling their own medication (Experiment 1), and in a large sample of healthcare practitioners with responsibilities in prescribing (Experiment 2).

Experiment 1: Younger and Older Adults

There are a number of reasons why it is important to assess whether findings with university students generalize to an older population. First, older adults (typically, those over 65 years of age) use more medicines than any other age group,[13] with many taking multiple medicines at the same time.[14] From this it could be argued that they are more likely to be in a situation where different products may be confused with one another, particularly since it has been reported that almost 40% of older adults in the US have difficulty reading the prescription label.[15]

Reasons for postulating differences between younger and older adults include the observation that working memory capacity, which plays a crucial role in reading comprehension,[16] declines with aging.[17] There is evidence to suggest that older adults allocate resources differently compared with younger adults to compensate for the decreases in cognitive capacity.[18] Furthermore, it has been claimed that older adults have difficulty interpreting ambiguous phrases.[19-22] Thus, it is possible that they may benefit more from a device that is designed to reduce ambiguity in language processing (such as Tall Man lettering). Indeed, recent research reports that older adults may be more sensitive to manipulations that focus their attention to certain aspects of a text.[23]

The task we adopt here is based on the sequential recognition task used by Schell.[11] Although Schell did not find that Tall Man letters reduced name confusion errors in this task when performed by college students, it may be the case that older adults are more sensitive to the effects of Tall Man lettering, given the observations presented above concerning differences in language processing with aging.

Methods

Participants

Twenty-eight younger adults recruited from the Glasgow University student population (mean age 21.8 years [SD 4.2]) and 28 older adults (mean age 72.0 years [SD 7.7]) were paid a nominal amount to participate. Ethical approval was granted from the Glasgow University Faculty of Information and Mathematical Sciences Ethics Committee, and British Psychological Society ethical guidelines[24] were adhered to. All participants gave informed consent. Pre-tests were carried out in order to gauge basic intelligence level and working memory span using the National Adult Reading test (NART)[25] and forwards and backwards digit span measures from the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III) for all participants. The two groups did not differ significantly in terms of years of education (younger adults: mean 16 years [SD 2.7]; older adults: mean 15 years [SD 3.5], Student's t test $[54] = 1.6$, $p > 0.05$) forward digit span (11.08 vs 10.53, $t[54] = 1.5$, $p > 0.05$). Older adults did have a higher predicted IQ on the NART[25] (118 vs 113, $t[54] = 4.9$, $p < 0.01$), but a lower backward digit span score than the younger adults (WAIS-III; 7.13 vs 8.13, $t[54] = 3.56$, $p < 0.01$).

Apparatus, Materials and Design

We used the 80 pairs of similar drug names developed by Filik et al. (see Appendix 1 in the Supplemental Digital Content 1 for a full list of experimental materials, http://links.adisonline.com/DSZ/A29).[10] The programme to present the stimuli was written in Psychology Software Tools E-Prime Version 1.1. The names were presented in 18 point Arial font as black text on a white background using a Dell Latitude D820 laptop with a 15.4 inch screen. Name pairs were presented with either both names in lowercase letters or both names having sections in Tall Man letters. The pairs presented could consist of two different, but potentially confusable, names (e.g. chlorpromazine – chlorpropamide) or of the same name presented twice. Four counterbalanced stimulus presentation files were created so that each name pair could be presented in each of the four conditions (lowercase/same, lowercase/different, Tall Man/same, Tall man/different) across the four files without participants seeing any individual name pair more than once (resulting in 20 pairs in each condition in each file).

There were two within-participants independent variables (similarity [names were either the same or different] and letter style [lower case or Tall Man]) and one between-participants variable (age group). The dependent variables were the percentage of errors made in each condition, and the response time. It is conventional to expect a tight link between response time measures and task difficulty; therefore, any influence of Tall Man lettering on ease of discrimination may be reflected in response times as well as errors.

Procedure

Data were collected between January 2008 and May 2008. Participants read a set of instructions on the computer screen. Their attention was then oriented towards the centre of the screen by the presentation of five adjacent crosses (+++++) for 1000 ms before the start of each trial. The first name of each pair was then presented for 400 ms for the younger adults (as in Schell[11]) and 500 ms for the older adults.[1] The target name was replaced by a pattern mask (consisting of a row of Xs) that appeared for 2000 ms. This mask was then followed by the presentation of a drug name that was either identical to the previously presented name or was a different name that was potentially confusable with the previously presented name. The participant's task was to indicate, as quickly and as accurately as possible, whether the second presented name was the same as or different from the first presented name. They indicated their response via two keys on the laptop keyboard ('1' for 'same' and '5' for 'different') and were instructed to use the same hand to press both response keys. Participants did not receive feedback on their responses. Four practice trials preceded the 80 experimental trials. The experiment took approximately 10–15 minutes in total.

Data Analysis

Data were analysed using a 2 (same vs different name) × 2 (lowercase vs Tall Man) × 2 (younger vs older adults) mixed design ANOVA (F-test). Prior to analysis, trials where response times were below 150 ms or above 4000 ms were removed, accounting for 1.6% of the data. Partial eta

1 Pilot data were collected from a small sample of older adults in order to determine a display time that would equate overall accuracy across age groups, so that patterns of performance could be compared on the same point of the performance scale (i.e. so that older adults were not simply performing at chance level).

squared (η_p^2) was calculated as a measure of effect size.

Results

Mean percentage errors and response times are shown in table I.

Errors

Participants made significantly more errors when the names were the same than when they were different: $F(1,54)=7.21$, $p<0.05$, $\eta_p^2=0.12$. This finding was also reported by Schell.[11] There was no main effect of letter style: $F<2.7$, $p>0.10$, $\eta_p^2=0.05$. Importantly, there was a significant similarity × letter-style interaction: $F(1,54)=18.07$, $p<0.001$, $\eta_p^2=0.25$. Analysis of simple main effects showed that when the two names were the same, there was no significant difference in the number of 'false positive' errors (i.e. participants reporting that the names were different) across the two letter-style conditions ($F<2.9$, $p>0.05$, $\eta_p^2=0.05$). Crucially, however, when the names were different from each other, there were significantly fewer 'name confusion' errors (i.e. participants reporting that the names were the same) when the names included Tall Man letters than when they were presented in lowercase: $F(1,54)=22.83$, $p<0.001$, $\eta_p^2=0.30$. That is, Tall Man letters made it significantly less likely that participants confused the target name with a similar name. There were no other significant effects (all F-values < 2.7). Importantly, there were no significant interactions with age group (all F-values < 1.2), suggesting that Tall Man letters effectively reduced name confusion errors for both age groups.

Interestingly, our findings differed from those of Schell,[11] who did not find a difference in name confusion errors across conditions. However, closer inspection of Schell's data reveals that in his Experiment 1, participants only made name confusion errors on approximately 1.5% of trials, and closer to 1% of trials in Experiment 2. Thus, it would appear that accuracy was so high that it would be difficult for Tall Man to make a measurable improvement; and Schell himself acknowledged that there may have been a ceiling effect of accuracy.

Response Times

Older adults had significantly longer response times than younger adults $F(1,54)=13.88$, $p<0.001$, $\eta_p^2=0.21$. There were also longer response times when the names were different than when they were the same $F(1,54)=5.30$, $p<0.05$, $\eta_p^2=0.09$. These main effects were qualified by a significant similarity × letter style interaction $F(1,54)=15.92$, $p<0.001$, $\eta_p^2=0.23$. Analysis of simple main effects showed that when the two names were the same, there were longer response times in the Tall Man condition than lowercase condition: $F(1,54)=13.35$, $p<0.005$, $\eta_p^2=0.20$. It is possible that in the Tall Man condition, participants initially looked at the Tall Man portion of the name as their attention would be drawn to this part. Finding that these letters were the same in the second name as in the first name, they would then have to scan the rest of the name to check there were no differences elsewhere. This would suggest that, in the Tall Man condition,

Table I. Descriptive statistics for Experiment 1, in which younger and older adults performed a same/different judgement task for names that were either in lowercase or contained Tall Man letters

Measure	Group	Same name [mean (SE)]		Different names [mean (SE)]	
		lowercase	Tall Man	lowercase	Tall Man
Error rate [%]	Younger	18.28 (2.24)	20.08 (2.52)	17.21 (2.32)	9.84 (1.64)
	Older	20.84 (3.02)	24.52 (3.42)	17.21 (2.94)	12.39 (2.84)
	Combined	19.56 (1.87)	22.30 (2.13)	17.21 (1.85)	11.12 (1.63)
Response time [ms]	Younger	1115 (56.0)	1204 (68.0)	1107 (50.96)	1076 (50.5)
	Older	1475 (74.7)	1528 (86.9)	1486 (84.78)	1414 (81.6)
	Combined	1295 (52.2)	1366 (58.9)	1297 (55.26)	1245 (52.7)

SE = standard error.

participants had not solely relied on the Tall Man portion of the name when making their response.

Conversely, for names that were different, there were longer response times for lowercase than Tall Man names $F(1,54) = 4.55$, $p < 0.05$, $\eta_p^2 = 0.08$. When the two names were different, if participants looked at the Tall Man section of the name first they would immediately detect the difference between the first and second presented name, leading to a decrease in response times in the Tall Man condition. Indeed, Schell[10] argued that a manipulation such as Tall Man may be effective in reducing errors as the enhanced letters in the name should be noticed first by the reader. Our response time data are consistent with this idea; however, further data, such as a record of participants' eye movements while they were reading the names would be informative to confirm whether their gaze was initially drawn to the Tall Man portion of the name.

Experiment 2: Healthcare Professionals

It is important to assess whether previous effects found for university students generalize to a participant group who are more familiar with drug nomenclature. The Reporting and Learning System (RLS) of the National Patient Safety Agency (NPSA) considered a base dataset of 72 482 medication incident reports in England and Wales occurring between 1 January 2007 and 31 December 2007. The majority of medication incidents (96%) had actual clinical outcomes of no harm or low harm. The wrong drug accounted for 10% of total incidents and 20 of the 100 deaths or severe harms reported.[26] It is clear that selection and use of the wrong medication by healthcare professionals has considerable impact upon the patient.

In addition, previous studies have used tasks that do not necessarily clearly relate to real life tasks. One exception to this is the study reported in Filik et al.,[9] where the task was designed to mimic that of searching for a drug product on a shelf. However, the selection of a product from a shelf is not the only stage during the medication process in which an error can occur. For example, a prospective study of inpatients where errors were detected during daily chart review reported that 49% of serious errors occurred during prescribing, 26% during administration, 14% during dispensing and 11% during transcription[27] (see also Berman[28] for an overview).

Thus, Tall Man lettering is not only potentially of use on drug packaging and labelling, but also at other stages in the medication process, such as prescribing. In Experiment 2, the aim was to investigate the influence of Tall Man lettering on name confusion errors in a task based on electronic prescribing, using healthcare practitioners as participants. Participants were given a target drug name that they subsequently had to search for in a list of drug names. If Tall Man letters reduce name confusion errors in this task, then participants should be less likely to indicate that the target name is present in the list when in fact a similar name is present instead. It is particularly important to examine ways to reduce name confusion in this task since recent research has indicated that the presence of visually similar names can influence performance in searching for a target word in a list.[29]

Methods

Participants

Participation was restricted to individuals who prescribe, dispense or administer medicines using prescribing software systems; specifically, 127 healthcare professionals comprising 48 general practitioners, 16 community pharmacists, 18 community pharmacy technicians, 1 hospital doctor, 18 hospital pharmacists (1 pre-registration), 25 hospital pharmacy technicians and 1 medical student participated (mean age 35.9 years [SD 9.6]). A nominal sum was paid to participants. As participants were practitioners in the National Health Service (NHS), advice from the National Research Ethics Service was first obtained concerning whether the project required ethical approval or not. The documented decision was that the work should be viewed as service evaluation and, consequently, NHS research ethics approval was not required. All participants gave informed consent.

Apparatus, Materials and Design

Opinion from experts at the NPSA and NHS Connecting for Health initiative was sought concerning which drug names are most commonly confused, of which 40 names (20 pairs) were selected as experimental materials (see Appendix 2 in the Supplemental Digital Content). In the task, one name from each confusable pair was presented as a target to search for. This resulted in 40 possible target names, as either the first name or the second name from each pair could appear as the target. The target was then present in or absent from a subsequently presented list of five drug names. When the target was absent from the list, it was replaced with the other half of its confusable pair, which was a 'distractor'. The other four items in the list all shared the same first letter as the target name, but had a different second letter wherever possible, so that only the distractor item was truly confusable with the target drug name. The target/distractor appeared an equal number of times in each position on the list (e.g. first, second, etc.) and other items were positioned randomly. Names were either presented in natural case (i.e for generic names the entire name appeared in lowercase; for brand names, the initial letter was capitalized) or had sections in Tall Man letters. In the natural case condition, the other items in the list also appeared in natural case. In the Tall Man condition, the other items also contained Tall Man lettering.

The letters that should be converted to uppercase in the Tall Man condition in both target and non-target drug names were determined according to the 'CD3' rule, which was developed by the authors in an attempt to standardize which letters in a name should be capitalized. According to this rule, no more than three letters that can be used to differentiate the two names are capitalized (see Appendix for a more detailed description of the CD3 rule). Names were presented in Arial 12 point font and items in the list were left justified. Software was developed with Visual Basic.net and loaded onto each of five identical Toshiba Satellite Pro L300-19S laptop computers (Pentium T3200 processor, 1024 MB RAM, Windows XP operating system) for data collection purposes.

The independent variables were whether or not the names contained Tall Man letters, and whether the target was present in or absent from the list. Each participant saw each item in each of the four conditions, resulting in 160 experimental trials in total. Dependent variables were error rates and response times.

Procedure

Data were collected between December 2008 and February 2009. Participants were given on-screen instructions describing the task, followed by 16 practice trials. During each trial, participants were first presented with a fixation cross in the centre of the screen (figure 1a). They were instructed to look at the cross and then to press the space bar when they were ready for the target drug name to appear. The target drug name was shown for a period of 200 ms (figure 1b). The target was replaced by a pattern mask (consisting of a row of Xs), which remained on the screen for 500 ms (figure 1c) before being replaced by a list of five drug names (figure 1d).

Participants had to indicate whether the target was present in or absent from the list by pressing the 'O' key on the keyboard for absent and the 'P' key for present. Again, participants were instructed to use the same hand to press both response keys. Participants were instructed to respond as quickly and as accurately as possible. The experiment took between 15 and 20 minutes to complete. During the same experimental session, participants completed two other experiments relating to drug name confusion. The order in which the experiments were performed was rotated across participants.

Data Analysis

Data were analysed using 2 (target absent vs target present) $\times$ 2 (natural case vs Tall Man) repeated measures ANOVAs. Prior to analysis, trials where response times were below 150 ms or above 5000 ms were removed, accounting for 1.6% of the data.

Results

Mean percentage errors and response times are shown in table II.

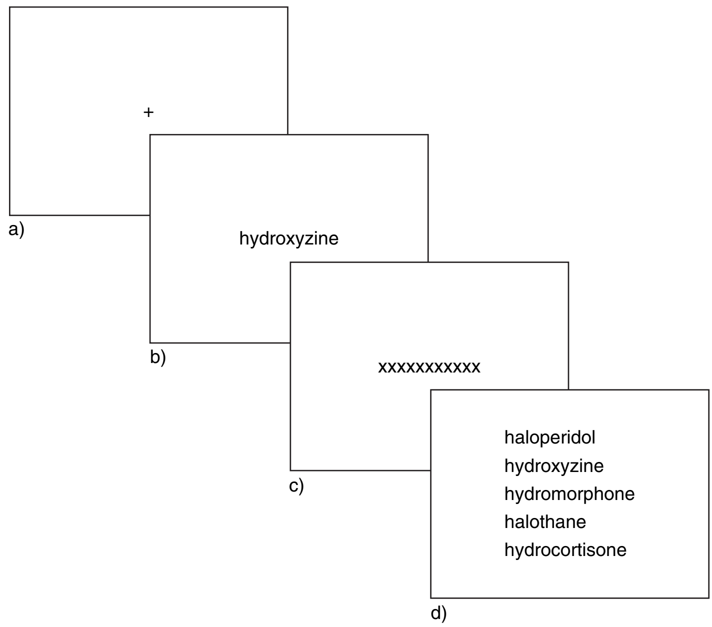

Fig. 1. Illustration of trial sequence in Experiment 2.

Error Rate

There were significantly fewer errors for Tall Man names than natural case names: $F(1,126) = 6.81$, $p < 0.05$, $\eta_p^2 = 0.05$. There was also a trend towards fewer errors for absent than present conditions: $F(1,126) = 3.13$, $p = 0.08$, $\eta_p^2 = 0.02$. Importantly, there was a significant interaction: $F(1,126) = 4.29$, $p < 0.05$, $\eta_p^2 = 0.03$. Analysis of simple main effects revealed that when the target was absent from the list, participants were less likely to indicate that the target was present when the name included Tall Man letters than when it was in natural case: $F(1,126) = 11.33$, $p < 0.005$, $\eta_p^2 = 0.08$, i.e. participants made fewer 'name confusion errors' in the Tall Man condition. In contrast, when the target was present, there was no difference between the two conditions ($F < 1$).[2]

Response Times

There were significantly longer response times for Tall Man names than natural case names: $F(1,126) = 29.54$, $p < 0.001$, $\eta_p^2 = 0.19$. There were also longer response times when the target was absent than when it was present: $F(1,126) = 883.68$, $p < 0.001$, $\eta_p^2 = 0.86$. There was no interaction: $F < 1$.

General Discussion

There were two key findings. First, that Tall Man lettering appeared to reduce drug name

2 Because of high accuracy scores, in order to reduce the likelihood of a ceiling effect, additional analyses were carried out on a dataset where participants who had scored over 95% correct in all conditions had been removed, resulting in a reduced dataset of 75 participants. Findings were essentially the same as those for the full set of participants. In particular, there was still a significant interaction, $F(1,74) = 6.99$, $p < 0.05$, $\eta_p^2 = 0.09$, indicating that when the target was absent from the list, participants were less likely to indicate that the target was present (i.e. to confuse a similar distractor for the target) when the name contained Tall Man lettering: $F(1,74) = 14.06$, $p < 0.001$, $\eta_p^2 = 0.16$. In contrast, when the target was present, there was no difference between the two conditions: $F < 1$. This would suggest that significant effects were not simply due to the reduced variance associated with high accuracy scores.

Table II. Descriptive statistics for Experiment 2, in which healthcare practitioners performed a task based on electronic prescribing

Measure	Target absent [mean (SE)]		Target present [mean (SE)]	
	natural case	Tall Man	natural case	Tall Man
Error rate [%]	4.34 (0.48)	3.07 (0.43)	4.48 (0.36)	4.31 (0.37)
Response time [ms]	2246 (39.58)	2304 (42.91)	1635 (27.17)	1699 (32.66)

SE = standard error.

confusion errors in a sample of older adult participants as well as in a younger sample of university students when performing a sequential same/different task (Experiment 1). Second, Tall Man letters lead to a small but significant reduction in name confusion errors for a sample of healthcare practitioners engaging in a task based on electronic prescribing. This would suggest that earlier reported findings with university students[9,10] generalize to other key participant groups, as well as to different tasks. In Experiment 2, Tall Man lettering also lead to a small (~60 ms) but significant increase in response times. Without further work it is difficult to assess how this finding would translate to a practical setting, but, over the large number of prescriptions produced each year it is possible that there may be an associated cost. However, if such an increase in time results in fewer errors, it might be considered a worthwhile trade-off.

The current study examined name confusion errors in a relatively controlled laboratory setting, necessarily excluding other influences such as workload and stress,[30] or environmental factors such as noise,[31] lighting conditions[32] and distractions.[33] It is likely that errors in real life result from the interaction of several factors, thus it is necessary to gain support from findings in the field. Preliminary support may come from a recent survey conducted by the Institute for Safe Medication Practices (ISMP) to garner opinion regarding the use of Tall Man letters.[34] Of the 451 responses received, 87% of participants felt that the use of Tall Man lettering helps to reduce drug selection errors, although, of course, this finding is a measure of user opinion rather than objective evidence of effectiveness. Nevertheless, 64% reported that it had actually prevented them from dispensing or administering the wrong medication. When respondents were asked to rank various different methods of emphasizing the parts of the names that differ across look-alike name pairs, the use of Tall Man letters was by far the most popular first choice. Possible alternatives were ranked as follows: font differentiation, coloured background, italics, underline and reverse print (e.g. white letters on a dark background).[34]

Thus, subjectively, Tall Man lettering appears to be the preferred option, but it may still be the case that other methods may be objectively more effective at making names less confusable; this is a possible avenue for future investigation. However, it is worth noting that a recent survey of manufacturers of electronic prescribing systems in the UK[35] indicated that, while it would be possible to implement Tall Man lettering, all companies responded that some other possibilities, for example, italic or bold font, were not currently an option. Thus, from these responses it would appear that in comparison to some other possibilities, Tall Man may currently be the most easily implemented from a practical perspective, for electronic prescribing at least.

Remaining issues include a lack of standardization in terms of which names should include Tall Man letters, and exactly which letters in these names to present in uppercase. Regarding which names should include Tall Man letters, this is likely to relate to the degree of similarity between the two names. Since this is a factor that can be manipulated systematically (but was not in the current experiments), this is a potential avenue for further study. Regarding which letters in each name should be highlighted, in Experiment 2 we utilized the 'CD3' rule, which was a pragmatic attempt to maximize the differences between look-alike drug names while accounting for the similarity between uppercase 'I' and lowercase 'l'. One final issue is that caution must be exercised to ensure that the positioning of Tall Man lettering (or whatever alternative) does not introduce confusion where previously there was none. For example, participants in the ISMP[34] survey commented that drawing attention to the letters 'PAM' in clonazePAM and LORazePAM could contribute to confusability rather than detract from it. Thus, it is clear from this that the full story regarding Tall Man lettering is not yet known, and caution should be exercised in recommending its use. As with all interventions, there is the risk of creating new, unanticipated problems.[36]

Conclusions

Results from the current experiments suggest that previous findings showing a benefit for Tall Man letters in reducing drug name confusion in a population of university students do seem to generalize to other participants groups, as well as to different tasks. Thus, the current findings offer some support for the use of Tall Man letters as a possible systems change that could be made by both pharmacies (on medication labels and shelf labels) and manufacturers (on medication packages and labels, computer software, particularly electronic prescribing), in an effort to reduce error caused by drug name confusion.

Acknowledgements

No funding was received for the conduct of Experiment 1. Experiment 2 was supported by funding from the UK NHS Connecting for Health initiative. The funding organization specified the issue to be investigated and advised on drug names that are often involved in error, but were otherwise not involved in the conduct of the study, interpretation of results or preparation of the manuscript. David Gerrett received consultancy remuneration to undertake specific tasks for this research. He continues to collaborate with the research team and is now working with the National Patient Safety Agency, which has an interest in furthering knowledge in this area. All other authors have no potential conflicts of interest to declare that are directly relevant to the content of this study.

Appendix

Instructions for Producing CD3-Type Tall Man Drug Names

To apply the CD3 Tall Man rule, firstly collect drug names into groups of two or more names that are orthographically similar (in our case, groupings were determined in consultation with the NPSA and NHS Connecting for Health initiative). Then, on a letter-by-letter basis, start from either end of each drug name and work towards the middle; the first letters encountered at either end that differ across at least two drug names in the group, along with all letters occurring between them, are deemed to fall within a critical portion of each drug name and are candidates for capitalization. Capitalize a maximum of only three of these letters per drug name. Where more than three letters are present in the critical portion of the drug name, capitalize the centre most three. Where this would result in letters that are common amongst all the drug names of the group in those positions being capitalized, then capitalize the next most peripheral letters that differ across at least two drug names. The initial letters of proprietary drug names are always capitalized. In order to prevent confusion with a lowercase letter 'l' and the capital letter 'I', the lowercase letter 'i' is not capitalized unless it was the initial letter of a proprietary drug name. Using the CD3 rule, cefixime, cefotaxime, ceftazidime, and cefuroxime would become cefiXime and cefOTAxime, cefTAZidime, cefUROxime.

References

1. Hoffman JM, Proulx SM. Medication errors caused by confusable drug names. Drug Saf 2003; 26: 445-52
2. Flynn AF, Barker KN, Carnaham BJ. National observational study of prescription dispensing accuracy and safety in 50 pharmacies. J Am Pharm Assoc 2003; 43: 191-200
3. NHS Business Services Authority. Update on growth in prescription volume and cost in the year to June 2009 [online]. Available from URL: http://www.nhsbsa.nhs.uk/PrescriptionServices/Documents/Volume_and_cost_year_to_June_2009.pdf [Accessed 2009 Oct 31]
4. National Pharmacy Association. Similar names [online]. Available from URL: http://www.npa.co.uk/ [Accessed 2009 Apr 20]
5. Lambert BL, Lin S-J, Tan HK. Designing safe drug names. Drug Saf 2005; 28: 495-512
6. Cohen MR, editor. Medication errors. Washington, DC: American Pharmaceutical Association, 1999
7. FDA. Name differentiation project [online]. Available from URL: http://www.fda.gov/Drugs/DrugSafety/MedicationErrors/ucm164587.htm [Accessed 2009 Jun 27]
8. ISMP. FDA and ISMP lists of look-alike drug name sets with recommended Tall Man letters [online]. Available

from URL: http://www.ismp.org/tools/tallmanletters.pdf [Accessed 2009 Jun 27]
9. Filik R, Purdy KJ, Gale AG, et al. Drug name confusion: evaluating the effectiveness of capital ('Tall Man') letters using eye movement data. Soc Sci Med 2004; 59: 2597-601
10. Filik R, Purdy KJ, Gale AG, et al. Labelling of medicines and patient safety: evaluating methods of reducing drug name confusion. Hum Factors 2006; 48: 39-47
11. Schell KL. Using enhanced text to facilitate recognition of drug names: evidence from two experimental studies. Appl Ergon 2009; 40: 82-90
12. Gabriele S. The role of typography in differentiating look-alike/sound-alike drug names. Healthc Q 2006; 9 (Special Issue): 88-95
13. Ferrini A, Ferrini R. Health in the later tears. 3rd ed. Boston (MA): McGraw Hill, 2000
14. Wilson IB, Schoen C, Neuman P, et al. Physician-patient communication about prescription medication non-adherence: a 50-state study of America's seniors. J Gen Intern Med 2007; 22: 6-12
15. Moisan J, Gaudet M, Grégoire J-P, et al. Non-compliance with drug treatment and reading difficulties with regard to prescription labelling among seniors. Gerontology 2002; 48: 44-51
16. Daneman M, Merikle PM. Working memory and language comprehension: a meta-analysis. Psychon Bull Rev 1996; 3: 422-33
17. Verhaegen P, Marcoen A, Goossens L. Facts and fiction about memory aging: a quantitative integration of research findings. J Gerontol 1993; 48: 157-71
18. Brebion G. Working memory, language comprehension, and aging: four experiments to understand the deficit. Exp Aging Res 2003; 29: 269-301
19. Just MA, Carpenter PA. A capacity theory of comprehension: individual differences in working memory. Psychol Rev 1992; 98: 122-49
20. Just MA, Varma S. A hybrid architecture for working memory [reply]. Psychol Rev 2002; 109: 55-65
21. King J, Just MA. Individual-differences in syntactic processing: the role of working memory. J Mem Lang 1991; 30: 580-602
22. MacDonald MC, Just MA, Carpenter PA. Working memory constraints on the processing of syntactic ambiguity. Cogn Psychol 1992; 24: 56-98
23. Price JM. The use of focus cues in healthy aging [dissertation]. Glasgow: the University of Glasgow, 2008
24. The British Psychological Society Code of Ethics and Conduct [online]. Available from URL: http://www.bps.org.uk/the-society/code-of-conduct/code-of-conduct_home.cfm [Accessed 2010 Jun 6]
25. Nelson H. National Adult Reading Test (NART). 2nd ed. Berkshire: NFER-Nelson, 1982
26. National Patient Safety Agency. Improving reporting and learning from medication incidents. London: National Patient Safety Agency, 2009 Sep
27. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events: implications for prevention. ADE Prevention Study Group. JAMA 1995; 274: 29-34
28. Berman A. Reducing medication errors through naming, labeling, and packaging. J Med Syst 2004; 28: 9-29
29. Léger L, Rouet J-F, Ros C, et al. Impact of the visual appearance of words on visual search within word lists [poster]. Presented at the 49th Annual Meeting of the Psychonomic Society; 2008 Nov 13-16; Chicago (IL)
30. Reilly S, Grasha AF, Schafer J. Workload, error detection, and experienced stress in a simulated pharmacy verification task. Percept Mot Skills 2002; 95: 27-46
31. Flynn EA, Barker KN, Gibson JT, et al. Relationships between ambient sounds and the accuracy of pharmacists' prescription-filling performance. Hum Factors 1996; 38: 614-22
32. Buchanan TL, Barker KN, Gibson JT, et al. Illumination and errors in dispensing. Am J Hosp Pharm 1991; 48: 2137-45
33. Flynn EA, Barker KN, Gibson JT, et al. Impact of interruptions and distractions on dispensing errors in an ambulatory care pharmacy. Am J Health Syst Pharm 1999; 56: 1319-25
34. ISMP. Use of Tall Man letters is gaining wide acceptance [online]. Available from URL: http://www.ismp.org/newsletters/acutecare/articles/20080731.asp [Accessed 2009 Jun 27]
35. Gerrett D, Gale AG, Darker IT, et al. The use of Tall Man lettering to minimise selection errors of medicine names in computer prescribing and dispensing systems. Report to the UK National Health Service Connecting for Health Initiative. Leeds: National Health Service, 2009. Report no.: ER-07-0612
36. Day RS. Solving drug name confusions can create new problems [poster]. Presented at the 50th Annual Meeting of the Psychonomic Society; 2009 Nov 19-22; Boston (MA)

Correspondence: Dr *Ruth Filik*, School of Psychology, University of Nottingham, University Park, Nottingham NG7 2RD, UK.
E-mail: ruth.filik@nottingham.ac.uk

