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Attraction and distraction of attention with roadside advertisements

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Abstract

The optimum positioning of roadside advertisements is recognized by the industry as an important factor in attracting the attention of passing drivers. Less acknowledged is the possibility that the location of an advertisement may distract attention from vital driving-related information. This study compared street-level advertisements (SLAs; predominantly bus shelters) with raised-level advertisements (RLAs) of the same size that were suspended 3 m above the ground, on their ability to attract attention under different task conditions. Participants were split into two groups and watched video clips of driving, rating them for hazardousness while their eye movements were recorded. One of the groups was additionally primed to attend to advertisements. SLAs received the most fixations when participants were solely looking for hazards, and the fewest fixations when primed to look for advertisements. Though SLAs also had longer fixations than the RLAs, they were more poorly recognized in a subsequent memory test. We conclude that SLAs attract and hold attention at inappropriate times compared to raised-level advertisements.

Keywords: Advertisements; Attention; Distraction; Driving; Eye movements

1. Introduction

In most undemanding driving situations drivers often let their eyes wander to irrelevant objects. Percentage estimates of driving time where drivers' attention is directed to scenery and other irrelevant items vary from 20% or less, to 50% (e.g. Green, 2002; Hughes and Cole, 1986; Land and Lee, 1994). This reflects the spare attentional capacity that drivers have at any particular moment. It is this spare capacity that roadside advertisements are designed to attract. There is concern however over the potential for such advertisements to attract attention above and beyond spare capacity (e.g. Wallace, 2003). Attention to advertisements at the expense of processing vital driving information is *distraction* rather than *attraction* of attention, and may lead to impairment of driving performance. Though it is acknowledged that research into advertisement distraction has been extremely limited (Beijer et al., 2004), the few studies that have been conducted have demonstrated that drivers do look at and process roadside advertisements (Hughes and Cole, 1986), and that fixations upon advertisements can be made at short headways or in other unsafe circumstances (Smiley et al., 2004). Previous studies of accident statistics have also identified external distractors, including advertisements, as a significant self-reported cause of traffic accidents (Stutts et al., 2001). Other research has however questioned the probability of a direct link between distraction due to advertisements and accident liability (Andreassen, 1985).

One of the few examples directly linking advertisements to accident rates was given by Ady (1967). He looked at accident rates on portions of roads before and after the erection of billboards. One specific billboard caused a particular problem. It was placed at the corner of a sharp bend and had bright lights attached to it. It appeared that the combination of an extremely eye-catching advertisement and poor billboard location increased the number of accidents on that stretch of road compared to a control location. On the basis of these and similar data, a recent review (Wallace, 2003) concluded that there is a real risk that advertisements may distract drivers' attention to the extent that it may increase the probability of an accident, but that this effect is situation specific.

The main factor underlying these situation specific effects is likely to be the level of cognitive demand placed on the driver at any one point, which often dictates what the driver should be attending to. For instance, when driving around a curve (as in Ady's study, 1967), eye movements need to focus more upon the lane markings and road edges in order to extract vital information for steering (Land and Lee, 1994; Shinar et al., 1977). These extra visual demands during curve negotiation result in less spare capacity. Therefore, advertisements placed

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on bends are less likely to attract spare attentional resources. If they do receive fixations, the greater driving demands associated with bends would suggest that such advertisements are more likely to distract attention from vital driving tasks, than advertisements that are fixated during straight segments of road. Unfortunately, placing advertisements in a bend is a very attractive location for advertising agencies, as these locations will be closer to the driver's original line of sight as one enters the bend. Under these circumstances, it is unsurprising that such advertisements can receive more fixations than advertisements on straight roads, though the possibility of fixations on these advertisements impairing driving performance is greater (Beijer et al., 2004).

Beyond the effects of specific locations, there are many other factors that are associated with increased driver demand such as transient hazards (Chapman and Underwood, 1998; Horswill and McKenna, in press), traffic density (Miura, 1990), speed (Harms, 1986), concurrent verbal and spatial-imagery tasks (Recarte and Nunes, 2000), and conversing on a mobile telephone (Garcia-Larrea et al., 2001), to name but a few. Some of these increased demands can be predicted on the basis of the specific location, while others cannot be easily taken into account because they depend upon driver variables and upon interactions between drivers.

Transient hazards can be particularly hard to predict, especially when they are location independent, or when they interact with driver variables such as fatigue or experience. Such events can directly influence the driver's probability of an accident (Chapman and Underwood, 1998; Horswill and McKenna, in press). These may include a pedestrian suddenly stepping into the road, or a car pulling out from a side street. If attention is distracted by an advertisement during the onset of a sudden hazard, the chance of an accident occurring will increase. Though many of these hazards are location independent to an extent, there are however certain visual search patterns that relate to hazard detection which can be potentially used to inform the placement of advertisements.

The most enduring pattern is the predominance of a horizontal search window. Several studies have found that drivers will tend to move their eyes more in the horizontal plane than in the vertical plane (e.g. Mourant and Rockwell, 1972; Crundall and Underwood, 1998). This is primarily because relevant environmental information is distributed in greater density along the horizontal plane. Straight ahead (often called the focus of expansion) is the most important location, as this is where the driver is heading. This gets the majority of fixations, and when drivers look somewhere else in the scene, there is a greater probability that their gaze will return to the focus of expansion before looking at any other stimuli (Underwood et al., 2003).

When not looking straight ahead, the eyes tend to move to the left and right of the focus of expansion, looking at pedestrians, parked cars, side streets and other potential hazards. This creates a horizontal window of visual search where the majority of the fixations fall, most of which will be motivated by the search for driving-relevant information. The first panel in Fig. 1 contains a fixation density plot taken from Chapman and Underwood (1998). Aggregated over a number of participants, this plot represents those areas of the visual scene where the eyes fell the most while watching video clips of highly demanding driving, with the majority of fixations falling at the focus of expansion, with each subsequent ring containing less and less fixations.

Therefore, we argue that if an advertisement is positioned within this horizontal window of inspection it will get more fixations than other advertisements, though as the intention behind

Fig. 1. The left panel represents a standard density plot for fixations falling on a roadway during normal driving (taken from Chapman and Underwood, 1998; image courtesy of Pion Limited, London). The two middle panels show driving scenes with a street-level advertisement (bus shelter) and a raised-level advertisement. The advertisements are circled in white. The two panels on the right superimpose the density plot over the two centre images. The SLA falls within the 'safety inspection window', whereas the RSA does not. This suggests that SLAs may need to be filtered out of visual search for driving safety, whereas RSAs can be filtered in, and looked at when the driver feels safe to do so.

most saccades within this window will be to search out driving-relevant information, a large proportion of fixations on these advertisements are likely to be unintentional and may distract the driver from continuing their visual search for driving-relevant information. If an advertisement, when at its most legible, falls outside this inspection window, it should be less likely to distract attention away from scanning for hazards, as there is a reduced probability that the eyes will inadvertently land on the display if search is restricted to a narrow horizontal band.

Fig. 1 contains two different types of advertisements. The upper panels contain a bus shelter advertisement which at its most legible falls within the superimposed hazard inspection window. We refer to this type of advertisement as a street-level advertisement (SLA). The lower panels contain an example of a raised-level advertisement (RLA). At its most legible, the RLA falls outside the typical inspection window and should therefore be less likely to distract attention when the visual search is primarily concerned with hazard detection and spare capacity is low. However, when the driver has spare capacity for driving-irrelevant stimuli (which is not constrained to the horizontal search window by top-down factors) the considerable bottom-up saliency of these displays may still attract attention.

The current study aimed to compare these two different types of outdoor media in an attempt to see which type attracts the most attention under different levels of demand, and whether this pervades into memory. It was predicted that when participants watch video clips taken from the driver's perspective under high demand conditions (primed to look for hazards) SLAs would receive the most attention, whereas fixations on RLAs should only increase when demands are lower (when instructions allow them to search for advertisements). SLAs, however, should produce the worse scores on a subsequent memory test if they tend to receive most attention when the participant is actually concerned with hazard detection.

2. Method

2.1. Participants

Thirty-two participants (17 women) with a mean age of 29.4 years took part in this study. On average they had 10.4 years of driving experience (since passing their driving test). Their average annual mileage was 8386.

2.2. Stimuli and apparatus

The clips were filmed via a dashboard-mounted digital video camera filming through the windscreen of a car around the streets of Coventry, Derby, Rochdale and Nottingham. Thirty-four video clips were created, half of which contained a street-level advertisement (bus shelter advertisements or equivalent free-standing displays. The other half contained a raised-level advertisement. These were approximately equal in size to SLAs (1.8 m × 1.2 m) but were located 3 m above the ground on a pole or streetlight. Of the 34 video clips, 20 clips were *matched*, in that the advertisement in an SLA in one clip was repeated in an RLA on another clip (though participants only ever saw one of the clips). Of the 10 matched advertisements, 5 advertisements represented advertising campaigns during the period January/February 2004 and 5 were fake advertisements created for us by Streetbroadcast Ltd. The remaining clips contained unmatched advertisements filmed during the period January/February 2004, of which 10 were recorded in daylight and 4 during dusk. The dusk clips are not analysed in the current paper, and are therefore not discussed further. The edited video clips were 42–61 s in length ($M = 57.0$), and the advertisements were on screen for an average of 7.6 s for RLAs and 7.8 s for SLAs. Advertisement onset during the clip was pseudo-randomly varied.

The experiment was controlled by an Apple G4 computer and the quick time clips were projected onto a large screen (170 cm × 128 cm) 2 m in front of the participant, creating a visual angle of 33° by 27°.

For the subsequent memory test, a series of slides was designed containing three distractors and one of the matched advertisements. The distractors were as similar as possible to the target in terms of their content (e.g. all advertising movies), but different in visual appearance. The distractor advertisements were obtained from media websites representing campaigns that appeared during May 2004. All images for the memory test were taken from the original artwork.

Eye movements were recorded at 250 Hz using the SMI Eyelink system.

2.3. Design

A 2 × 2 mixed design was employed. The between-group variable was instruction set. The first group (the *hazard* group) were given instructions to concentrate on the hazardous nature of each clip. The second group (the *advertisement* group) had less emphasis placed on the hazard perception task, and in addition they were told to watch out for advertisements that they might pass, as these would play a part in a subsequent memory test. This was intended to simulate differences in visual search as induced by high demand (only searching for hazards) and low demand (scanning for hazards, but also devoting attention to driving-irrelevant objects).

The within-groups factor was advertisement presentation, either as an SLA or RSA.

Dependant variables included fixations upon advertisements, hazard ratings for each clip, and recognition memory scores for identification of matched advertisements in a subsequent forced-choice test.

Only matched advertisements were used as targets in the memory test. Combined with the counterbalancing of participants who saw the advertisements displayed as either SLAs or RSAs, this ensured that the memory test was only influenced by the type of media, rather than the intrinsic salience of the advertisement.

2.4. Procedure

Participants were seated 2 m from the screen in a semi-dark room and allowed to read the instructions. After calibration they were randomly presented with 24 clips (including 10 matched clips). After each clip, the participant was asked to rate the hazardousness on a scale of 1 (not at all) to 7 (very much). The *hazard* group was specifically told to concentrate on producing an accurate hazard rating, while the *advertisement* group was also told that could pay attention to other stimuli such as advertisements. Both groups were aware that there would be a subsequent memory test. The memory test presented participants with a series of slides each containing one of the matched advertisements and three distractors. They were instructed to mouse-click on the advertisement they thought they had seen. Additionally, participants were asked to rate how confident they were that they had remembered the selected advertisement on a scale from 1 (complete guess) to 7 (100% certain).

3. Results

This section reports analyses of the participants' fixations on the advertisements, their hazard perception ratings for the clips, and the forced-choice memory scores.

During each experimental session, a video recording of the clips was taken, with a dot overlaid on the image to represent the focus of the participants' eyes (as measured by the eye tracker). These videos were coded, frame by frame, to assess whether the participants actually looked at particular advertisements. Several variables were recorded and analysed, including the number of advertisements that participants actually looked at, the time it took for participants to look at the advertisement from its first appearance, the number of fixations that the participants tended to make per advertisement, the average total amount of time spent looking at an advertisement, and the average fixation duration on the advertisements. The means for these measures can be found in Table 1.

The numbers of RLAs and SLAs that participants fixated were entered into a 2 × 2 mixed ANOVA with instruction set as the second variable. There were no main effects, but an interaction between the two factors was identified ($F_{(1,30)} = 4.3$, MSE = 2.65, $p < 0.05$; see Fig. 2). Conservative *t*-test mean comparisons with Bonferroni corrections identified that the main cause of the interaction is the large difference in fixations on SLAs between the hazard group and the advertisement groups ($t_{30} = 3.5$, $p < 0.001$). No other differences were significant.

For those trials during which the target advertisement was fixated, the amount of time between the advertisement first appearing on the screen and the participant's eye landing on it was calculated. One participant was removed from any further analysis as he did not look at any RLAs (and only two SLAs), leaving an empty cell. All remaining analyses in this section omit this participant.

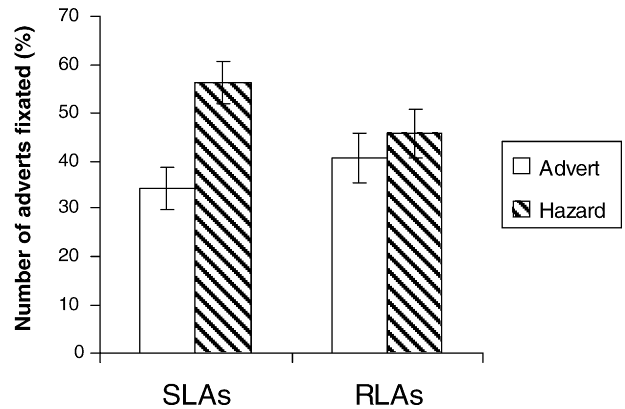

Fig. 2. The average percentage of advertisements that drivers looked at, across participants in the advertisement condition and the hazard condition, split according to type of advertisement (either SLA or RLA; with standard error bars).

On average SLAs were fixated 2.75 s after they first became visible on the screen, whereas RLAs were fixated 3.75 s after their appearance. This difference was found to be significant in a 2 × 2 mixed ANOVA ($F_{(1,29)} = 6.9$, MSE = 2.26, $p < 0.05$). Additionally, instruction set had an effect upon the time to fixate an advertisement ($F_{(1,29)} = 8.4$, MSE = 1.61, $p < 0.01$) with participants fixating advertisements sooner when primed to do so.

Another 2 × 2 mixed ANOVA was conducted on the mean number of fixations per advertisement (on those advertisements that were actually fixated). SLAs were found to get more fixations on average than RLAs (2.1 fixations compared to 1.5 fixations, respectively; $F_{(1,29)} = 19.1$, MSE = 0.31, $p < 0.001$). The total gaze durations (a summation of all fixations on the advertisements) was also analysed and a main effect of media type was found with greater total gaze durations found for the SLAs (928 ms) rather than the RLAs (522 ms; $F_{(1,29)} = 20.1$, MSE = 127,564, $p < 0.001$). Mean fixation durations just on the advertisements produced the same pattern when subjected to the same analysis, with SLAs attracting longer fixation durations (433 ms) than RLAs (354 ms; $F_{(1,29)} = 5.5$, MSE = 17,255, $p < 0.05$). Mean fixation durations across the whole clips were also calculated. A comparison of the average length of an advertisement fixation to the mean fixation durations across the whole clips can be seen in Fig. 3. Though inferential statistics are inappropriate for this comparison (as the two measures of fixation

Table 1
Means for eye movement measures that landed upon the target advertisements across all conditions (with standard deviations)

Instruction set media type	Advertisement		Hazard	
	RLAs	SLAs	RLAs	SLAs
Percentage of advertisements looked at (%)	40.6 (17.3)	34.4 (14.6)	45.6 (23.1)	56.3 (20.1)
Time from advertisement appearance to first fixation (ms)	3643 (1098)	1918 (1184)	3858 (1323)	3759 (1945)
Number of fixations on target advertisement	1.52 (0.34)	2.31 (0.78)	1.44 (0.35)	1.87 (0.56)
Total gaze duration on target advertisement (ms)	553 (254)	965 (578)	491 (221)	864 (382)
Mean fixation duration on target advertisement (ms)	371 (143)	406 (165)	338 (109)	448 (182)

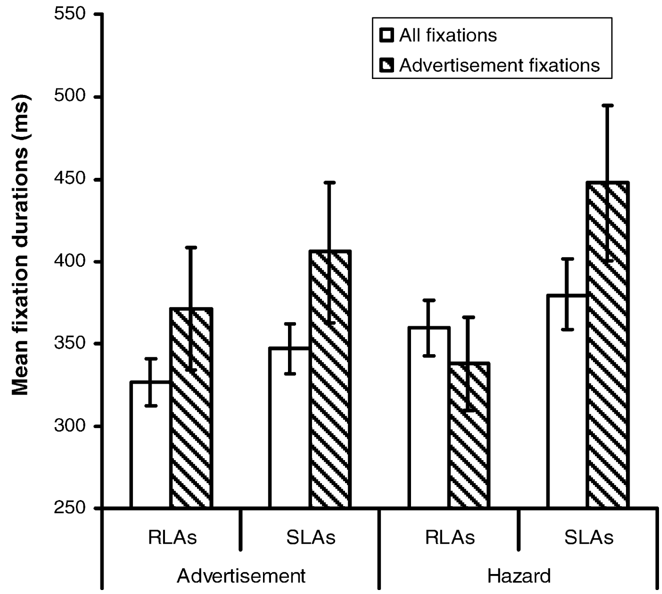

Fig. 3. A comparison of fixation durations for the whole video clips compared to average fixation durations on the advertisements (with standard error bars).

duration are not independent), the graph suggests that all adverts are associated with an increase in fixation duration above the clip averages, except RLAs when drivers are searching for hazards.

At the end of each clip, participants were required to rate how hazardous the drive was on a scale from 1 to 7, where higher numbers indicate a more hazardous interpretation of the clip. Analysis revealed a small but significant effect of media type ($F_{(1,30)} = 7.3$, $p < 0.05$) with clips involving RLAs being judged as less hazardous than clips with SLAs (with ratings of 3.4 and 3.7, respectively). No other significant effects were found.

Correct answers to the subsequent forced-choice memory test were subjected to a 2 × 2 mixed ANOVA. Though no main effects were evident the interaction between the two factors was marginally significant ($F_{(1,30)} = 3.7$, MSE = 329, $p = 0.06$). Post hoc mean comparisons revealed only one difference after Bonferroni corrections, between the memory scores for RLAs and SLAs in the *advertisement* group ($t_{15} = 2.9$, $p < 0.01$). The mean number of signs recognised in the memory test was not however significantly different from the mean chance expectancy (determined by a series of two-tailed one-sample *t*-tests), except for the SLAs when viewed by participants who were given instructions to look at the advertisements ($t_{(15)} = 4.7$, $p < 0.01$), but this result went in the opposite direction. The 10% of correct responses in this condition was significantly *less* than one would expect by chance. This surprising result is explored further in Section 4. The pattern of the results that produces the interaction can be seen in Fig. 4, and shows that when comparing relative memory scores, recognition for RLAs is better than that for SLAs, but only for those participants in the advertisement group. No significant differences were found between RLAs and SLAs in regard to participants' ratings of their confidence in their answers on the memory test and the interaction was not significant [$F_{(1,30)} = 1.3$].

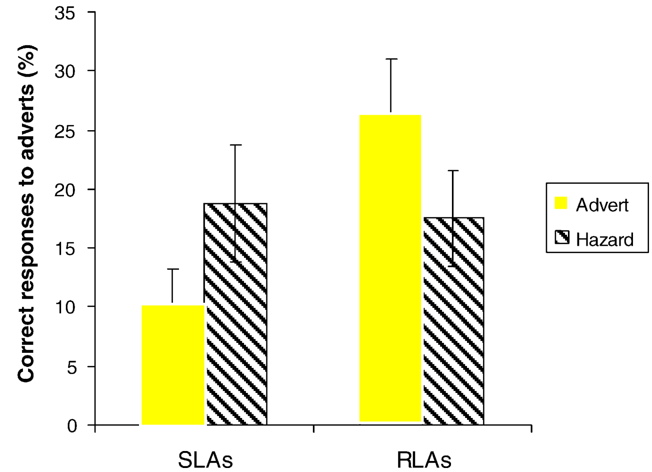

Fig. 4. The percentage of advertisements correctly recognized in the forced-choice memory test (with standard error bars).

4. Discussion

The results of this study have suggested a number of differences between RLAs and SLAs. Fig. 2 suggests that when participants are asked to just look for hazards, they fixate the majority of the SLAs. However, when primed to look for advertisements, participants fixate the SLAs significantly less. RLAs are however more consistent, falling somewhere in between the two extremes shown by the SLAs.

The increased number of fixations on SLAs in the hazard condition may reflect the fact that SLAs (predominantly bus shelters) are a source of potential hazards rather than the advertisement being the driving force behind the fixation. However, none of the clips contained pedestrians in the bus shelters that housed SLAs, and only fixations on the actual advertisements were counted (rather than all fixations on any part of the bus shelter being counted). All SLAs on bus shelters were on the outside of the shelter resulting in fixation locations that were distinct from fixations within the shelters (that may have been motivated by a search for pedestrians). Instead we suggest that the intention to move the eyes to wards an SLA is motivated by a search for hazards (favouring the horizontal search window), but the subsequent fixation upon the SLA is probably an inadvertent distraction of attention, and provides no information regarding potential hazards. Fig. 3 further suggests that when a fixation lands upon an SLA in the hazard condition, it tends to produce a longer fixation duration than the average clip fixation. Hazard perception searches in visually cluttered environments tend to have higher sampling rates and shorter fixation durations than in less complex environments, until, that is, a hazard is identified. At this point, visual search is restricted to the localized hazard and fixation durations increase (Chapman and Underwood, 1998). Fig. 3 suggests that the SLAs produce similar effects on fixation durations as an actual hazard, stopping search for other hazards, and potentially reducing peripheral attention, as increased resources are devoted to the fixated stimulus (Crundall et al., 1999).

The comparison of total attention devoted to the advertisements revealed SLAs to hold attention for longer compared to RLAs across both the hazard and advertisement groups. There are a number of reasons why this may be the case. First, increased fixation durations are usually seen as a measure of processing difficulty (e.g. Rayner, 1998). As half of the SLAs were identical to half of the RLAs (between-groups), this is less likely to be simply due to systematic differences in the nature of the advertisements. Instead the increased processing may be due to the location of the advertisement. SLAs tend to appear in more cluttered areas of the visual scene, close to other street furniture, passing vehicles, etc. The proximity of distractors to a target has long been recognized to increase the amount of time it takes to respond to the target (e.g. Eriksen and Eriksen, 1974; Logan, 1996), and visual clutter in realistic scenes tends to increase visual search time for a target element (Boersema, 1989). The embedded nature of SLAs within a complex scene may produce the same result. RLAs, however, have the benefit of being placed outside the horizontal window of information, and it is possible that the reduced visual clutter of RLAs' background (usually viewed against the sky or high buildings when at the point of greatest legibility) results in shorter fixation durations being required to extract the same level of information.

A second explanation for shorter fixation durations and gaze durations on RLAs may be related to the visual angle at which they are presented compared to SLAs. Drivers tend to become uncomfortable looking away from the road for longer than a second, and prolonged fixations away from the road ahead can negatively affect steering behaviour (Land, 1998). Though RSAs may benefit from being outside the horizontal window (by not distracting attention at the wrong moment, or from the high contrast with a less cluttered background), their location (when most legible) requires the driver to move their eyes further up in the visual scene than drivers are normally used to. The desire to continue processing a RLA after the initial fixation must be weighed against the urge to return to looking at the road ahead (typical of many scan paths—Underwood et al., 2003). The greater the distance between the fixation on an advertisement and the road ahead, the greater the impulse to return the eyes to the forward position as soon as possible. As RSAs are further away from the optimum fixation position than SLAs, it is natural that drivers will tend to fixate RSAs for a shorter amount of time.

The results of the memory test, when considered in terms of their relative scores, demonstrated an advantage for RSAs over SLAs for those participants who were primed to look for advertisements, despite shorter fixation durations, suggesting that the longer time spent looking at SLAs did not improve recognition memory. In addition to the possible added difficulty of processing SLAs compared to RLAs due to the background they are embedded in, there is also the likelihood that as participants in the hazard group were not intending to process the advertisements, any inadvertent processing that was done was not stored.

One caveat to the memory performance must be pointed out however. The forced-recognition test had a chance probability of 0.25. If this is taken into account, then only the SLAs in the advertisement condition are significantly different from chance, but they are correctly identified significantly *less* than chance. This is most probably due to the chance expectancy being biased away from 25%. All of the distractor advertisements in the memory test were real advertisements used in real campaigns. The majority of these advertisements were taken from websites detailing marketing campaigns, and as such they were mostly current advertisements with a reasonable profile. The target advertisements however were recorded onto video clips 3 months prior to testing, and therefore due to the fast turnover of advertisements in the outdoor media industry, were less likely than the distractors to have been in circulation at the time when the experiment was conducted. Additionally, in order to make sure that we had 10 fully matched advertisements in our stimulus set, half of the advertisements were made up especially for this study and were filmed as both SLAs and RLAs. This has the unavoidable side effect that our participants would have not seen these particular advertisements previously, whereas the distractor advertisements may have been seen by the participants in the days preceding the study. This possibility is further reinforced by the participants' wrong answers. In some of the trials where incorrect responses were made to a distractor advertisement, one of the three distractors accounted for the majority of the incorrect responses. This suggests that this particular distractor was especially salient, either due to bottom-up factors such as colour, or top-down influences (perhaps the participant saw the distractor advertisement on their way to take part in the experiment).

Both of these problems suggest that while chance guessing might indicate a 25% mean chance expectancy, when one factors in potential bias caused by particular distractors, the actual expectancy may be much lower. On this basis, one must be wary of judging the memory test against chance expectancy, though there is no reason to doubt the relative differences between the memory performance for RLAs and SLAs across the factor of instruction set. There are no systematic differences in the advertisement content that could account for these findings, as all the memory targets were matched across media and participants.

One further potential concern is the extent to which eye movements while watching video clips of driving reflect the visual patterns that would occur with real driving. The current results however compare favourably with the few studies that have measured eye movements during real driving when looking at advertisements. Smiley et al. (2004) noted an average of 1.9 fixations on video advertisements which she reported was comparable to other studies that had used static advertisements during real driving (Luoma, 1991; Zwahlen, 1987). The averages for the current study ranged from 1.4 to 2.31 across all conditions. Fixation durations and total gaze durations also compare favourably with Smiley's data. Our own research has investigated eye movements during real driving (Crundall and Underwood, 1998), and while watching video clips of the exact same roads (Underwood et al., 2002). The results suggested that eye movement patterns were similar despite the difference in visual input, though the presentation of video clips needs to strictly controlled in terms of visual angle and resolution if the best results are to be achieved (Staplin, 1995).

In conclusion, it appears that SLAs tend to attract more attention than RLAs but this is predominantly when participants were more concerned with looking for hazards. We argue that this suggests SLAs can capture (or distract) attention at inappropriate times, potentially reducing drivers' attention to task-relevant stimuli. This does not benefit the advertiser as the increase in fixations does not necessarily represent meaningful processing or storage, as evidenced by the results of the memory test. More important, however, is the potential for such distraction to increase the probability of being involved in an accident. Assuming that drivers' propensity to search for hazards is positively correlated with the actual likelihood of a hazard (which is the aim of hazard perception training), then a real hazard is more likely to occur while a driver is fixating an SLA than an RLA. If attention is held by an SLA during the onset of a hazard, then any required emergency manoeuvres may be delayed, increasing the likelihood of an accident.

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