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## 'Sorry I meant the patient's left side': impact of distraction on right/left discrimination

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**'Sorry I meant the patient's left side': *impact of distraction on right/left discrimination.***

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## **AUTHOR CONTRIBUTIONS**

All authors helped conceive, design and supervise this project. JMCK wrote the first draft which was revised by all authors, with JMCK coordinating rewriting and agreement on the final article. MD provided statistical expertise. GJG is guarantor.

## **ABSTRACT**

**Introduction** A significant proportion of the population have difficulty distinguishing right from left, including medical students. Some of the most infamous errors in medicine have occurred when a procedure has taken place on the wrong side, such as removal of the wrong kidney or limb. In clinical practice, healthcare professionals encounter many distractions and interruptions during the course of their work. To date there is limited information on how such distractions can affect human performance, specifically in a clinical context. In medical students, using a neuropsychological paradigm we aim to elucidate the impact of different methods of distraction on left-right (LR) discrimination ability.

**Methods** Medical students were recruited to take part in this study. Participants' demographic details including handedness, were captured using a questionnaire. Their perceived LR discrimination ability was recorded using a visual analogue scale. There were four arms to the study, with participants in either a 1) Control group (*i.e. no distraction*) 2) Auditory distraction group (*i.e. continuous ambient ward noise*) 3) Cognitive distraction group (*i.e. interruptions with clinical cognitive tasks*) and 4) both auditory and cognitive distractions combined. In each of these arms participants LR discrimination ability was objectively measured using the validated Bergen Right-Left Discrimination Test (BRLDT). MANOVA was used to analyse the impact of the different forms of distraction on participants' performance on the BRLDT. Additional analyses included looking at effects of age, sex and handedness on performance in the BRLDT with and without distraction. Pearson's correlation coefficient was used to examine the association between participants' perceived LR discrimination ability and their performance in the BRLDT.

**Results** 234 students were recruited. Cognitive distraction had a greater negative impact than auditory distraction on performance in the BRLDT. Combined auditory and cognitive distraction had a negative impact on performance, but only in the most difficult LR task was this negative impact on performance found to be significantly greater than cognitive distraction alone. There was a significant, medium sized correlation between perceived LR discrimination ability and actual overall BRLDT performance.

**Discussion** Distraction has a significant impact on performance in this key cognitive function. LR discrimination is a contextual skill and, for some, can be a significant challenge. Multifaceted and strategic approaches are required to reduce LR errors occurring. From an educational perspective, a greater emphasis is required in linking theory and application of knowledge into clinical practice. This further supports the emphasis of patient safety and human factor training in medical school curricula. Non-technical issues, such as distraction, have the potential to impair an individual's ability to accurately make LR decisions. Training, starting at an undergraduate level, needs to make students mindful of the potential impact that distractions can have on their ability to make such critical decisions.

## **INTRODUCTION**

Early on in medical degree curricula, the importance of correct spatial orientation is emphasised and taught to medical students. Knowing anterior from posterior, superior from inferior are vital for healthcare professionals to describe and potentially target a wide range of treatments. However, correctly knowing right from left is assumed to be an inherent skill that we all use correctly on a daily basis. Not the case. A significant proportion of our population have difficulty in distinguishing right from left.<sup>1-4</sup> Medical students do not escape this trend either, with female students, and those students aspiring to be general practitioners or psychiatrists, having the greatest difficulty.<sup>5</sup>

Confusing a patient's right side, from their left, has the potential to cause a serious adverse event and devastating consequences for patients. Some of the most infamous errors in medicine have occurred when wrong-sided decisions have been made e.g. wrong-sided craniotomy, operating on the wrong eye, removal of the wrong limb, lung, kidney or testicle.<sup>6-10</sup> Such major left-right (LR) errors may only represent the tip of the iceberg; little is known about the frequency of more minor LR errors such as ordering a wrong-sided radiological image or applying therapy to the wrong side of the body.<sup>6,7</sup> Despite the attempts of the National Patient Safety Agency, The Joint Commission and other organizations, wrong-sided errors continue to occur.<sup>10-12</sup> Having systems in place such as 'time-out' and checklists - attempt to mitigate such LR errors. However these 'never events' continue to take place.<sup>10-12</sup> Although such errors are frequently attributed to system failures, individual human error is considered to be a significant contributory factor and a root cause in many cases.<sup>6</sup> Error is considered to be an inherent characteristic of human behaviour.<sup>13</sup> Medical students with LR confusion appear to be aware of their own difficulties and attempt to develop compensatory mechanisms - for example relating their left, or right side, to a number of features including a physical activity (*e.g. which hand they strum a guitar with*), an accessory feature (*e.g. a wedding ring or wrist watch*).<sup>5</sup> Overall individuals who use these techniques still have difficulty in distinguishing right from left.<sup>5</sup>

Clinical competence is nested in a wide range of situational and contextual factors. When making LR decisions in the workplace, healthcare professionals encounter many distractions.<sup>14-17</sup> Interruptions can arise from many sources including verbal interruptions by colleagues (*i.e. cognitive distractions*) and environmental noise and electronic pagers / telephones (*i.e. auditory distractions*). Disturbances are known to be contributory factors to other types of errors such as medication errors.<sup>18,19</sup> However it is unclear how distraction impacts upon healthcare professionals' LR discrimination ability.

Left-right discrimination is a complex process involving several higher functions such as the ability to integrate somesthetic and visual information; receptive and expressive language function; visuospatial function when mentally rotating images and memory in retaining instructions related to tasks.<sup>20,21</sup> One of the most widely accepted models of attentional and memory processes is the multicomponent model of working memory.<sup>22,23</sup> It is considered that working memory is used in tasks that require integration of new

stimuli with long-term memory, and the maintenance of information for complex tasks. Importantly, working memory is considered to be of limited capacity. Left-right discrimination can be assumed to be a demanding task on the working memory system.<sup>20,24</sup> In a situation where an individual is required to divide their attention between performing a mentally demanding task (*e.g. LR discrimination*) and responding to external stimuli (*e.g. distraction*), it could be hypothesised that they might struggle to successfully complete both tasks, particularly when the secondary task is also taxing to their working memory system.

To date no studies have investigated the impact of distraction on an individual's LR discrimination ability. Given the importance of healthcare professionals making LR decisions, and that training begins at an undergraduate level, we aim to assess the impact of different distraction modalities (*i.e. cognitive and auditory*) on LR discrimination ability in medical students. Secondary research objectives were to determine i) if there was any correlation between medical students' perceived and actual LR discrimination ability and ii) the impact of demographic factors such as age, sex and handedness on medical students LR discrimination performance.

## **METHODS**

### **Study Design**

The study was observational in nature and involved the use of a validated psychometric tool to quantitatively assess LR discrimination ability.

### **Study setting, sample size and recruitment**

The study was set in the Centre for Medical Education, Queen's University Belfast. The medical degree program follows a five year integrated curriculum model. In May 2012, second year students attending a clinical skills course, were invited to take part in the study (n=269). At this stage of their training, students' studies mainly focused on the scientific foundation of clinical practice, with incremental patient contact in various clinical environments. One quarter of the year group (c.68) were expected to attend each of the randomly-allocated four clinical skills training afternoons. Ethical approval (Reference number: 12/01v2) was obtained from the School's research ethics committee.

We aimed to recruit a minimum of 128 students in total (*i.e.* 32 subjects per each of the 4 arms of the study) to provide 80% power to detect a significant difference in the main effects of an ANOVA with  $\alpha=0.05$  and assuming an effect size of 0.06 (partial  $\eta^2$ ).

### **Subject questionnaire**

Consenting students were asked to complete an anonymised questionnaire capturing their sex, age and handedness (using the Edinburgh Handedness Inventory).<sup>25</sup> A self-rating questionnaire was used to

ascertain subjects' perceived LR discrimination ability and was recorded using a 78mm visual analogue scale (0='no problems' – 78='constant problems').<sup>26</sup>

### **Objective measurement of subjects' LR discrimination ability**

The Bergen Left-Right Discrimination Test (BRLDT) was used to measure participants LR discrimination ability, being administered according to the BRLDT protocol.<sup>4</sup> In this psychometric test, subjects are presented with a series of stick figures in which a white head indicates that the figure was being observed from the front and a black head indicates that the figure was being observed from behind (Figure 1).

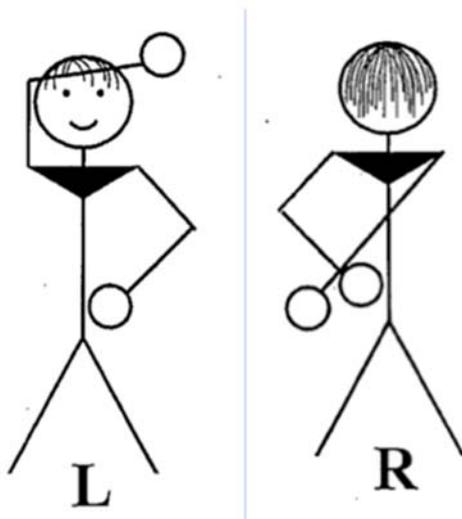


Figure 1: Sample stick figure from Bergen Left Right Discrimination Test (reproduced with permission)

A circle represents each of the stick figures' hands and below each figure is either the letter 'L' (Left) or 'R' (Right). Subjects are asked to place an 'X' in the appropriate circle as indicated by 'L' or 'R' below the figure. The BRLDT is administered in a timed fashion and consists of three subsections (each completed in 90 seconds). Each subsection contains 48 stick-figures, giving a score between 0-144 in total. In the first subsection, all of the figures are observed from the back; in the second, all are observed from the front and in the third, figures are observed in a mixed fashion. Subsections were administered in a counter-balanced sequence to account for order effects.

### **Deployment of distraction stimulus**

The study had four arms. Participants in arm 1 (control) performed the BRLDT without distraction in a quiet lecture theatre. In arm 2, participants were asked to complete the BRLDT, as for in arm 1, with the addition of auditory distraction in the form of a pre-recorded sample of typical clinical ward noise, which contained background human voices, alarming monitors and telephones (played at 70 dB). In arm 3, participants were asked to complete the BRLDT, as for in arm 1, with the addition of cognitive distraction in the form of a series of 3 sets of 5 verbal statements (short pieces of clinically relevant information; see appendix 1), each delivered in a timed fashion throughout the course of the BRDLT. After each subsection, subjects were

asked to pause and write down answers to 5 questions, one pertaining to each of the 5 distraction statements (scored either 'correct' or 'incorrect'). Arm 4 involved administering the BRLDT with the auditory distraction utilized in arm 2 and the cognitive distraction used in arm 3 (simultaneously).

### **Data analysis**

The primary analysis examined the differences between each subsection of the BRLDT scores in each arm of the study. This was performed using a between-groups MANOVA, where the factor was study arm (control, auditory distraction only, cognitive distraction only and cognitive and auditory distraction) and the 3 dependent variables were BRLDT subsection (facing away/facing forward/mixed). Post hoc Tukey tests were used to make pairwise comparisons of the study arms for each BRLDT subsection. Additional analyses included ANOVA looking at effects of age, sex and handedness on performance in the BRLDT with and without distraction. For the ANOVA models, the effect size used was partial  $\eta^2$ , with values  $\geq 0.06$  and  $< 0.14$  considered medium and  $\geq 0.14$  considered large.<sup>27</sup> Pearson's correlation coefficient was used to examine the association between participant's perceived LR discrimination ability and their performance in the BRLDT. All analyses were conducted on SPSS version 21.

## **RESULTS**

### **Response rate and participants demographics**

234 out of 269 students participated in the study (recruitment rate 87.0%). Recruitment exceeded the required 32 subjects per arm to achieve power. 55.2% (122/221) of participants, who recorded their sex, were female and 44.8% (99/221) were male. 88% (207/233) of participants were right handed and 11.2% (26/233) left handed. The majority (62.8%; 145/231) of participants were aged 18-20 and 37.2% (86/231) were aged 21 and over. Table 1 summarises the age, sex and handedness of participants in each of the study arms.

**Table 1: Participants' sex and handedness in each of the study arms**

	Arm 1 <b>No distraction</b>	Arm 2 <b>Auditory distraction</b>	Arm 3 <b>Cognitive distraction</b>	Arm 4 <b>Auditory and cognitive distraction</b>
<b>Female/Male (%)</b>	69.6 / 30.4	52.5 / 47.5	47.3 / 52.7	51.0 / 49.0
<b>Left / Right handed (%)</b>	15.0 / 85.0	6.3 / 93.8	10.5 / 89.5	13.5 / 86.5
<b>Age 18-20 / 21+ (%)</b>	63.9 / 36.1	57.8 / 42.2	61.4 / 38.6	65.4 / 34.6

**Impact of different modalities of distraction on participants BRLDT performance**

A statistically significant difference between the 4 arms of the study was found on the overall BRLDT performance [ $F(9,690)=5.97$ ,  $p<.001$ , partial  $\eta^2=0.07$ ]. Table 2 summarises the results for each subsection of the BRLDT and shows that a significant difference was found between the 4 arms of the study for each subsection of the BRLDT. Post hoc tests indicate that the cognitive only, and cognitive and audio distraction arms were significantly different from the control arm in each subsection of the BRLDT. The audio only distraction was not significantly different from the control arm in any of the BRLDT subsections.

In addition, the post hoc tests showed that the cognitive only, and cognitive and audio combined arms did not differ significantly on the BRLDT facing away and facing forward subsections. On the BRLDT mixed subsection, those in the cognitive and audio distraction arm performed significantly poorer than those in the cognitive only distraction arm.

**Table 2: Mean correct responses in BRLDT based on figure orientation**

	BRLDT figures facing away	BRLDT figures facing forward	BRLDT figures in mixed orientation
<b>Arm 1 (control) n=61</b>			
Mean score*	43.6	39.6	36.9
Standard deviation	7.7	9.8	8.5
<b>Arm 2 (auditory distraction) n=64</b>			
Mean score*	42.0	38.6	34.7
Standard deviation	6.5	8.7	9.4
<b>Arm 3 (cognitive distraction) n=57</b>			
Mean score*	37.4†	35.0†	32.6†
Standard deviation	7.5	10.3	8.2
<b>Arm 4 (mixed auditory and cognitive) n=52</b>			
Mean score*	35.0†	31.1†	27.3†
Standard deviation	8.4	10.1	7.8
	F(3,230)=16.24, p<.001, $\eta^2=0.18$	F(3,230)=8.98, p<.001, $\eta^2=0.11$	F(3,230)=12.63, p<.001, $\eta^2=0.14$

\*BRLDT Scale of 0-48 for each subsection

†statistically significant difference from control group (p<.05)

### Impact of handedness, sex and age on participants' BRLDT performance

The separate potential moderating effects of handedness, age and sex on the relationship between distraction type and overall BRLDT performance were examined but were not found to be significant. Both sex and age were found to be significant additional covariates, in that, in general, males outperformed females [ $F(3,211) = 3.53, p<.05, \text{partial } \eta^2=0.05$ ] and the 18-20 age group outperformed the  $\geq 21$  age group [ $F(3,224) = 3.30, p<.05, \text{partial } \eta^2=0.04$ ] on overall BRLDT performance.

### Analysis of perceived LR discrimination ability and BRLDT performance.

A Pearson's correlation coefficient ( $r$ ) was calculated to assess the correlation between baseline perceived LR discrimination ability and actual performance in the BRLDT. There was a significant, medium sized correlation between perceived LR discrimination ability and actual overall performance in the BRLDT ( $r = -0.39, p<.001$  two-tailed).

## DISCUSSION

The results of this study suggest that cognitive distraction, more than auditory distraction, has an impact on medical students' ability to discriminate right from left.

Background auditory distraction, on its own, appears to have little impact on medical students' overall BRLDT performance. Pure cognitive distraction demonstrated a significant negative effect on medical students' performance in the BRLDT throughout all subsections. There is no previous literature addressing the impact of cognitive distraction on BRLDT, however literature relating to the effects of distraction in the anaesthetic and surgical environments highlights the frequency of distraction in the clinical environment and thus potential impact upon patient safety.<sup>28-30, 38</sup> Investigators looking at the impact of different modalities of distraction in the urological theatre environment found verbal communication between staff more distracting than simple background noise such as pagers and telephones ringing.<sup>28</sup> This supports our finding that direct verbal communication with subjects is more distracting than exposing subjects to background noise.

Urologists are exposed to a lot of distraction during their operative work and it has been suggested that surgeons, with increased experience may develop the ability to filter out the distracting stimuli albeit incompletely as many still report distractions as a major stressor in the operative environment.<sup>29</sup> This hypothesis has been tested and the process whereby surgeons develop the ability to 'ignore' distractions referred to as 'technical automatisations'.<sup>31</sup> In a simulated surgical environment, Hsu *et al* developed a laparoscopic paradigm, whereby a cohort of experienced surgeons and a cohort of novices were trained to transfer pegs in a laparoscopic simulator.<sup>31</sup> Before any distraction was implemented, both cohorts had to demonstrate consistent proficiency in the peg transfer task. When this phase was completed both cohorts were exposed to cognitive distraction whereby they were asked to complete the simulated laparoscopic task whilst completing mental arithmetic problems. The study demonstrated that experienced surgeons were able to complete the simulated laparoscopic task in a technically proficient way despite distraction; with no drop off in peg transfer score and similarly they were able to complete the mental arithmetic task accurately.<sup>31</sup> In the novice cohort, whilst there was no significant drop off in peg transfer score with cognitive distraction, there was a significant negative impact on performance in the arithmetic task in terms of percentage correct responses and numbers of questions attempted – suggesting the possibility that doctors can be trained to adapt to cognitive distraction by developing a degree of technical automatisations in the tasks they are completing.<sup>31</sup> This suggests that experience and repeated exposure to distracting stimuli are key to developing a more 'automatic' approach to tasks and these are thus potential areas to be developed in the undergraduate medical curriculum to improve patient safety.

The BRLDT is made up of three subsections, each more difficult than the previous due to figure orientation. This is evident in the trend of scores, which show a deterioration in performance across the three subsections regardless of the study condition. The only other study looking at performance in BRLDT in this population demonstrated a similar pattern of performance.<sup>5</sup> For the first two subsections of the BRLDT, students in the combined cognitive and auditory distraction condition did not perform significantly worse than students in the cognitive distraction only condition. However, in the third, most difficult subsection of the BRLDT, the combined auditory and cognitive distraction resulted in poorer performance on the BRLDT than the cognitive distraction alone. This suggests that, when faced with a cognitively complex task, although auditory distraction does not have a significant impact, it can have a significant additive effect when cognitive distraction is also present. Perhaps it is the case that people reach a ceiling in terms of the cognitive load of managing a cognitively complex task in the face of cognitive distraction. In this circumstance, an otherwise relatively innocuous distraction can become an added burden that further affects performance.

#### **Medical students' perceived and actual left-right discrimination ability**

Results from our study indicate that medical students' perceived and actual LR discrimination ability correlate only at a moderate level, suggesting that students' perception about this ability is, in general, inaccurate. The pattern of results suggests that students both over and under estimated their LR discrimination ability. This is an area of concern, particularly in those situations where students do not perceive a problem with their discrimination ability. Therefore, a simple but important role for medical educators could be providing students with an opportunity to test their LR discrimination. Both medical students and practicing doctors need to accurately and continually appraise their own abilities. They need to identify areas of practice that require further development and training – not only with technical skills but also human factor skills such as LR discrimination.

#### **Impact of demographic factors and handedness on left-right discrimination ability**

This study also sought to identify if there was a sex difference in LR discrimination ability in medical students and if this modified in any way the impact of different modalities of distraction on their performance in the BRLDT. Our results suggest that there was a significant effect of sex on overall performance in the BRLDT and that this effect approached a medium effect size whereby males outperformed females. These results corroborate the findings of those who have demonstrated experimentally a consistent effect of sex on LR discrimination ability.<sup>4, 32-35</sup> Regarding the mechanism by which males outperform females in tasks of LR discrimination the consensus in the literature would appear to sit with the theory that males demonstrate a greater degree of functional hemispheric asymmetry and superiority of visuospatial function.<sup>32,35</sup> Handedness has no overall effect on LR discrimination ability.<sup>32,33</sup> Our study supports this conclusion as no

significant effect of handedness was seen in medical students, nor did it modify the effect of different distraction modalities.

### **Limitations of the study**

A key strength of this study is its attempt to explore an area that has been relatively under investigated to date. However the findings of this study have to be considered within its limitations. The use of a single cohort of medical students at a single centre is a limitation and the results may not be fully generalisable to other institutions. To control for cognitive speed the BRLDT was performed in a timed fashion. If there was no time limit for the completion of the test, participants could take time during the test to develop novel strategies to overcome the challenges of the task, masking underlying impairment of left-right discrimination ability and reducing the sensitivity of the test. This strategy is also a potential limitation of the study, as completing the BLRDT under the stress of time pressure may, in and of itself impact negatively on performance. To control for confounding factors the study was not carried out in an ecologically valid setting (*i.e. a working clinical ward*). Nonetheless the distractors used were based on real examples of commonly experienced clinical distractors. This study did not set out to investigate the effect of distraction on LR discrimination, coupled to actual errors occurring in clinical practice as for example theorised in Perrow's Normal Accident Theory.<sup>36</sup>

### **Implications of this study and recommendations**

LR discrimination represents a human factor patient safety issue that is pertinent in a wide range of clinical contexts. This study is the first to demonstrate that distraction has an impact on the LR discrimination ability in medical students and thus suggests that such a human factor in healthcare can be negatively influenced by environmental factors such as noise and verbal distraction. Not only has it been demonstrated that distraction can negatively impact upon non-technical skills such as LR discrimination but also that non-modifiable factors such as age and sex impact upon performance, a factor that needs to be taken into consideration when designing a non-technical skills curriculum. Furthermore it has been demonstrated that a significant proportion of medical students do not appear to be able to recognise their limitations in terms of LR discrimination ability.

Practicing medicine encompasses the integration of many complex and socially positioned skills which are often subject to many different contextual stimuli that are invariably present in such busy workplaces. Therefore educational frameworks need to consider the environment that clinicians and medical students work in, and the complex interplay between the individual and the environment. The aviation industry has demonstrated that non-technical skills cannot be acquired reliably in the work place without specific training in crew resource management.<sup>37</sup> Medical education can learn from aviation as in the case of postgraduate training in anaesthetics, there is no reason why 'crew resource management' type training

cannot begin as an undergraduate.<sup>37,38</sup> The operating theatre is but one example of an environment with potentially unlimited distractors; yet is the very place where important LR decisions are made such as the removal of a paired organ or limb. Anaesthetists refer to the 'sterile cockpit concept' whereby the administration of an anaesthetic agent should be considered akin to the 'cockpit rule for pilots'.<sup>39</sup> The 'cockpit rule' stipulates that pilots must refrain from all 'non-essential conversation and activity' during the critical phases of a flight.

Medical schools should be proactive in helping students to identify proneness for making such non-technical skill errors. Perhaps students, at an early stage in their training, could be offered the opportunity to objectively assess their LR discrimination ability (e.g. by an online version of the BDRLT). If identified to be challenged in making LR decisions, faculty could offer measures for these students to develop these skills and provide advice about coping strategies, particularly in the work place. The introduction of teaching methods, such as high fidelity clinical simulation, could offer students exposure to concepts such as situational awareness and the myriad of stimuli often encountered in the busy working environment. Interprofessional-based educational programmes have an important role to play in emphasising the use of effective of communication skills between healthcare professionals, and the potential impact that interruptions can have on an individual's performance.

In summary, LR discrimination is contextual skill and, for many, a challenge. Multifaceted and strategic approaches are required to reduce LR errors occurring. From an educational perspective, a greater emphasis is required in linking theory and application of knowledge into clinical practice and further supports the emphasis of patient safety in medical school curricula. Non-technical issues, such as distraction, have the potential to impair an individual's ability to accurately make LR decisions. Training, starting at an undergraduate level, needs to make students mindful of the potential impact such distractions may have on their ability to make critical decisions. Their learning should also equip them with coping strategies to mitigate such error provoking situations and potential adverse patient events from occurring.

### **COMPETING INTERESTS**

The authors JMCK, MD, GG have no competing interests to declare.

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