Allocation of attention in familiar and unfamiliar traffic scenarios

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Abstract

Increased travel worldwide has led to an escalation of road traffic accidents, particularly among tourists driving in unfamiliar, opposite traffic flow driving scenarios. Ability to allocate attention to driving-relevant information and regions is predicted to be the main cause of tourist accidents, with a lack of attention directed to areas of space that are inhibited in familiar traffic conventions but relevant in overseas driving. This study investigated the influence of habit and expectancy on driver behaviour and allocation of attention in familiar (left-hand traffic; LHT) and unfamiliar (right-hand traffic; RHT) contexts. Twenty-eight drivers from the UK were presented with video clips of driving taken in the UK and in Poland and asked to judge whether it was safe to enter a roundabout in each clip. Half were given information about differences in LHT and RHT situations prior to the task. Judgement performance was not influenced by this information, however accuracy was higher for LHT and the RHT task was rated more difficult, supporting the notion that driving in unfamiliar surroundings is more effortful. In LHT both groups made more fixations to the right side of each roundabout, however in RHT, whilst the control group allocated attention in the same way, the intervention group made significantly more fixations to the left. Pre-drive preparatory information can therefore increase attention to the most relevant areas of space in unfamiliar driving contexts. This has implications for drive tourism and it is suggested that such information is made more explicit to drivers.

Keywords: attention; habit; driving; expectancy; road accidents; tourism.

1. Introduction

Transport is a key aspect of a traveller's spatial mobility, either as a means of travel between origin and destination, travel within the destination itself, or multi-destination travel (Masiero & Zoltan, 2013). However, whilst *drive tourism* has its benefits, driving in unfamiliar environments can lead to increases in road traffic accidents (RTAs). The quantification of such RTA fatalities is difficult to estimate, as often no data for tourists exist (Ball & Machin, 2006), and where consular or local data has been collected the extent of the problem is often minimised by the exclusion of non-fatal incidents, underreporting, or inaccuracies in the police and coroner reports (McDonald, Davie, & Langley, 2009). Despite this, the International Travel and Health report from the World Health Organisation (WHO, 2012, p51) states that "road traffic collisions are the most frequent cause of death among travellers".

The Commission for Global Road Safety (2010) distinguishes between *destination* road safety risks (safety of local infrastructure, fatality rates, and levels of safety enforcement) and *tourist-specific* road safety risks, such as unfamiliarity, disorientation, distraction, and fatigue. The focus of the current work is unfamiliarity and habitual driving which are frequently cited as risk factors for tourists driving in traffic contexts that are different from that of their home country (Wilks & Pendergast, 2011). This is particularly the case when they are confronted with unfamiliar driving rules such as when driving from a *left-hand traffic system* (LHT; whereby individuals drive on the left-hand side of the road, approaching traffic comes from the right, and usually the driver is seated in the right-hand side of the vehicle) to a *right-hand traffic system* (RHT; vehicles drive on the right, oncoming traffic approaches from the left, and the driver is usually seated on the left). For instance, in Oceania, which operates a LHT system, international visitors face a higher RTA risk than residents (22.0 and 10.8 per 100,000, respectively), and they account for 13% of road fatalities and 8% of injuries (Catchpole, Pratt, & Pyta, 2014; Watson et al., 2004). Crucially, tourists from RHT systems (around 65% of all visitors), i.e. with a different traffic convention, are significantly overrepresented in these figures (Dobson, Smith, McFadden, Walker, & Hollingworth, 2004; Leggat & Wilks, 2009; Wilks & Pendergast, 2011). Consistent findings have also been reported in RHT countries such as Greece where pleasure-driving tourists from LHT are 2.5 times more likely to be involved in RTAs than RHT visitors (Petridou, Askitopoulou, Vourvahakis, Skalkidis, & Trichopoulos, 1997).

A survey commissioned by the Foreign and Commonwealth Office (FCO, 2008) reveals the extent of the difficulties associated with travelling from one traffic convention to another with 31% of UK residents admitting to driving on the wrong side of the road overseas, 10% driving the wrong way around a roundabout, and 54% reporting problems crossing the road as a pedestrian. Petridou et al. (1997, p. 691) refer to these types of errors as resulting from “a lack of reflexes conditioned on reverse traffic direction”, indicating that limited experience with the opposite traffic convention means drivers are unable to complete the task effectively. A recent study by Wu (2015) supports this by exploring the safety issues and coping techniques of Chinese drivers (RHT) travelling to Australia (LHT). Unfamiliar driving rules were rated as one of five safety concerns and individuals noted that they had to be more attentive and cautious when travelling in LHT to avoid error.

The findings of Wu (2015) reflect the importance of allocating attention in unfamiliar environments. Despite the common assumption in tourism literature that once a holiday destination is reached, foreign drivers loss their common sense and change into ‘*tourons*’ (half tourist, half moron; Walker & Page, 2004), research suggests that many RTAs involving tourists can be explained due to attentional factors involved in adapting to the new traffic environment (and from the familiar traffic environment). Selective attention guides resources to relevant and informative areas and stimuli within the environment and is influenced by both top-down and bottom-up factors (e.g., Folk, Remington, & Johnston, 1992; Schneider & Shiffrin, 1977; Theeuwes, 1993). Trick, Enns, Mills, and Vavrik (2004) have proposed a framework that describes the interaction between these factors and task demands. Exogenous shifts of attention are characterised by automatic *reflexes* (bottom-up capture of attention by sudden onsets) and controlled *exploration* (allocation of attention to salient information in the environment). Endogenous shifts of attention include *habits* (automatic allocation of attention to relevant information and locations) and *deliberation* (conscious processing of information).

Whilst deliberation is effortful and occurs in unfamiliar situations, such as when an individual is learning to drive, habits are developed over time due to repeated exposure to similar situations. Habitual selection requires fewer cognitive resources and therefore reduces the cognitive workload involved in the driving task; however it can also lead to errors (Trick et al., 2004). Specifically, because a habit is automatic it may be applied in a situation in which it is not relevant. This is termed ‘habit lag’ (Mannell & Duthie, 1975) and can be related to ‘lapses of attention’ whereby an insufficient amount of attention is devoted to the task resulting in the misapplication of routine rules or actions to inappropriate situations (Reason, 1990). This is evidenced by the work of Shrira and Noguchi (2016) who examined all motor vehicle fatalities in the United States between 1990 and 2010 on the basis of whether the individual lived in a rural or urban setting, whether they were driving in a rural or urban setting at the time of death, and whether this setting was in the home county or a different county. There was a greater risk of RTAs on rural roads than urban roads, however this risk increased significantly for those who lived in urban areas and had travelled to rural (unfamiliar) areas. Shrira and Noguchi (2016) argue that different driving environments have unique risks and drivers in unfamiliar settings may not adapt to these new risks.

The strength of a habit is modulated by practice and habitual responses can be overcome by increasing control over attentional selection. However, this requires more cognitive resources because the habitual response must be inhibited and attention must instead be deliberately guided on the basis of the task goals (Hofmann, Schmeichel, & Baddeley, 2012). It is argued that this in turn increases a driver's subjective mental workload, an account supported by Wu, Zaho, Lin, and Lee (2013) who found that experienced international drivers report higher mental workload and make more wrong turn errors when they navigate intersections in unfamiliar road environments compared to familiar road environments.

One way to measure the habitual allocation of attention in practiced tasks is to investigate a driver's visual search strategy. This is illustrated in a study by Shinoda, Hayhoe, and Shrivastava (2001) in which participants were asked to drive along a simulated route while their eye movements were recorded. Part way through the drive a "no-parking" sign (located at an intersection or on a straight stretch of road) changed to a "stop" sign and findings showed that when the sign was located at an intersection participants made more fixations to it and were more likely to detect the change compared to when it was located on a straight road. The effect was more pronounced when participants were instructed to adhere to traffic regulations. This shows that drivers allocate attention based on task demand, knowledge of the driving environment, and expectation. Drivers assign attentional weights (importance) to relevant objects and locations and with practice can apply these automatically when in a similar situation. The findings of Labbett and Langham (2006) support this as when experienced drivers (more practiced) watched video clips of drivers approaching a T-junction they fixated the most informative areas in the scene, whereas novice drivers (less practiced) did not constrain their search in the same way. It is therefore argued that driving errors in unfamiliar contexts are caused by a visual search strategy based on previous exposure to familiar contexts. This results in a failure to look in the direction of approaching traffic and therefore a failure to attend to and process information in this direction (Van Elsande & Faucher-Alberton, 1997).

One factor that may activate a habitual ‘search schema’ in the driving task is the similar spatial layout of road infrastructures across the world (Wu, Wick, & Pomplun, 2014). Despite the complexities of the visual environment, driving contexts are characterised by regular spatial structures in which objects co-occur. Drivers are sensitive to these semantic dependencies; once the primary reference object is recognised, the most probable spatial location(s) of target(s) relative to this reference object can be inferred. For example, roundabouts are a familiar road context with a spatial configuration that is similar across different countries, the main difference being that traffic flows clockwise in LHT and anti-clockwise in RHT. Roundabouts have been shown to trigger a habitual search strategy whereby drivers allocate attention to the side of the roundabout that they expect approaching traffic (Rasanen & Summala, 2000). These spatial dependencies between objects, known as *spatial priors*, are also responsible for directing a driver’s eye to the pavement when they search for pedestrians (Torralba, Oliva, Castelhano, & Henderson, 2006).

The benefits of this type of contextual learning have been demonstrated by Chun (2000) who found that repeated exposure to complex visual displays facilitates progressively quicker detection of targets. Via the consistent mapping of associations between the spatial layout of a scene and likely target location within, drivers implicitly learn statistical probabilities of target positions. This causes changes in long-term memory and, when the same context is encountered in the future, attention is habitually guided to relevant locations (Le-Hoa Võ & Wolfe, 2015). Again, this habitual selection is not under conscious control and so allows resources to be used elsewhere, however, the activation of a search schema can become detrimental if the scene context remains the same but the location of targets changes (e.g. Jiang, Swallow, Rosenbaum, & Herzig, 2013). This is one of the contributing factors to RTAs in tourist drivers; the road environment is common across different countries (Wu et al., 2014) and so triggers the habitual search schema, yet when the location of targets is not the same (i.e. when drivers travel from a LHT system to a RHT system) attention will be directed to incorrect areas and this will influence the ability to detect and process relevant information (e.g. hazards).

Very few countermeasures exist to address the risks of habitual search and these are usually limited to warning signs such as “keep left/right” on country borders (Walker & Page, 2004) and online educational resources, for example “Know Before You Go” (FCO, 2013) and the “Visiting Drivers Project” (Ministry of Transport, 2014). However, a small case study by Summala (1998) shows that providing tourist drivers with information about different priority rules at intersections reduces habitual behaviours in an unfamiliar country and facilitates adoption of new visual search strategies at intersections. With the exception of the research completed by Summala there has been very little empirical work that investigates how drivers adapt to an opposite lane traffic system and how their habitual behaviours link to RTAs. It remains unknown whether these adaptation failures arise from a lack of preparation prior to the change, or a lack of attention to spatial cues in the new environment. It is also unclear whether establishment of new top-down settings for opposite traffic rules can benefit tourists.

The aim of the current study was to examine whether pre-drive information about traffic regulations in opposite lane traffic systems can influence attention and performance in an unfamiliar driving environment. Participants viewed driving clips from familiar (LHT) and unfamiliar (RHT) traffic scenarios and were given instructions on the route to take at specific points (i.e. similar to using a sat nav). In each clip participants were required to make a right of way judgement and their eye movements were measured. Half the participants were given information about RHT regulations prior to viewing the clips and it was predicted that this material would allow participants to prepare for the task and adapt the way in which they allocate attention.

2. Method

2.1 Design

The experiment used a 2 (group) x 2 (traffic direction) mixed measures design. *Group* referred to exposure to the safety information presented to participants. The Intervention Group was shown the information prior to the driving task, and the Control Group viewed the information after the driving task. *Traffic direction* was the direction of the traffic flow in the driving videos; in each video, traffic was approaching either from the left (RHT) or the right (LHT). Whilst selective attention has a number of attributes (Driver, 2001), it is argued that deployment of gaze can reflect the focus of attention (Henderson, 2003). The use of eye movements to record attention in the driving task is common practice and studies show that visual attention is closely linked to driver safety (e.g., Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Crundall, Underwood, & Chapman, 1999). It is also important to establish the effect of attentional allocation on task performance and many studies exploring eye movements and attention in driving also take a measure of accuracy to indicate effective allocation of attention, such as hazard detection (e.g. Shahar, Poulter, Clarke, & Crundall, 2010) or lane maintenance (e.g. Hurtado & Chiasson, 2016). On the basis of this, the current study measured selective attention using accuracy in the judgement task (total number of trials in which participants correctly assessed the priority rules at a roundabout) and attention allocation (the proportion of fixations to the left and right side of the road in each video). These areas were defined horizontally using the edge of each roundabout (see figure 1). They were calculated every second from the point when a roundabout became fully visible to the driver and then averaged for each clip. One further aspect of the study was to measure perceived cognitive workload in LHT and RHT. Selective attention is influenced by load (Lavie, 2005) and whilst this has been found to influence certain aspects of driving (e.g. speed) it does not always influence others (e.g. lane maintenance; Hurtado & Chiasson, 2016). In addition to measuring the effects of load indirectly using accuracy and eye movements a subjective level of mental workload was also recorded (measured using participant difficulty ratings for each video). Ethical approval for the study was obtained from the School of Health Sciences Ethical Approval Committee at the University of Salford.

Figure 1: A video frame with the areas of interest marked. The proportion of fixations made to the left and right was compared for each clip.

2.2 Participants

A sample of 28 students from the University of Salford took part in the experiment. All participants had a valid driving licence and they were randomly allocated to the intervention or control group. The intervention group consisted of 10 females and 4 males, aged 19 to 37 years (*M* = 25.64, *SD* = 5.891), with a mean driving experience of 5.75 years (*SD* = 5.54, 1–16 years). The control group included 10 females and 4 males, aged 20 to 30 years (M = 23.43 years, *SD* = 3.48), with a mean driving experience of 4.82 years (*SD* = 3.6, 1–13 years). A total of 42.86% of participants in the intervention group and 50% of participants in the control group reported that they had driven in RHT in the past, and the other participants only had experience of LHT. Participants reported normal or corrected to normal vision and all were given course credit for their participation.

2.3 Materials

All participants completed a short questionnaire asking about length of driving experience and experience of driving in RHT. To assess the effect of providing information to drivers prior to driving in RHT a leaflet outlining differences between driving in LHT and RHT was created. A visual representation of basic driving rules was created for each traffic convention (see figure 2 for an example). The main task consisted of 40 video clips of driving selected from a collection of opportunistic on-road filming in Greater Manchester, UK (53°30′N 2°19′W) and Złotów, Poland (53°21′37″N 17°2′27″E). Video clips were taken from a driver's perspective in a right-hand drive vehicle in the UK and a left-hand drive vehicle in Poland. Videos were taken using a windscreen mounted Xblitze Black Bird driving recorder, which captures a 170-degree wide view of the road with a resolution of 1024 x 768 pixels. The footage was edited using the Windows Moviemaker tool. A total of 20 LHT clips (UK) and 20 RHT clips (Poland) were used and each one incorporated a drive along an urban road towards a roundabout that contained no signposting. Each clip ended just prior to the driver entering the roundabout but provided sufficient visual information for the participant to judge whether it was safe to pull out onto the roundabout, or whether to stop and yield priority to others. A centrally presented black arrow preceded each clip and indicated the type of manoeuvre the participant should prepare for at the roundabout (going straight across, making a left, or a right turn).

Within the 20 RHT and LHT clips there were 10 in which it was safe for the participant to enter the roundabout and 10 where they would have to stop and yield priority to other cars (due to a car approaching from the relevant traffic direction). For the videos in which the driver could safely enter the roundabout, in 50% of the clips the roundabout was empty, and in the other 50% a car was exiting the roundabout). Three experienced LHT drivers and three experienced RHT drivers rated the videos for appropriateness in their respective traffic systems. The level of agreement between raters was high (95.5%) and the final correct judgement for each roundabout scenario was selected by choosing the most frequent answer given. The mean clip duration was 16s and ranged from 7s to 27s. The clips were modelled on hazard perception video clips used in driving research and the durations were chosen based on a selection of past work. For example, Shahar, Alberti, Clarke, and Crundall (2010) designed hazard clips lasting a maximum of 30 seconds, Sagberg and Bjørnskau (2006) presented drivers with naturally occurring driving situations in which hazards could appear within 'critical intervals' of between 4 and 25 seconds, and Crundall (2016) measured hazard prediction across short (mean duration of 10s), intermediate (mean duration of 24s), and long (mean duration of 44s) driving clips and found lower accuracy in the longer clips. In the current study each clip had two temporal epochs: *pre-onset*, where the car moved straightforward while approaching the roundabout, and *critical window*, which began at the point where the roundabout was fully visible to the viewer and ended when the clip ended. The length of these epochs varied between clips due to different traffic situations. All epochs were defined via discussion between the researchers and a driver with significant experience of driving in both countries.

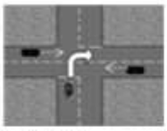
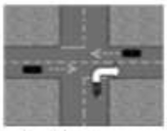
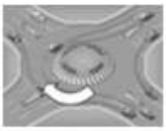
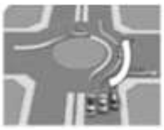
LEFT-HAND TRAFFIC	RIGHT-HAND TRAFFIC
 Turning Right – look left for crossing traffic in the near-side lane and look left for oncoming traffic.	 Turning Right – Look right for crossing traffic in the near-side lane and look right for oncoming traffic. Look left for crossing traffic in the far-side lane.
 Clockwise traffic on the roundabout, give way to the right.	 Anticlockwise traffic on the roundabout give way to the left.

Figure 2: Examples of material used in the study leaflet. The information and visual representations outline differences between LHT and RHT when turning right and entering a roundabout.

The experiment was designed and run using E-Prime 2.0 software on an Intel Core Duo computer with a 17-inch TFT monitor. Eye movements were recorded using a Tobii T120 Eye Tracker with a sampling rate of 120 Hz, which recorded the movements from both eyes.

2.4 Procedure

Participants were given full information about the task and were asked to sign a consent form. Participants in the intervention group were first asked to read the leaflet and were then seated 60 cm from the screen with their head in a chin rest to minimise head movements. On-screen instructions asked participants to watch the videos and judge the safety of entering each roundabout by pressing ‘z’ for STOP and ‘m’ for GO when prompted. They were shown a sample scenario of a car stopping at a roundabout with a car approaching from the right side. Eye movements were then calibrated using a five-point calibration procedure and the LHT block with one practice trial began. In each trial, a fixation cross was presented for 500ms in the centre of the screen followed by an arrow displayed for 2000ms. A video was then shown in 16:9 aspect ratio in a 'letterbox' format with two black bars above and below the video display. Following the video, a black screen appeared for 1000ms, and participants were prompted to make their decisions about whether it was safe to enter the roundabout. They were then asked to rate the difficulty of making this judgement on a 7-point scale ranging from 1 – *easy, not difficult at all* to 7 – *extremely difficult*. After completing 20 LHT trials (presented in a random order), participants were asked to imagine that they are overseas and were about to drive in RHT. Eye movements were re-calibrated and the second RHT block with one practice trial began. Participants were presented with 20 clips of RHT traffic in a random order and instructions were the same as those given in the LHT clips. After completing the experiment, participants were debriefed and thanked. This procedure was the same for participants in the control group with the exception that they read the information about driving in RHT at the end of the task, prior to being debriefed.

3. Results

Analysis was conducted on participants' ability to make the correct judgement at each roundabout, their subjective mental workload ratings, and attention allocation within the critical window of each clip (distribution of fixations to left- and right-hand sides). Each measure was compared between the intervention and control groups across the two blocks of LHT and RHT driving.

A 2 (group) x 2 (traffic direction) mixed measures ANOVA was conducted to examine the effect of the pre-drive information (intervention vs. control) on the accuracy of judgements when driving in familiar (LHT) and unfamiliar (RHT) environments. The dependent variable was the mean proportion of correct scores to the judgement tasks, with higher scores indicating greater accuracy. There was a significant main effect of traffic direction, F (1, 26) = 5.310, $p < .05$, and accuracy was significantly higher for LHT (.91) than RHT (.86). There was no significant effect of group, F (1, 26) = 3.037, $p > .05$, and no interaction between group and traffic direction, F (1, 26) = .245, $p > .05$ (figure 3).

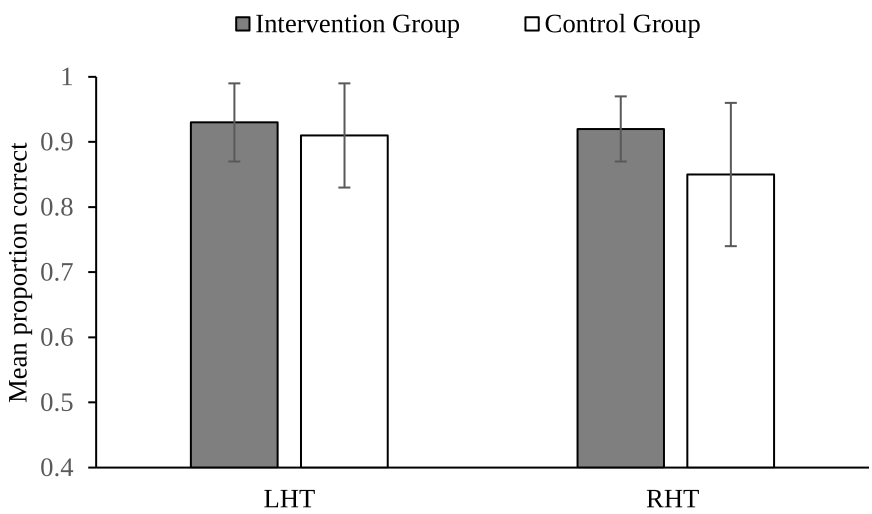


Figure 3: Mean accuracy in the roundabout task as a function of traffic direction and group. Error bars represent standard deviation from the mean.

A 2 (group) x2 (traffic direction) mixed measures ANOVA was also conducted on participants' subjective rating of mental workload. The dependent variable was the mean difficulty of making a decision at each roundabout with higher scores indicating more difficulty in assessing driving situations. It should be noted that overall the data suggest that participants found the task relatively easy, with a mean of 1.85 (measured on a scale of 1–7). There was a significant effect of group, F (1, 26) = 6.881, $p < .05$, with the control group rating the task as more difficult than the intervention group. There was also a significant effect of traffic direction, $F(1, 26) = 4.537$, $p < .05$, and participants found the RHT (1.88) more demanding than the LHT (1.69). There was no interaction between group and traffic direction, $F(1, 26) = 2.758$, $p > .05$ (figure 4) [1].

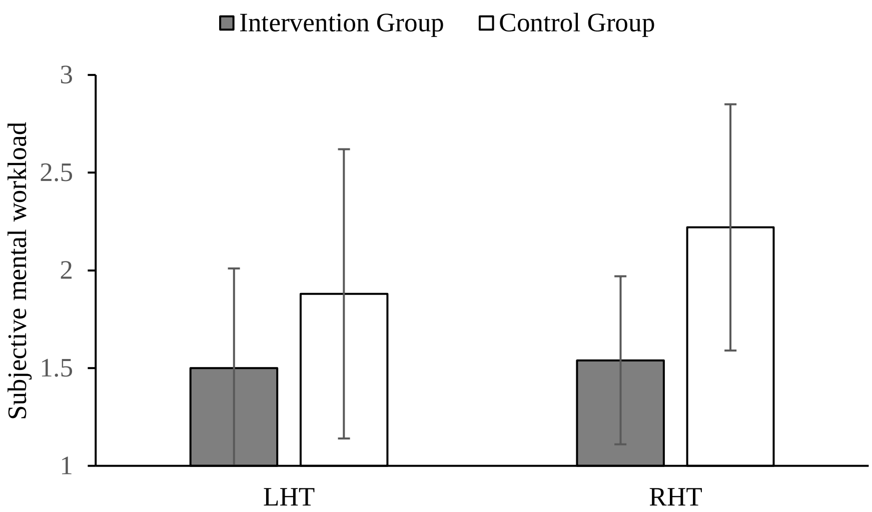


Figure 4: Subjective mental workload ratings as a function of traffic direction and group. Error bars represent standard deviation from the mean.

To explore the effects of pre-drive preparation (intervention vs. control) and different driving environments (traffic direction: LHT, RHT) on an individual's visual attention a 2 (group) x 2 (traffic direction) x 2 (area of interest) mixed measures ANOVA was conducted on the number of fixations directed to the left and right sides of each roundabout. As the number of fixations made to each clip varied across

[1] Data for accuracy and perceived mental workload was also compared for the first 10 and last 10 trials in each block to determine any impact of the preparatory information that may have dissipated across the course of the task as participants became more accustomed to each driving setting. This analysis has its limitations given that trials were randomised and there were an unequal number of trials in which the roundabout was clear and the number in which participants had to yield to another vehicle. In accordance with the overall data there was limited effect of the pre-drive preparation. Across the course of the experiment accuracy was higher for LHT, RHT was perceived as more demanding, and the only impact of preparation was that the intervention group found the experiment easier. These effects did not vary across the course of each block.

participants, the percentage of fixations made to the left and right side in each video was calculated for each participant.

There was no difference between the two groups, F (1, 26) = .018, $p > .05$, and no difference between the number of fixations made in the LHT and RHT video clips, F (1, 26) = 1.52, $p > .05$. Analysis did however show that participants allocated more attention to the right hand side of roundabouts (25.1%) than the left (20.71%; F (1, 26) = 13.558, $p < .001$. There was no interaction between traffic direction and group, F (1, 26) = .778, $p > .05$, and no interaction between group and area of interest, F (1, 26) = 1.528, $p > .05$. Crucially there was a significant two-way interaction between traffic direction and area of interest, F (1, 26) = 97.785, $p < .001$, with participants directing more attention to the right (33.75%) than to the left in LHT (11.81%) and more attention to the left (29.61%) than to the right in RHT (16.5%). There was also a significant three-way interaction between group, traffic directionality, and area of interest, F (1, 26) = 8.616, $p < .01$ (figure 5). This was explored using two separate repeated measures ANOVAs, one for the intervention group and one for the control group.

For the intervention group the interaction between traffic direction and area of interest was significant, F (1, 13) = 66.711, $p < .001$. Bonferroni adjusted paired samples t-tests indicated that participants in this group directed significantly more attention to the relevant right-hand side of roundabouts in LHT (35.98%) than to the left-hand side (10.32%; t (13) = 8.701, $p < .001$, and made more fixations to the left-hand sides of roundabouts in RHT (32.74%) than to the right (12.90%; t (13) = 6.041, $p < .001$. Participants in the control group also allocated significantly more attention to the relevant right-hand side in LHT (31.50%) rather than the left-hand side (13.30%; t (13) = 7.817, $p < .001$, however, there was no difference in the number of fixations made to the left (20.02%) and right side in RHT driving (26.49%; $t(13) = 1.898$, $p > .05$.

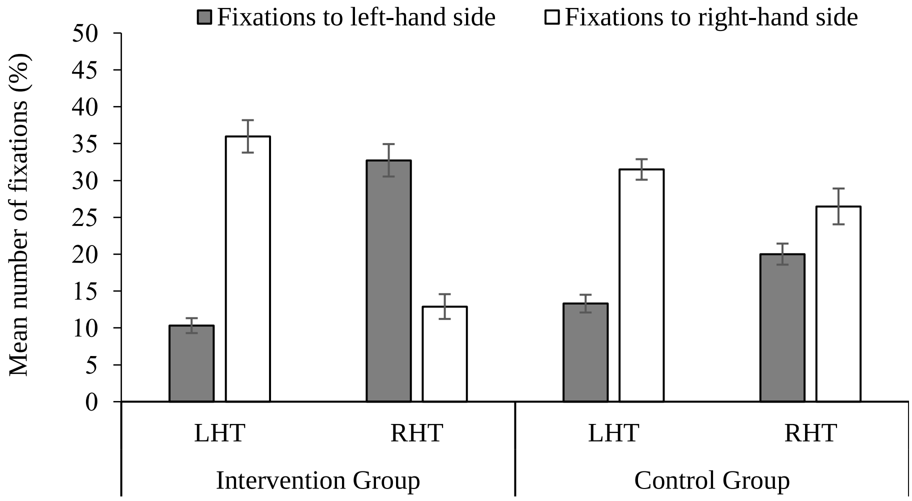


Figure 5: Mean number of fixations made to right-hand sides and left-hand sides of roundabouts for each group when viewing LHT and RHT videos.

4. Discussion

Driving in opposite lane traffic systems is a high-risk activity for visiting drivers and this is supported by a growing number of tourist RTAs (Wilks, Watson, & Hansen, 2000). Despite the popularity of drive tourism, there is little research explaining why drivers fail to adapt to new driving rules and what can be done to improve their road safety. This study investigated whether pre-drive preparatory information facilitates effective attention allocation among individuals accustomed to driving in a different traffic system. This was examined by showing drivers video clips depicting roundabout approaches in familiar (left hand traffic) and unfamiliar (right hand traffic) situations. For each video, drivers made judgements about whether it was safe to enter the roundabout. Accuracy to this judgement task, ratings of task difficulty, and visual search (percentage of fixations) to the sides of each roundabout were collected. Prior to viewing the driving videos half the participants were provided with educational information about differences in LHT and RHT.

The higher cognitive demands imposed by unfamiliar driving environments are known to affect mental workload, on-road visual behaviour (e.g. scanning of safety relevant areas in intersection approach) and driving performance (e.g. breaking) (Harbluk, Noy, Trbovich, & Eizenman, 2007). These effects of familiarity were apparent in the current study; accuracy in assessing priority was higher in LHT, participants perceived the judgements to be less demanding in LHT, and participants looked more towards the right hand side of roundabouts than to the left in LHT. This was expected; drivers direct their attention to the most informative regions and this is based on their knowledge and experience of the task (in LHT drivers can only expect on-coming cars on the right side of roundabouts). These findings support previous research showing that drivers allocate their attention to various road features in a very stereotypical manner, often focusing their gaze only on the most informative regions in a scene (Labbett & Langham, 2006; Rasanen & Summala, 2000).

However, in RHT, whilst the control group adopted the same search strategy, the intervention group changed their spread of search and allocated more attention to the (now relevant) left hand side of roundabouts. These results clearly demonstrate the beneficial impact of the preparatory information in altering visual search and enhancing allocation of attention to critical regions. In accordance with Summala (1998), drivers exposed to educational information update their visual search and suppress the dominant search tendencies in RHT. The significantly larger proportion of fixations to the left hand side of roundabouts in RHT shows that preparatory information about a task can override habitual search behaviour and promote flexible visual search in a changing environment (Trick et al., 2004).

The control group directed almost the same proportion of fixations to both sides of a roundabout in RHT. This persistence of visual search from LHT to RHT suggests a strong influence of habit and poor adaptation to the new situation. The visual search strategy used by this group in RHT demonstrates that unprepared drivers will continue to look towards an area of the road that does not provide any critical safety information even if the road situation changes. It may be that drivers in the control group utilised a universal search strategy because they were unable to anticipate the location of the conflicting traffic. The pattern of gaze distribution supports this and is similar to that of novice drivers reported by Labbet and Langham (2006). Alternatively, it may be that the familiar context of a roundabout cued the activation of a practiced search schema that subsequently guided attention towards the right (Le-Hoa Võ & Wolfe, 2015; Wu et al., 2014).

According to Leber, Kawahara, and Gabari (2009), once an attentional set is established in a particular context, it will persist and influence subsequent attention and search in a similar context. They showed that observers trained to use a feature search (searching for a specific unique feature, e.g. colour) to identify targets in a rapid serial visual presentation task would utilise the same search one week after the training. This shows the lasting effects of previous experience. Moreover, the effect of learning occurred even when specific features changed (e.g. the colours of targets and distractors changed so that the targets appeared in the previously-irrelevant distractor colour). This shows that individuals do not always alter their attentional settings in accordance with a change in task demand (Thompson, Underwood, & Crundall, 2007).

A change in task or context requires reconfiguration of the attentional settings. This involves activation of new settings and inhibition of the old settings and utilises cognitive resources, leaving fewer resources to complete the task (Kiesel et al., 2010; Monsell, Sumner, & Waters, 2003). Rogers and Monsell (1995) have shown that the costs associated with switching set are reduced if an individual can 'prepare' for the switch. This was demonstrated in a predictable task switching paradigm that manipulated spatial attention by presenting participants with images of faces and cuing them to respond to the image itself, or to respond to a target presented on the image (Longman, Lavric, & Monsell, 2013). Performance deficits were found on 'switch trials' when the cue changed, however these 'switch costs' were smaller when the time between the cue and the image increased (allowing participants to prepare for the switch and reconfigure the attentional settings). Together with the present findings this shows that allocation of attention can be positively influenced by the ability to prepare for a change in task settings. Whilst the ratings of subjective mental workload were very simplistic in the current study (i.e. Wu et al. (2013) utilised the NASA-TLX measure of workload which is an established and validated tool), the findings do support the argument that preparation can reduce switch costs. Overall participants in the control group found the task more demanding than the intervention group, potentially due to the fact that they were not given the study leaflet until after they had responded to all video clips. This would indicate that pre-drive preparation may reduce the workload associated with switching from familiar to unfamiliar driving contexts.

Task switching studies show that preparation does not fully eliminate switch costs and it may be argued that this is demonstrated by the current findings. Whilst the preparatory information had an impact on the spread of visual attention, it did not improve task performance. The results revealed that drivers are significantly better at judging priority situations at roundabouts in a familiar traffic convention compared to an unfamiliar road system. These findings again support the notion that habitual search schemas (based on previous experience with a particular road context) enhance orienting of attention to probable locations of safety-critical information in that driving context (Wu et al., 2014; Labbett & Langham, 2006). However, accuracy rates were expected to be higher in RHT for the intervention group than the control group and findings showed no impact of the preparatory information on judgements.

This may be due to bottom-up influences whereby oncoming vehicles captured attention automatically. Contrasting features (e.g., colour, intensity, motion relative to the surroundings; Itti & Koch, 2000) capture attention automatically and it is estimated that salience may account for around 30–35% of attentional capture by information outside of a vehicle (Glaze & Ellis, 2003). Petridou et al. (1997) suggest that tourist RTAs are caused by a lack of bottom-up reflexes; however, since reflexes are determined biologically (Trick et al., 2004), this argument offers little explanation as to why tourist drivers pull out onto a roundabout or road and drive in the opposite direction to local rules. Indeed, a stop-or-go experiment conducted by McCarley, Steelman, and Horrey (2014) demonstrated that reflexes are insufficient to account for road safety. They found that accuracy of judgements to road safety scenarios was significantly lower when only salient information was provided. This indicates that pure selection of low-level features is an inefficient search strategy and without consideration of top-down factors and important non-salient cues that are critical to safety, drivers are unable to gain an understanding of the road situation.

Findings from Hurtado and Chiasson (2016) are consistent with the current results. Using a driving simulator they measured lane maintenance whilst participants were exposed to familiar and unfamiliar traffic signs. Participants spent longer fixating on the unfamiliar signs but this had no impact on their accuracy to maintain the correct lane position. This would suggest that familiarity may influence visual attention without impacting on performance. However, when fixating the unfamiliar signs participants reduced their speed. The researchers argue that this reveals a detrimental impact of unfamiliar information on both attention and performance; more attention was directed towards the unfamiliar signs leaving fewer resources to attend to the speed of the vehicle. This highlights a drawback to the current research as the task was simple (as evidenced from overall ratings of subjective workload) and only one measure of performance was recorded. It may be the case that an unfamiliar driving context and the effects of pre-drive information can influence certain aspects of driving behaviour but not others.

Given the importance of top-down information in the driving task it is suggested that the non-significant difference in RHT judgement accuracy between the two groups is due to the simplicity of the clips selected for the task, and the task used. Drivers are exposed to complex environments and road situations and they also have the additional physical demands involved in driving (selection of the correct route and lane, changing gear, maintaining lane position, checking mirrors, etc.). In comparison, the task used for the current experiment was much less demanding. There was limited visual clutter in each of the clips and participants were given instruction regarding the manoeuvre they should prepare for in each clip. This could have enabled drivers to focus their attention on the roundabout without having to inhibit irrelevant information. Demanding driving conditions are associated with a narrowing of attention as drivers reduce their attention to peripheral areas of the road and fixate on the road ahead (Harbluk et al., 2007). This is consistent with the effects of perceptual load found by Lavie (2005) whereby increased load reduces the effects of irrelevant distracters. It is therefore possible that due to the low levels of demand participants in the current experiment had more resources and were able to adopt a wider focus. This enhanced scope of attention would allow for any salient information to capture attention regardless of whether it appeared in task-relevant locations or not. As RHT scenarios are less familiar accuracy was lower in this condition and the pre-drive information given to the intervention group had no impact because participants were using bottom-up rather than top-down information.

Due to the simplicity of the task used the current results are not able to fully reflect the impact of preparing for unfamiliar driving situations in real-world driving conditions. It would be interesting to measure the effects of preparatory information using more complex clips and a more demanding task to determine whether a lack of preparation limits performance for the control group when they are unable to adopt a wide focus and use bottom-up attention. It is predicted that in more demanding environments when drivers are relying on past experience and knowledge of the task, preparatory information will have a beneficial impact.

An alternative explanation for the lack of any impact of the preparatory information on accuracy is the switch costs associated with changing tasks. The intervention group were given clear information about the differences between LHT and RHT and were therefore prepared for a change to the task. Consequently they may have reverted to more conscious processing of the clips in the second block (deliberation; Trick et al., 2004). This is more effortful compared to a strategy using habit and the resources used may have limited the ability to make an accurate judgement (Hofman et al., 2012; Wu et al., 2013). As a result, any benefit from the preparatory information may have been overshadowed by the additional resources used to engage with the new driving context.

The argument that the clips used for the present study were very simplistic is supported by the ratings of task difficulty as overall participants found the task very easy. Yet these ratings did reflect the advantages of familiarity, as significantly lower levels of mental workload were reported for LHT than RHT. This is consistent with a survey reporting that 60% of British drivers find driving in RHT stressful and difficult (RAC, 2013) and visiting drivers find the unfamiliar environments more demanding (Wu, 2015; Wu, et al. 2013). Lower levels of mental workload in LHT indicate that drivers used implicit, automatic processes while making judgements in familiar traffic conventions, whilst higher levels of mental workload in RHT support the notion of the additional top-down control requirements imposed by unfamiliar environments (Trick et al., 2004).

Overall, the control group made fewer fixations to the relevant area in RHT but performed the same as the intervention group in this condition. These results match those observed by Summala and Räsänen (2000) indicating that cars approaching from unexpected locations can be considered a salient feature and can often be detected automatically. Despite this, using this type of visual search in real life driving is not a safe or practical strategy as it may not prevent a driver from using the wrong lane and could pose a risk to other road users (indeed, the current task was far-removed from real-world driving and focus was on safety judgements rather than the number of errors and violations made). In addition, this type of search does not equip individuals to make effective decisions when using the road. For instance, it has been shown that pedestrians crossing a road in unfamiliar traffic conventions tend to adopt a ‘cautious crossing strategy’, whereby they wait for all cars to disappear rather than use available gaps in the traffic (Johnston & Peace, 2007). Not knowing where to look and therefore expecting oncoming cars from both sides of a roundabout utilizes a greater amount of cognitive resources (this is indicated by higher levels of mental workload overall in the control group). In real life driving this would make the driving task more difficult and stressful and could increase exhaustion and/or frustration. To add to this, drivers will be more susceptible to interference from a well-practiced visual search strategy when they are tired or they are engaged in a secondary task (Reason, 1990; Liu & Wu, 2009).

The experiment did not fully support the anticipated benefits of the pre-drive information as performance for the intervention group did not improve (compared to the control group) in the unfamiliar driving scenarios and perceived difficulty of the unfamiliar scenarios was the same as the familiar scenarios. This could be attributed to the low-level of complexity and visual clutter in the driving clips (allowing the control group to benefit from bottom-up capture), or the possibility that the intervention group were using more resources to consciously adopt the new task settings because they were more aware of the changes. However, this may also be explained by the sequence of events in the experiment. The preparatory information was given at the beginning of the experiment (immediately prior to the LHT clips). This was intended to reflect real-world behaviour whereby a driver may explore the road conventions in their destination country before they start their journey. Therefore they would access this preparatory information, then drive in their familiar context before reaching their destination and driving in the unfamiliar context. This raises important questions about when information should be provided to tourist drivers. Phillips, Ulleberg, and Vaa (2011) found that driving campaigns reduce the frequency of RTAs by 9%, particularly when they are delivered in the immediate context. The current findings show that providing information at an early stage can improve attentional allocation, however it is predicted that having this information immediately prior to driving in the unfamiliar context will have a beneficial impact on both attention and performance. Future research could investigate whether delivering such interventions in the immediate context improves the ability of a driver to adjust to new traffic conventions and reduces the risk of RTAs. This would be best achieved by adopting a counterbalanced design rather than consistently presenting the LHT clips before the RHT clips. This would also remove the limitations associated with a constant order such as practice effects.

It is unclear whether UK drivers who are planning to drive abroad would prepare for their travel as a survey in 2013 showed that only 39% of drivers research the road regulations of their destination country. However, given that a brief amount of preparatory information has a beneficial impact on visual attention, it is suggested that preparing for travel abroad should be mandatory.

5. Conclusion

This study is the first to demonstrate that pre-drive preparatory information can influence the dominant search behaviour in LHT drivers and increase attention to relevant locations in an unfamiliar traffic convention. This supports the previous findings of Summala (1998) while providing new evidence for the effectiveness of educational campaigns in the promotion of road safety among international tourists. The tourism industry, as well as local transport agencies, could use these findings to improve road safety for tourists and locals.

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