Pharmacist dispensing error: The effect of neighbourhood density and time pressure on accurate visual perception of drug names

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Abstract
Objective: Two potential causes of dispensing error; neighbourhood density and time pressure, were analysed using a lab-based dispensing task.
Method: 60 participants were asked to select a target drug name from a selection of mock drug packets shown on a computer screen, where one or four similar non-targets might be present. Half of the group (30) completed the task under a 12 minute time limit.
Results: The number of similar drug names present had a significant impact on performance; four non-targets increased reaction times and decreased accuracy in comparison to trials where only one non-target was present. An additional deficit in accuracy associated with the imposed time limit was found.
Conclusion: The reported findings indicate that the number of similarly named products in proximity to a target medication can have an adverse effect upon selection accuracy. This adverse effect is increased when a time constraint is applied.

INTRODUCTION

Medication error is considered one of the most common causes of an adverse event; where a patient is injured through an error in medicine management (Leape, Brennan, Laird, Lawthers, Localio, Barnes, Hebert, Newhouse, Weiler & Hiatt, 1991). Patient injury related to drug error is estimated to cost hospitals several million a year due to associated factors such as; prolonged treatment; readmission to hospital; and, legal claims against General Practitioners (GPs) and hospital staff (Williams, 2007). Mistakes can occur during the prescription, dispensing or administration of a drug (Bates, Boyle, Vander Viliet, Schneider & Leape, 1995). However, to date, the majority of research examining medication error has focused upon prescribing and administration errors (Beso, Franklin & Barber, 2005).

It is estimated that more than 900 million prescriptions per annum are dispensed through hospital and community pharmacies across England and Wales (James, Barlow, McArtney, Hiom, Roberts & Whittlesea, 2009). There is a lack of consistent reporting on dispensing error, but a recent NHS report detailed dispensing error as accounting for approximately 17.8% of reported adverse drug events (ADEs) (Cousins, 2007).

A recent review of the literature indicated that the majority of reported dispensing errors were in the form of selection of the wrong drug, dosage or quantity, or the provision of incorrect labelling (James et al, 2009). Common contributory factors which are typically reported include; busy pharmacies, drug name similarity, inexperienced staff and staff shortage (Irwin, Ross, Seaton & Mearns, *in press)*.

Thus far, the research on dispensing error has produced two main findings related to orthographically similar drug names. The first relates to accurate perception of drug names, where similarity between two drug names has been shown to adversely affect accurate drug name recognition in computer based memory tasks (Lambert, Chang & Lin, 2001; Filik, Purdy, Gale & Gerrett, 2004). The second finding relates to neighbourhood density; a word's neighbourhood is commonly defined as the number of words that are the same length and differ by only one letter from the target word (Lambert, Chang & Gupta, 2003), density denotes the number of words within that neighbourhood. The impact of neighbourhood density upon dispensing error was tested by asking pharmacists to identify a series of distorted (names were blurred to mimic the effects of illegible handwriting) drug names presented on a computer screen (Lambert, Chang & Gupta, 2003). The authors reported that pharmacists were significantly less accurate at identifying the target drug if the name had a high neighbourhood density Critically, however, the task required participants to identify single drug names in isolation. This method does not allow consideration of the potential effect of multiple similar distracters presented in parallel with a target drug name. This is a potentially important consideration as during dispensing pharmacists must select the correct product from a pharmacy shelf, or storage area, where it is potentially surrounded by several competing similarly named products.

Dispensing medication in out-patient or community pharmacies encompasses several tasks, including; accurate perception of the details provided on a prescription, plus, selection of the correct product from a large array of medicines. Thus far only one study using a perceptual array, which required participants to pick the appropriate drug package from a selection of 20, has attempted to replicate the drug selection stage of the dispensing task (Filik et al., 2004). The results showed that orthographic similarity between drug name pairs resulted in errors in the selection of a drug pack from the perceptual array. Critically however, the target drug pack was never present within the perceptual array; in each trial a similar drug name was present in the array, with participants asked to indicate whether the target name was present or not. The propensity for error was therefore likely increased through the pressures of task performance – with the participants more likely to choose the incorrect drug in error through their expectations of the target being present.

The dispensing process can potentially be affected by several workplace factors, including workload, noise and distractions (Flynn, Barker, Gibson, Pearson, Berger & Smith, 1999). A survey of Australian pharmacists suggested that there should be guidelines regulating dispensing load, with 150 prescriptions dispensed per day considered to be the maximum number that can be delivered safely (Peterson, Wu & Bergin, 1999). Similarly, a survey of Finnish pharmacists states heavy workload as one of the most important factors contributing to error (Teinila, Gronroos & Airaksinen, 2008). These studies illustrate the potential impact of external workplace factors on pharmacist dispensing performance in addition to the task based perceptual factors discussed previously.

The current study aims to examine the effect of neighbourhood density and time pressure, upon dispensing error. We employed a similar methodology to that used by Filik et al. (2004), where we asked participants to select a target drug name from a 3D computer display of mock drug packets. This allowed the examination of selection behaviour for multiple medicines under controlled conditions. The neighbourhood density of the target drug names was also manipulated, with either one or four non-target similar drug names present in the perceptual array. The additional factor of time pressure was designed to emulate high workload, where a pharmacist is asked to dispense multiple prescriptions under a designated time limit, such as during discharge of patients.

METHOD

It has previously been shown that orthographic similarity has an adverse effect on accurate perception of drug pairs; we hypothesised that this effect would be increased with the addition of four similar distracters, thereby increasing the neighbourhood density of a target drug name within a defined perceptual field. The additional factor of a time constraint was also expected to have an adverse impact upon task performance.

Participants

A total of 60 naïve adult participants (42 female, 18 male) aged between 18 and 45 years (mean age: 20) were recruited from within the University of Aberdeen.

Stimuli

Target drug names (n = 100) were selected from the National Pharmacy Association published list of confusable drug names (NPA, 2006). These were combined with orthographically similar drug names to form 50 orthographically similar drug name pairs and 50 sets of four orthographically similar drug names. Similarity was confirmed using the bigram method, with one space inserted at the beginning and end of each word (Lambert, Chang & Lin, 2001).

Similar to the methodology described by Filik and colleagues (2004), 3D images of mock drug packs were constructed to display on a computer screen; each pack featured the name of the drug, an appropriate dosage level (e.g. 250mg, 2mg etc) and a coloured strip across the centre.

All 100 trials featured a perceptual array which consisted of 20 mock drug packs, arranged as four rows, each row featuring five packs. Presentation of the trials was randomised across participants. The trials were split into two groups; 50 trials (condition A) each featured a target, four non-targets which were orthographically similar to the target and 15 drug packs which had been screened to ensure they were dissimilar to the target using the bigram method. The remaining 50 trials (condition B) each featured a target, one orthographically similar non-target and 18 drug packs screened for similarity.

Procedure

Participants were seated within a quiet room, directly in-front of a Toshiba Satellite Pro widescreen (15.6”, 96 DPI) laptop. They were instructed that they would be presented with a series of 100 target drug names (one per trial), their task was to view each target drug name, memorise it and then locate it within the perceptual array. When they were ready to proceed in each trial, they were instructed to use the mouse to click on a box beneath the target drug name. They then viewed a fixation point for 1.5s, before being presented with the perceptual array. When they located the target within the perceptual array they then clicked on the box containing the target.

Participants were split into two groups, the first group completed the task with no time limit. The second group were instructed to complete the task in 12minutes, allowing them approximately 7.2 seconds to complete each trial. They were able to monitor time throughout the task by way of a digital clock presented at the top of the laptop screen. The clock counted down from 12 minutes, flashing red when only 30 seconds remained.

RESULTS

Analysis to determine the effect of the number of similar non-targets and time pressure upon performance was conducted using measures of reaction time and accuracy. Accuracy represents the number of drug names correctly identified within each set (condition A, 4 non-targets, or B, 1 non-target present in array) of 50 trials. Reaction times were recorded in milliseconds (ms) for the time taken for each participant to select and click on their chosen mock drug packet from the visual array.

Two mixed factor ANOVA’s were used in this analysis. The first compared reaction times across both experimental groups (Group 1; no time pressure, and Group 2; time pressure) and conditions (four non-targets versus one non-target). Results indicated that the mean reaction times for the two experimental conditions (number of non-targets present) differed significantly; $F(1, 58)$ 36.197, $p < 0.05$.

Furthermore, the mean reaction times of the two experimental groups also differed significantly; $F(1, 58)$ 5.1, $p < 0.05$, indicating that participants in the time limit group were making their drug selections significantly faster than participants with no time limit, though the number of non-targets present increased reaction times in both groups, as illustrated by Figure 1. There was no significant interaction between factors.

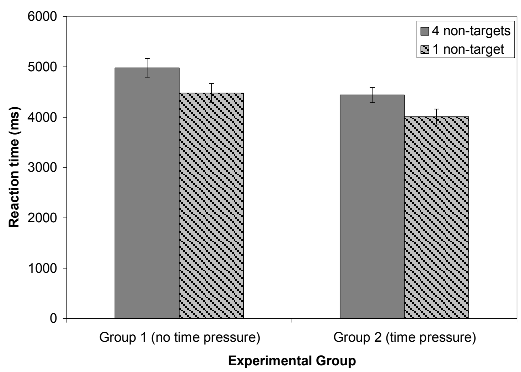

Figure 1: Mean reaction times (milliseconds) for participants selecting the target drug name from an array with no time pressure and when a time constraint of 12 minutes was in place. Shown with standard error bars.

The second mixed factor ANOVA (2 x time pressure; 2 x number of non-targets) compared accuracy across the two experimental groups. The results indicate that again the number of non-targets produced a significant effect upon accuracy, with four non-targets associated with a reduction in the number of drug names accurately identified; $F(1,58)$ 7.360, $p < 0.05$. Time pressure also appeared to make participants significantly less accurate, as shown by the between groups comparison; $F(1, 58)$ 10.905, $p < 0.05$ and illustrated by Figure 2. There was no significant interaction between factors.

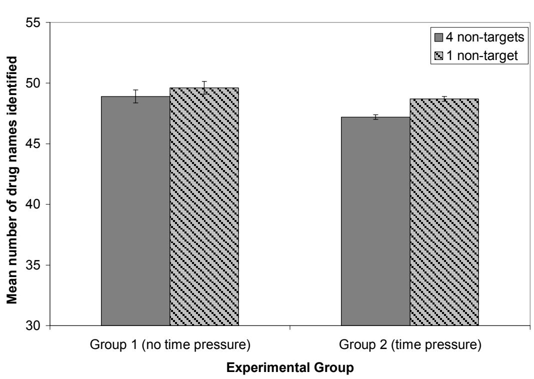

Figure 2: Mean number of drug names identified correctly by participants with no time constraints and when a time constraint of 12 minutes was in place Shown with standard error bars.

DISCUSSION

The current findings indicate that participants were less likely to correctly select the target drug name if four orthographically similar non-target drug names were present in the array. They were also slower to make their selection when four, as opposed to one, similar non-targets were present. This indicates that increasing the number of similar non-target distracters present in an individual's visual field has a negative effect upon their ability to accurately and effectively complete a drug-name recognition task. These findings correspond with reports of dispensing error when drug names are confused during selection of a product from the pharmacy shelf (Cousins, 2007), and with past research indicating an adverse effect of orthographic similarity on dispensing (Filik et al., 2004).

Participants in the time limit group were significantly less accurate at the simulated dispensing task than participants with no time limit, illustrating the adverse impact of time pressure upon the dispensing task. This finding provides further validation for the surveyed opinion of working pharmacists, who rated workload and high prescription volume as among the top listed causes of error (Peterson, et al., 1999).

Orthographic similarity

The results of these two studies extend previous reports of orthographic similarity effects with the finding that increased lexical neighbourhood density within the visual field exerts a significant adverse effect on drug selection accuracy. Essentially, by including more than one similar non-target in the perceptual array, we were increasing the neighbourhood density of the target word. Those neighbours were presented simultaneously and therefore the target was subject to multiple distracters. This required the participant to process both target and similar non-targets within the same computer based perceptual array, which necessitates both suppression of the non-targets and a focus of attention upon the target in order to accurately select the correct drug name. Lambert et al. (2003) reported that drug names with a high lexical neighbourhood density were more likely to be incorrectly identified by experienced pharmacists when the word was blurred. When combined with the present results this indicates that the neighbourhood density could have an impact on dispensing accuracy both when the drug name is presented in isolation; during perception of a prescription, and when those neighbours are presented concurrently with the target drug; during the visual search required to select a drug from a pharmacy shelf.

Time pressure

The results of the current study indicate that, even under controlled conditions, a time constraint can have a negative impact upon the accurate selection of drug names. Interestingly, behavioural research using the Iowa gambling task has shown that both real (Cella, Dymond, Cooper & Turnbull, 2007) and perceived (Dedonno & Demaree, 2008) time pressure has an adverse effect upon task performance. This provides an illustration of the impact of time pressure upon general task performance and illustrates that the *perception* of time pressure seems to be as important as actual time constraints. This has ramifications for the current study since we both imposed an actual time constraint, and made participants very aware of time pressure by providing a visual cue in the form of a countdown clock. It is possible that the visual cue accentuated the effect of the time constraint, perhaps contributing to the significant effect of time pressure in the current study.

Strategies to reduce error

In an effort to reduce dispensing errors related to similar drug names, Lambert et al. (2003) have suggested the use of a screening programme in the US. The programme would allow the development of new drug names to be checked against the current register of medications to check that the new name is not similar to that used by any other product. Such a scheme would also be useful in the UK, and could reduce the likelihood of future drugs being developed which would be easily confusable.

The present findings suggest that re-organising pharmacy shelves in order to place orthographically similar drug names far apart could also be a positive error reducing strategy. This would reduce the number of similar drug names within a pharmacist's visual field during selection, thus reducing the effects of neighbourhood density shown here. Finally, the use of barcode technology to scan dispensed medication has been shown to reduce dispensing error (Poon, Cina, Churchill, Patel, Featherstone, Rothschild, Keohane, Whittemore, Bates & Gandhi, 2006) as an additional checking mechanism. Such technology would also be applicable to reduce the effects of neighbourhood density on selection error.

Study Limitations

Throughout this study we have used naïve participants i.e. psychology students and staff members to test for basic effects and develop a method. The results shown here may not, therefore, generalise to healthcare professionals who are familiar with the drug names and may have developed strategies for avoiding drug name confusion. However, naïve participants have been used in previous studies of dispensing behaviour (Filik et al., 2004) and have been shown to exhibit the same pattern of results as experienced pharmacists (Lambert et al., 2001). Furthermore, the nature of pharmacy is changing, with pharmacy technicians becoming responsible for the selection and labelling of drugs, leaving pharmacists free to consult with patients. In this scenario, it is entirely possible that a relatively in-experienced individual will select prescribed medications to dispense.

CONCLUSION

Similarity between drug names has been shown to increase the risk of selection error within a hospital pharmacy. The current study builds upon that research by illustrating that an increasing number of lexical neighbours within an individual's visual field have a significant adverse effect upon accuracy in drug name recognition. This indicates that the propensity for error within a dispensary is increased not only by the existence of orthographically similar drug names, but that the organisation of pharmacy shelves could also substantially increase the risk of that error. Moreover, we have shown that time pressure has an adverse impact upon drug selection accuracy, illustrating the potential impact of workload related factors upon accurate perception of drug names.

REFERENCES

Bates, D.W. Boyle, D.L. Vander Viliet, M.B. Schneider, J. & Leape, L. (1995) Relationship between medication errors and adverse drug events, *Journal of General Internal Medicine, 10,* 199 – 205.

Beso, A. Franklin, B.D. & Barber, N. (2005) The frequency and potential causes of dispensing errors in a hospital pharmacy, *Pharmacy World Science, 27*, 182-190

Cella, M. Dymond, S. Cooper, A. & Turnbull, O. (2007) Effects of decision-phase time constraints on emotion based learning in the Iowa Gambling Task, *Brain and Cognition, 64*, 164 – 169

Cousins, D. (2007) *Safety in doses: Improving the use of medicines in the NHS*, The National Patient Safety Agency, London.

DeDonno, M.A. & Demaree, H. A. (2008) Perceived time pressure and the Iowa Gambling Task, *Judgement and Decision-Making, 3*, 8, 636 – 640.

Filik, R. Purdy, K. Gale, A. & Gerrett, D. (2004) Drug name confusion: evaluating the effectiveness of capital ('Tall Man') letters using eye movement data, *Social Science and Medicine, 59*, 2597 – 2601.

Flynn, E.A. Barker, K.N. Gibson, J.T. Pearson, R.E. Berger, B.A. & Smith, L.A. (1999) Impact of interruptions and distractions on dispensing errors in an ambulatory care pharmacy, *American Journal of Health-System Pharmacy, 56*, 13, 1319 – 1325.

Irwin, A. Ross. J. Seaton, J. & Mearns, K. (*in press)* Retrospective analysis of DATIX dispensing error reports from Scottish NHS hospitals, *International Journal of Pharmacy Practice.*

James, K.L. Barlow, D. McArtney, R. Hiom, S. Roberts, D. & Whittlesea, C. (2009) Incidence, type and causes of dispensing errors: A review of the literature, *International Journal of Pharmacy Practice, 17*, 9-30.

Lambert, B.L. Chang, K.Y. & Lin, S.J. (2001) Effect of orthographic and phonological similarity on false recognition of drug names, *Social Science and Medicine, 52*, 1843 – 1857

Lambert, B.L Chang, K.Y & Gupta, P. (2003) Effects of frequency and similarity neighbourhoods on pharmacists visual perception of drug names, *Social Science and Medicine, 57*, 1939 – 1955.

Leape, L.L. Brennan, T.A. Laird, N. Lawthers, A.G. Localio, A.R. Barnes, B.A. Hebert, L. Newhouse, J.P. Weiler, P.C. & Hiatt, H. (1991) The nature of adverse events in hospitalized patients: Results of the Harvard Medical Study II, *The New England Journal of Medicine, 324, 6,* 377 – 384.

Malone, D.C. Abarca, J. Skrepnek, G.H. Murphy, J.E. Armstrong, E.P Grizzle, A.J. Rehfeld, R.A. & Woosley, R.A. (2007) Pharmacy workload and pharmacy characteristics associated with the dispensing of potentially clinically important drug-drug interactions, *Medical Care, 45*, 5, 456 – 462.

National Pharmacy Association (2006) *Similar Names,* NPA, Hertfordshire.

Peterson, G.M. Wu, M.S.H. & Bergin, J.K. (1999) Pharmacists attitudes towards dispensing errors: their causes and prevention, *Journal of Clinical Pharmacy and Therapeutics, 24*, 57 – 71.

Poon, E.G. Cina, J.L. Churchill, W. Patel, N. Featherstone, E. Rothschild, J.M. Keohane, C.A. Whittemore, A.D. Bates, D.W. & Gandhi, T.K (2006) Medication dispensing errors and potential adverse drug events before and after implementing bar code technology in the pharmacy, *Annals of Internal Medicine,* 145, 426 – 434.

Teinila, T. Gronoos, V. & Airaksinen, M. (2008) A system approach to dispensing errors: a national study on perceptions of the Finnish community pharmacists, *Pharmacy World Science, 30,* 823-833.

Williams, D.J.P. (2007) Medication Errors, *Journal of the Royal College of Physicians of Edinburgh, 37*, 343-346.