Examining the effect of advertisements on the perception of a road scene: a comparison of change blindness in drivers and non-drivers

Georgina Frost

Supervised by: Dr Adam Galpin

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ABSTRACT

External-to-vehicle items such as roadside advertisements have the potential to divert attention greater than a driver's attentional capacity which may lead to changes to road scenes going unnoticed and result in road accidents. The aim of this research was therefore to understand the role of advertisements and attention during change detection and to determine the effect advertisements have on scene perception. Through the use of an opportunity sample 17 drivers and 13 non-drivers took part in the experiment. The experiment employed the flicker paradigm and participants were asked to identify a change between two road scenes that were identical apart from the one change. As anticipated, faster reaction times were identified in the no advertisement conditions compared to both the large and small advertisement conditions. Furthermore, faster reaction times and superior detection accuracy were found in the conditions with large advertisements compared to those with small advertisements. Unexpectedly though driving experience did not affect change detection. It was concluded that road-side advertisements have an adverse effect on the successful perception of a road-scene, however, the effect advertisement size has on scene perception requires more exploration.

KEY WORDS:	**CHANGE BLINDNESS**	**ATTENTION**	**MEMORY**	**ADVERTISEMENTS**	**DRIVING**

INTRODUCTION

The Department for Transport (2010) reported that during 2009, 38% of people who reported a road accident to the police stated 'failing to look properly' as the main reason for such an incident. This indicates that 'failing to look properly' is still the biggest contributory factor for road accidents on British roads, a finding which can be attributed in part to an insufficient visual search by the driver. However, what is less well explained is accidents caused by 'looking but failing to see', a concept where a driver may actively search a visual scene and yet may not notice any observable changes to it (Koustanai et al, 2008). This failure to notice change is recognised as change blindness which refers to the phenomenon in which "people fail to notice large changes to visual scenes", and demonstrates, in the driving domain, the significant effect a failure to notice change has on the perception of a complex visual scene such as a road (Simons & Ambinder, 2005, p.44). Change blindness is important in understanding key cognitions including visual perception, memory, and attention, with driving experience being an important factor affecting these cognitions when an individual is in a driving situation. Indeed, the vulnerability of inexperienced drivers is particularly well documented, especially within crash statistics in which novice drivers are significantly over-represented (Konstantopoulos et al, 2010). These differences mean there is disparity in the perception, memory and attention of the road between individuals with differing driving experience which ultimately have an effect on observing changes to road scenes.

Roadside advertisements pose a distraction to the attention of drivers on the road, with the car insurance company Privilege (2005; cited in the Highways Agency, 2008) stating that roadside advertisements had distracted 83% of people at least once whilst driving. The Highways agency (2008) also states there are specific characteristics of road-side advertising, such as size, that may distract road users from attending to the road sufficiently. Size is an important element of advertisement as bigger advertisements are attended to more so than smaller ones (Outing & Ruel, 2004). What is less well known however is the possible effect the size of roadside advertisements have on driver distraction, and this combined with an application to the change blindness paradigm, forms the basis of this research.

Change Blindness

An inability to notice changes to visual scenes, or change blindness, is an area of cognition with great significance, with the failure to notice even large changes between visual scenes showing that the brain does not hold a complete representation of the visual world (Tatler and Land, 2011). Indeed, changes between scenes have been found to be unnoticed in even brief moments of visual disruption such as the blink of an eye (O'Regan et al, 2000), a saccade (Henderson & Hollingworth, 1999), or in regards to a driving situation for example, a splash of mud on the windscreen (O'Regan et al, 1999). The effect of change blindness can be quite striking. Simons and Levin (1998), for example, found in a change blindness field experiment that more than 50% of pedestrians that had been asked for directions failed to notice that the person that had initiated the conversation for directions was different to the one they were speaking to at the end of the conversation. The change was accomplished by a door separating the pedestrian and the experimenter midway through the conversation, and although the replaced person differed in clothes, voice and appearance, change blindness still occurred.

This suggests that visual memory may play a part in change blindness as the specific details of a scene are unable to be retained from one moment to another and to be remembered therefore need to be integrated into memory. Supporting evidence for this comes from one of the earliest studies conducted using a change blindness paradigm by McConkie and Currie (1996), who discovered that if changes to a house scene were made during a saccade, that large changes to that scene could be missed by participants. They attributed this inability to notice change to the brain, integrating information gathered from successive fixations which are aimed at making the world appear coherent, inadvertently missing changes that may have occurred during saccades. However, several limitations emerged in McConkie and Currie's (1996) study. Firstly, as changes to the scene were only made during saccades, numerous participants did not make a sufficient number of saccades for the changes to take place.

Also, eye tracking issues arose when a participant blinked. These limitations have been overcome in subsequent change blindness experiments by the flicker paradigm in which changes to scenes are not made during saccades but in which changes to scenes are separated by a 'flicker' (e.g. Rensink et al, 1997). This enabled researchers to establish that change blindness was not just attributed to eye movements but other visual disruptions as well. These types of visual disruptions disguised 'motion signals' which can capture attention when change occurs without a disruption and led authors such as Rensink et al (1997) to ascertain that to perceive change, attention is also needed. They concluded that without the visual disruptions, changes would be easy to observe. Conversely, Simons et al (2000) found that change blindness could occur without a visual disruption, if for example the change occurred gradually, and that motion signals did not seem to draw attention to the change as would be expected.

Such a notion holds particular significance with the driving domain as drivers hold an internal belief that their attention will be drawn to a visible change and therefore do not need to memorise details of a visual scene in order to detect a change (Levin et al, 2000). However, as Simons and Rensink (2005, p.17) acknowledge "the mistaken belief that unexpected events always draw attention might help account for 'look but didn't see' automobile accidents". As drivers also engage in more saccades when driving than when viewing a static scene, which from previous studies (e.g. McConkie and Currie, 1996) has been found to affect change blindness, changes can be easily missed (Cohen, 1981). The importance of change blindness in the driving domain is therefore significant. Numerous studies have been conducted in such a domain and several factors that attenuate change blindness have been identified. Semantic relevance is one such factor.

Since it is understood that only until a fixation is made to an object that visual information is retained (Ashcraft, 2006), such a belief relates predominantly to bottom-up processing where until a stimulus is successfully attended to, it will not be perceived or able to enter short term memory, and as a result changes to such a stimulus will be unnoticed (Styles, 2005). As bottom-up processing is influenced by top-down processing and existing memory, change blindness to items that conform to that of an individual's schema are typically less attention grabbing than items that do not fit with such a schema which are able to grab attention (e.g. Friedman, 1979). Semantic relevant items are therefore less attention grabbing than non-semantically relevant items and changes to such items are therefore harder to determine. In relation to the driving domain, however, an opposite effect has mainly been noted. Galpin et al (2009), for example, found using a flicker paradigm that changes to a road-scene that were relevant to the correct safety of the road were located more quickly than changes to irrelevant objects. Galpin et al (2009) attributed this difference to an activation of a driving schema whilst viewing the stimuli which directed attention to elements of the scene which were relevant to driving. This goes against the belief that items that are unrelated to a schema are more likely to direct attention, a result of which could lie with the complex nature of a road-scene meaning attention has to be focussed.

Galpin et al (2009) also found that the effect of semantic relevancy was not mediated by driving experience, such that drivers and non-drivers were able to find changes to the road scenes in moderately the same amount of time. This is against previous research which has determined that the experience of an observer affects change blindness; Werner and Thies (2000, p.163) found in a comparison of 24 American football experts against 24 American football novices that experts were able to perceive changes to American football-related stimuli greater than the novices, and concluded that “expertise in a specific domain increases observers’ sensitivity to semantic changes of domain-related images”. A more recent study in the driving domain by Osborn and Owens (2010) supported such findings and established that non-drivers were slower at responding to changes to road scenes compared to drivers with over 3 years of driving experience. If change blindness is to be truly applicable to the driving domain then specific characteristics that differentiate drivers on the basis of experience, and that attenuate change blindness, must also be apparent; evidence of which will be explored now.

Driving Experience

Throughout 2009, in excess of 220,000 road causalities were reported to police; the overall fatality rate of which was highest for 17-21 year olds (Department for Transport, 2010). This age category is highly synonymous with inexperienced drivers, and differences in fatality rates have been attributed in part to the lack of experience such road users have (The Royal Society for the Prevention of Accidents [RoSPA], 2010). If driving experience is a key component of resulting accidents then why is this so? Several explanations have been proposed which infer that novice driver’s driving ability is inferior to that of more experienced drivers in a number of different ways (Mayhew and Simpson, 1995). These explanations have included differences in hazard perception, visual scan paths, and attention.

Firstly, differences in hazard perception between novice and experienced drivers have been identified. Deery (1999) found in a comparative study of hazard and risk perception between young-novice and experienced drivers that the risk of an accident was significantly underestimated and hazards were detected much slower in the young-novice drivers. This is supported by Sagberg and Bjornskau (2006) who after comparing hazard perception in drivers either 1, 5 or 9 months after they had passed their test against experienced drivers, concluded that response times to the hazards were significantly related to driving experience, such that as driving experience increased, hazard perception also increased. Deery (1999, pp. 225-226) based such findings on novice driver’s “limited experience to develop complex, higher-order perceptual and cognitive skills required to safely interact with the traffic

environment". If this is true then such an explanation could elucidate why differences in change-blindness between those of differing driving experience exists.
A further explanation, which is particularly attributable to change blindness, relates to a difference in visual scan paths between individuals of differing expertise. Various research has been conducted in this area including expertise in pilots (Bellenkes et al, 1997); goalkeepers (Savelsbergh et al, 2002); and chess players (Reingold et al, 2001), and all have concluded that expertise in a particular field equals widened visual scan paths to areas they are searching, and more fixations to essential items. In the driving domain similar findings have also been found. Underwood (2007) examined visual search strategies for novice, experienced, and police drivers watching driving video-clips of various road types and discovered that experienced drivers increased their visual scan paths when faced with an increase in the complexity of a road more so than novice drivers and that this effect was even more increased in police drivers.
These results have been replicated in a number of other experiments conducted by Underwood (e.g. Underwood et al, 2002; Underwood et al, 2003), and the use of video-clips in such studies allowed the elimination of in-vehicle demands in order to focus solely on visual scan paths. A comparison of learner drivers and instructors also demonstrated a wider visual scanning of the road in the experienced drivers (i.e. instructors) compared to the learner drivers and found that the instructors had a greater fixation of the rear view mirror than the learner drivers (Konstantopoulos, 2009). Underwood et al (2002) stated that results from such studies indicate that novice drivers are unable to scan roads sufficiently as they have not yet acquired the knowledge of hazardous events that occur on roads; findings of which link closely to memory, a key dimension of change blindness, which again could suggest why differences in change blindness for drivers of differing experience exist.
Another factor that separates drivers on the basis of experience is attention. A wide range of in-car elements have been found to distract road users and divert vital attention away from the road including mobile phones (Lamble et al, 1999; Patten et al, 2004), satellite-navigations or 'sat-navs' (Jensen et al, 2010), and other passengers (Vollrath et al, 2002), and it is understood that the effect of distracters is underestimated in drivers as they do not recognize their reduced attentiveness or hazard perception (RoSPA, 2007). These effects though are mediated by driving experience, such that less experienced driver's direct attention to elements within the vehicle, which are not required to maintain the correct safety of the road, more so than experienced drivers. Vollrath et al (2002) identified that in certain circumstances though not all, passengers provided a protective effect to drivers to maintain cautious driving by identifying hazardous situations; in novice drivers though this was significantly reduced.
These results have been replicated in numerous studies examining the effect of passengers and the experience of driver (e.g. Chen et al, 2000; Doherty et al, 1998; Preusser et al, 1998). As well as in-car distractions, several external-to-car distractions, such as pedestrians and other motorists, also exist which can divert attention (Baker & Spina, 2007). The most prominent external-to-car distraction though is road-side advertisements which divert attention around 30%-50% of the time, reflecting the substantial amount of spare attentional capacity a driver may have (Hughes & Cole, 1986). Despite road-side advertisements diverting a substantial amount of attention, minimal research has been conducted on whether

this is accentuated by driving experience. It is important to ascertain therefore if driving experience affects attention when a road-side advertisement is present, particularly if such attention is diverted at the same time as a change to the road-scene. This is an area which will be discussed further in a later section, below.

In sum, there is an essential problem with diverting attention to irrelevant elements of the road, a problem that relates to the term inattentional blindness. Similar to change blindness, inattentional blindness refers to the failure “to see an object we are looking at directly, even a highly visible one, because our attention is directed elsewhere” (Mack, 2003, p.180).

Inattentional blindness can have major implications for road safety, a factor of which led to a road safety campaign by Transport for London (TfL) aimed at highlighting the effect inattentional blindness can have on cyclists (The Guardian, 2008). The campaign was based on one of the most widely demonstrated inattentional blindness studies by Simon and Chabris (1999) in which two teams wearing either black or white clothes passed a basketball around their respective group, with participants calculating the number of times the basketball was passed between either the black or white group. As the two teams passed around the basketball, either a woman carrying an umbrella or a woman dressed in a gorilla suit infiltrated the scene for 5 seconds. Out of 192 observers, only 54% were aware the unexpected event had occurred, a finding which demonstrates the importance of attention in perceiving changes to scenes, and relates particularly to the driving domain where the effects of inattention in inexperienced drivers are pronounced.

However, it must be noted at this point that experience does not always equal expertise. It has been widely demonstrated that as humans age, our cognitive functions of attention, memory, and perception decrease (Keefover, 1998; Rabbitt, 2002). These functions have significant importance when we drive and it has been extensively conveyed that older drivers, even though they have an abundance of driving experience, may be less safe than drivers that are of a younger age and who have acquired less driving experience (Wood & Mallon, 2001). Such beliefs have been applied to the change blindness paradigm where it has been noted that as age increases, reaction times also increase, a result that is attributed to deteriorating memory and attention (Rizzo et al, 2008). Age, therefore, appears to be a confounding variable which can influence driving experience. In order to eliminate such a problem from this study and to determine differences attributable purely to driving expertise, drivers will be compared with non-drivers. As other change blindness studies (e.g. Galpin et al, 2009; Osborn & Owens, 2010) have followed such a method, this appears to be an appropriate methodology to follow.

Advertisements

The risk of road-side advertisement on driving safety has become one of rising concern due to the fact that road-side advertisements affect drivers by “directly distracting or confusing them while driving; taking [their] eyes off the road; and obstructing visibility” (Bendak & Al-Saleh , 2010, p.233). As a result, road-side advertisements are classed as one of the greatest external-to-car distractions a driver may face when in a driving situation which could be due in part to the very purpose of advertisement designs; to attract attention (Young & Mahfoud, 2007). In 2005, the car insurance company Privilege (cited in The Highways Agency, 2008) found that road-side advertising had distracted 83% of drivers at least once whilst driving. This is unsurprising given the vast amount of attention that is able to be diverted to road-side advertisements. As previously mentioned, advertisements divert up to 50% of attention at any given time, a figure reflecting the spare attentional capacity that a driver may have when driving (Hughes & Cole, 1986). However, the increasing complexity of the visual driving world means the possibility of road-side advertisements diverting attention greater than a driver's spare attentional capacity is amplified (Wallace, 2003). This effect has been examined extensively on reaction times. Johnston and Cole (1976; cited in Wallace, 2003), for example, conducted an experiment in which participants had to respond to an arrow and a small spot of light on screen whilst being presented with numerous advertisements. They found that response times worsened as the number of advertisements increased. Holohan et al (1978), also in an experimental design, discovered that the time needed to locate a target stimulus (i.e. a stop sign) decreased as the number and proximity of advertisements increased. Both these studies indicate the distracting effect advertisements and a complex visual environment have on the perception of a scene, effects of which could increase the likelihood of accidents occurring if attention is diverted.

Indeed, the effect of road-side advertisements on accident rates has been studied for several years. In one of the earliest studies conducted in the area, it was found that the rate of accidents over a two-year period was greatest in an area containing 90% of the wider population's road-side advertisement (Rusch, 1951). This is supported by Staffeld (1953) who discovered that there were higher rates of accidents in areas with road-side advertisement compared to roads without. However, these studies have been criticised on the basis that they are correlational and fail to establish a true cause and effect relationship (Wallace, 2003). Despite their high ecological validity, they do not confirm if road accidents are purely attributable to road-side advertisements. Such a problem has been overcome in subsequent studies by experimental designs. Bendak and Al-Saleh (2010), for example, used a driving simulator to assess driving performance on a road with advertisement present and an identical road without such advertisement. They found that driving performance indicators of 'drifting from lane' and 'recklessly crossing dangerous intersections' were significantly poorer in the simulated roads with road-side advertisements than the simulated roads without, and although there were differences in the driving performance indicators of 'number of tailgating times', 'over-speeding' and 'turning or changing lanes without signalling', these differences were not significant.

The findings of the above studies relate to a theory of cognitive overload; a theory which emphasises the problem of too much visual information or 'visual clutter' on driver attention (Wallace, 2003). If a driver is presented with too much visual clutter, they will typically be unable to view and process the information given due to being mentally overloaded (The Highways Agency, 2008). The adverse effects of cognitive overload have been supported by a number of studies including the ones presented above (e.g. Young et al, 2009; Young & Mahfoud, 2007). A study of particular importance comes from Luoma (1984) who, when comparing driver perception, found that the accurate perception of road-side advertisements and traffic signs increased as the duration of fixations also increased. However, Luoma (1984) also discovered that when both the road-side advertisements and traffic signs were presented in the same stimuli, the accurate perception of the traffic sign was reduced, an effect that was not attributed by Luoma (1984, p.128) to a difference in fixation but to a “prevention of further information processing”. Such studies show a possible link to the change blindness paradigm where the need to locate a change in a road scene may be impacted on by increasing visual clutter such as road-side advertisements. It therefore appears necessary to determine the effect of advertisements on change detection to establish the true consequence of road-side advertisement distraction.

Furthermore, although road-side advertisements have been found to affect driver attention, it has also been identified that specific characteristics of road-side advertisements may distract drivers from attending to the road sufficiently more so than others. This can include the location, content, illumination or size of the advertisement (The Highways Agency, 2008). Size is an important element of advertisement and it has been found that bigger website advertisements are attended to quicker than smaller ones (Outing & Ruel, 2004). Despite its importance there has been limited research on the relationship between the size of road-side advertisement and driver distraction, and if this is further influenced by driving expertise. This therefore appears to be a suitable area to explore in greater detail within this study.

Thus, with the increasing presence of an array of advertisements on the road-side it is of interest as to the effect such advertisements have on the visual perception of a road scene. This research was conducted to determine whether external-to-vehicle elements that distract attention, such as road-side advertisements, were related to change blindness during the perception of a road scene, and if drivers were able to detect changes to road scenes more quickly and efficiently than non-drivers.

Aims and Hypotheses

The aim of the study was to see if drivers show a difference in the perception of a road scene compared to non-drivers; specifically a difference in the change blindness of driving relevant objects (in order to activate a driving-related schema) in either the presence or absence of large versus small road-side advertisements. The main aims of the study were to assess the relationship between driver’s experience and the perception of road-scenes; to establish whether drivers notice changes to road-scenes more quickly than non-drivers; to determine if road-side advertisement had an effect on the detection of change to road relevant objects; and to determine whether the size of road-side advertisements affected the attention of drivers.

This was examined in two groups; drivers and non-drivers who participated in a change blindness experiment using the flicker paradigm. Stimuli consisted of road scenes, a third of which consisted of roads with a large advertisement present, a third of which consisted of roads with a small advertisement present, and a third of which consisted of roads with no advertisements present. Reaction times and accuracy scores were gathered from the participant’s response to and location of the change.

It was hypothesised that:

1. Drivers would be quicker and more accurate at responding to changes to road-scenes than non-drivers.
2. Change-detection would be quicker and more accurate in road-scenes with no advertisement present than road-scenes with advertisement present.

3. There would be a difference in accuracy and response times to changes in road-scenes with large advertisements versus road-scenes with small advertisements.

METHOD

Design

The design of the experiment was multi-factorial with repeated measures. The experiment used two factors which included the ‘experience of driver’ and ‘type of advertisement’. The between-groups factor of ‘experience of driver’ focused on two levels; driver and non-driver and the within-groups factor of ‘type of advertisement’ focussed on three levels; large advertisement, small advertisement, and no advertisement. The dependent variables consisted of response time, which was measured using E-prime computer software which recorded the time (in milliseconds) it took to respond to the change in the stimulus presented on screen, as well as accuracy, which again was measured using E-prime computer software which recorded whether a participant correctly indentified the location of the change in the stimulus.

Participants

Participants were chosen through the use of an opportunity sample of undergraduate psychology students at the University of Salford and were recruited through lectures and seminars. A priori power analysis with a medium array size and power size of 0.8 indicated that a total of 30 participants were needed to take part in the experiment. 30 participants (24 female and 6 male, aged between 19 and 40) agreed to take part in the experiment of which 17 were drivers and 13 were non-drivers. Drivers were classified as those who held a valid full driving licence for a car and drove on average 1 day a week. All participants had normal or corrected to normal vision.

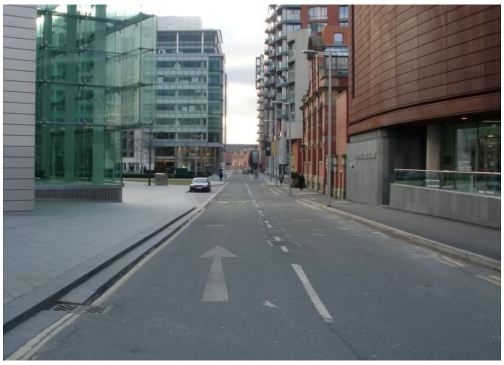
Materials

Road scene images:

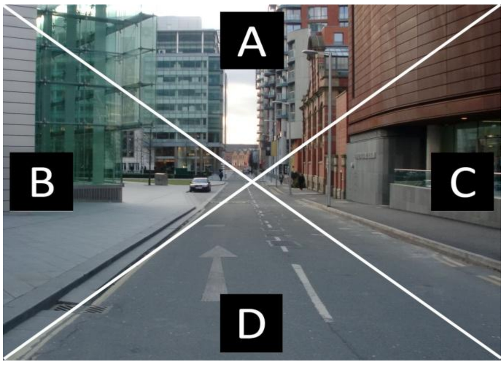
65 images of road scenes, which were taken from the driver’s perspective, were used in the experiment of which 20 showed a road scene with a small advertisement present, 20 showed a road scene with a large advertisement present, and 20 showed a road scene with no advertisement present. A further 5 images were used as practice trials at the start of the experiment. Images were duplicated and road relevant changes (such as changes to signs and cars) to the duplicated image were made by either the deletion of an object or insertion. A split screen image divided into four marked sections (A, B, C, and D) was also made from the first original image; however, if the second (changed) image had encountered a road relevant change by insertion, then the split screen image was created on the second image instead. The split-screen was required to determine whether participants were correctly identifying the changes to the stimulus or were just guessing. If any participant was guessing, the forced-choice location test would show accuracy at approximately 25%.

Each image was used only once in the experiment. The images were specifically taken for the experiment on a digital camera and comprised of urban roads in the Manchester, Salford, and Macclesfield areas. Each image was edited using Adobe Photoshop (Version 12.0) software. Examples of the road scene images can be seen in figure 1. A total of 60 paired stimuli were created for the experiment and were shown randomly by E-prime (Version 1.0) computer software. A further 5 paired stimuli were created for practice trials and were again shown randomly by E-prime computer software.

Original Image



Changed Image



Split Screen Image

Figure 1: Example road scene images.

E-Prime computer software:
E-prime computer software was used to measure the response times and accuracy of the participants. It measured response times by calculating the time (in milliseconds) the participant took to respond to the change in the stimulus, and measured accuracy by calculating the number of times the participant correctly identified the location of the change in the stimulus.

Procedure
Prior to the experiment beginning participants were provided with the information sheet detailing the nature of the experiment and asked to read it (Appendix 1). The

information sheet gave a brief overview of what would happen in the experiment. The information sheet also explained that results would be kept confidential and anonymous, would only presented as group data, and that participants would be free to withdraw from the study at any time, without giving reason by contacting the principle researcher. The information sheet also informed participants that there would be no possible risks of taking part in the experiment, and that the experiment would not be testing their driving proficiency if applicable. Contact details of the principle researcher and supervisor were also provided, along with details of a relevant road safety website. Participants were given a minimum of 24 hours to read the information sheet and had the opportunity to ask questions if they did not understand any aspect of the experiment. If they agreed to participate, participants were then asked to complete a consent form (Appendix 2) and a demographic questionnaire (Appendix 3).

All participants that wished to take part in the experiment were required to complete the consent form which asked them to confirm that they had 1) read and understood the information sheet for the study and understood what their contribution would be, 2) been given the opportunity to ask questions, either face-to-face or via email, 3) agreed to take part in the experiment aspect of the study, 4) understood that their participation was voluntary and that they could withdraw from the study at anytime without giving reason, and 5) agreed to take part in the study. Participants were then required to sign and date the consent form as further confirmation of this. Demographic information such as the age, gender, and driving experience of the participant were collected separately. After both the consent form and demographic questionnaire were completed by the participant they then began the experiment.

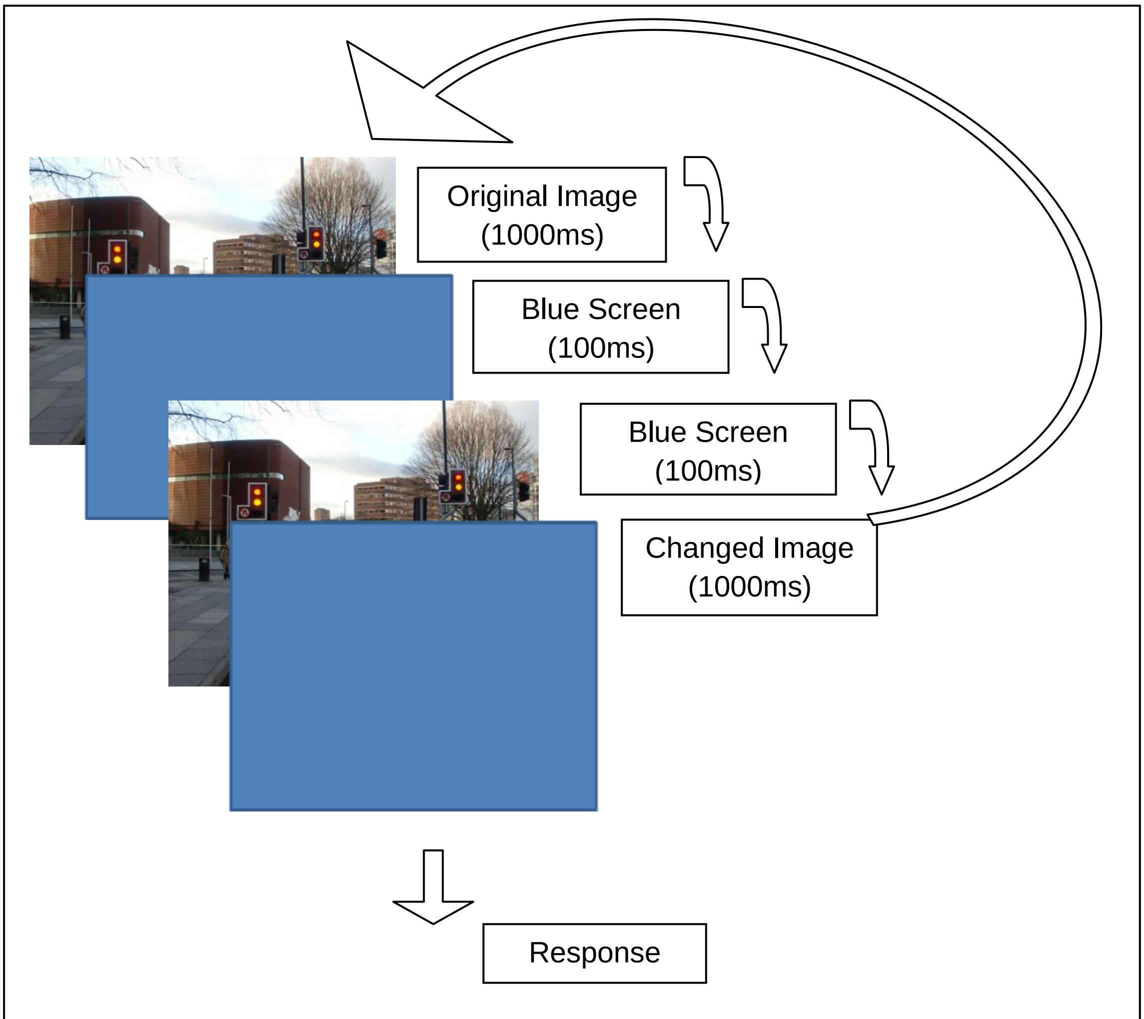
The experiment took place on E-prime computer software, with participants being presented with a set of instructions on the initial screen. The instructions were taken from a previous change blindness experiment (Galpin et al, 2009). After participants had read and understood the instructions and had the opportunity to ask questions about any aspect of the experiment they did not understand, they then began the practice trials. Once the practice trials had commenced, participants were presented with a fixation cross in the middle of the screen which they had to focus on, the first of the paired stimuli images was then presented (i.e. the original image) followed by the second of the paired stimuli images (i.e. the changed image). The participants then had to identify a change between the images by pressing the spacebar. The images were displayed for 1000ms each and were separated by a blue screen for 100ms. The stimuli were shown on a loop (i.e. original image for 1000ms, blue screen for 100ms, changed image for 1000ms, blue screen for 100ms) until the participant had responded to the change.

Participants were then presented with a split screen divided into four equal sections (A, B, C, D) in which they had to identify the part of the image the change had occurred. An example of the sequence of stimuli displayed in the experiment can be seen in figure 2. However, if a participant was unable to find the change in the scene, even after searching the scene thoroughly, they then had to respond to the scene as if they had seen the change, i.e. by pressing the spacebar, but then pressing ‘E’ when they got to the split screen. This allowed participants to avoid guessing the location of the change once they had arrived at the split screen; however, this option was regarded as a last resort and the participant must have thoroughly searched for the change in the image before doing this. After inputting an answer at the split screen stage, the participant was then told if they were correct or incorrect and the experiment moved onto the next trial. If a participant had pressed 'E' then they were automatically told they were incorrect. In total, 5 practice trials were completed by the participants.

After completing the 5 practice trials, participants were then informed that the practice trials had ended and asked if they had any questions about what to do in the experiment before beginning the experimental trials. This was the last opportunity for participants to ask questions about the experiment before the experimental trials began. Once participants had begun the experimental trials they were presented with one of the 60 paired stimuli; 20 depicted a road with no advertising, 20 depicted a road with small roadside advertising, and 20 depicted a road with large roadside advertising. Participants then had to identify the change in the image. Trials were randomised and each of the paired stimuli was presented once leading to a total of 60 trials. Both the practice and experimental trials combined took approximately 15 minutes to complete. Once the experiment was complete participants were debriefed and thanked for their time. Participants were also informed of their participant number and told they would need to quote this if they would like to withdraw from the study.

Analysis

For this experiment descriptive statistics (the mean and standard deviation) were calculated for each condition. Accuracy was calculated as a percentage of correct change locations. An inferential statistics test was then conducted. As the data was ratio data and the design of the study was multi-factorial with both repeated and between groups measures, the experiment met the conditions to use a parametric test of difference and so a 2 factor (3 x 2) mixed ANOVA was used.



Split Screen Image

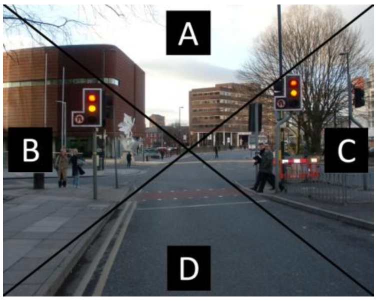


Figure 2: Sequence of stimuli used in the experiment.

RESULTS

The experiment went as expected without any abnormal events that may have produced error. Although several participants initially struggled with immediately pressing the spacebar when they had spotted the change or became confused as to whether the change was occurring on each of the paired stimuli, the practice trials allowed such problems to be eliminated from the experimental trials. It appeared that no participant was guessing to the location of the change as no participant's accuracy score was around chance or 25% (see Appendix 4: Raw Data). If a participant's accuracy score had been around chance or 25% they would have been eliminated from the study. Fortunately, in this study, this did not occur. The reaction times, accuracy, driving experience, gender and age of each of the 30 participants were therefore entered into a table of raw data for analysis (Appendix 4).

Reaction Time

The mean reaction times and standard deviation were calculated for each of the combined type of advertisement and driving experience conditions on correct responses only (Table 1).

Table 1

Mean reaction times (in ms) and standard deviation for the combined type of advertisement and experience conditions.

Type of Advertisement	Experience	Mean Reaction Time (in ms)	Standard Deviation	Number of Participants
Large Ad	Driver	7074	2068.65	17
	Non Driver	6647	1987.42	13
	Total	6889	2010.37	30
Small Ad	Driver	10092	4026.88	17
	Non-Driver	9905	3607.87	13
	Total	10011	3787.04	30
No Ad	Driver	5213	1641.84	17

	Non Driver	5338	1351.84	13
	Total	5267	1499.14	30
Total	Driver	7459	2239.68	17
	Non-Driver	7296	2141.62	13
	Total	7388	2161.51	30

The mean reaction times (Figure 3) show that reaction times were quicker for non-drivers in the conditions with advertisement present and quicker for drivers in the conditions with no advertisements present. Overall, reaction times were quicker when there was no advertisement present compared to when there was an advertisement present (Figure 3). In relation to the type of advertisement present, response times were quicker for both drivers and non-drivers for road scenes with large advertisements present compared to small advertisements. The fastest response time overall was experienced by drivers when no advertisements were present (Table 1). The standard deviations (Table 1) were also very high in all conditions showing that response times were widely spread across from the mean.

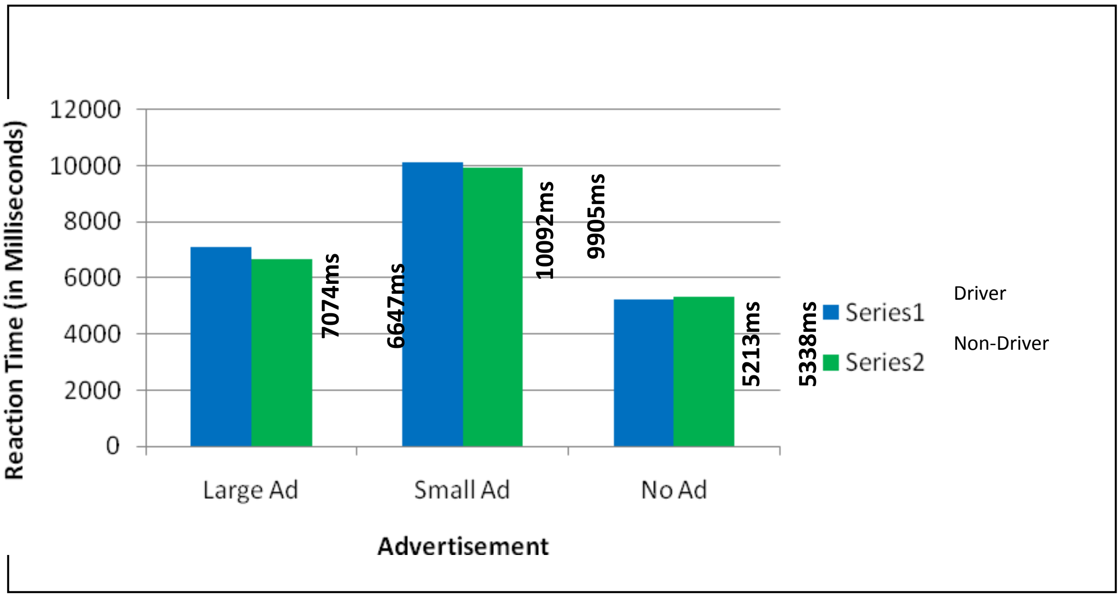


Figure 3: Mean reaction times for 'type of advertisement' condition for drivers and non-drivers.

A two factor, 3 (Type of advertisement) x 2 (Driving experience), mixed ANOVA was used to analyse the reaction time data (Appendix 5). It was revealed that the main effect for 'type of advertisement' was significant $f\ (2,\ 56) = 50.006$, $p<0.01$. Therefore, response times between the 3 groups were significantly different. A

Bonferroni corrected post hoc test, with a p-value of 0.014 showed that there was a significant difference (p = 0.00) between mean reaction times for the large advertisement and small advertisement conditions, with participants having quicker response times in the large advertisement condition. A significant difference (p = 0.00) between mean reaction times was also found for the large advertisement and no advertisement conditions, with participants having quicker response times in the no advertisement conditions. A further significant difference (p = 0.00) between mean reaction times was also found for the small advertisements and no advertisement conditions, with participants having quicker reaction times in the no advertisement condition. The main effect for 'driving experience' was not significant, f (1, 28) = 0.040, p>0.05, suggesting response times between both drivers and non-drivers were not significantly different.

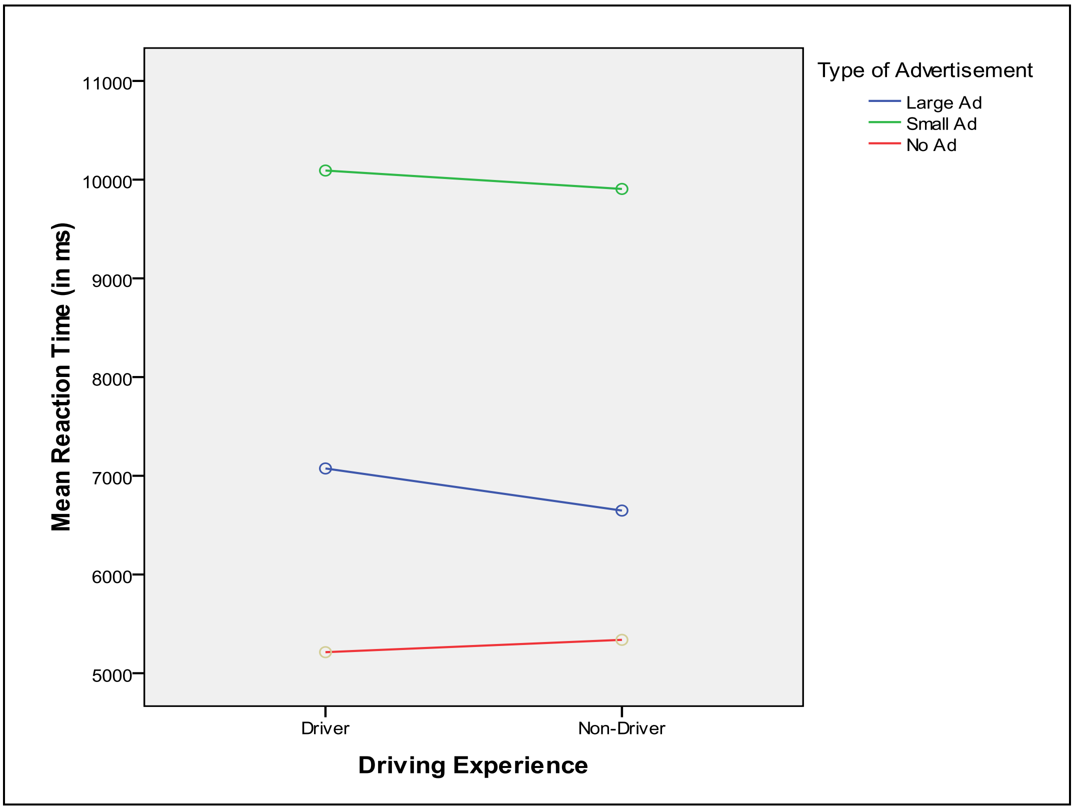


Figure 4: Interaction of existence of advertisement and driving experience on response times.

There was a non-significant interaction between 'type of advertisement' and 'driving experience' for reaction times, f (2, 56) = 0.165, p>0.05, which is shown in figure 4. This suggests there was no significant difference in response times for the combined 'type of advertisement' and 'driving experience' conditions.

Accuracy

The mean accuracy and standard deviation were calculated for each of the combined type of advertisement and driving experience conditions (Table 2).

The mean accuracy scores (Figure 5) show that accuracy was greatest for both drivers and non-drivers in the condition where no advertisement was present. In relation to the size of advertisement present, accuracy was greater when there was a large advertisement present compared to a small advertisement, which was true for both drivers and non-drivers (Figure 5). On average, drivers were more accurate than non-drivers for all conditions (Table 2). Overall, the greatest accuracy was experienced by the drivers in the conditions with no advertisement present. The standard deviations (Table 2) for all conditions were relatively small showing that accuracy totals were not widely spread across from the mean.

Table 2
Mean accuracy and standard deviation for the combined type of advertisement and experience conditions.

Type of Advertisement	Experience	Accuracy (%)	Standard Deviation	Number of Participants
Large Ad	Driver	91.18	5.45	17
	Non Driver	86.92	7.22	13
	Total	89.33	6.53	30
Small Ad	Driver	79.12	15.30	17
	Non-Driver	73.85	14.16	13
	Total	76.83	14.82	30
No Ad	Driver	94.41	7.26	17
	Non Driver	90.77	8.62	13
	Total	92.83	7.95	30
Total	Driver	88.20	8.49	17
	Non-Driver	83.81	8.97	13
	Total	86.30	8.83	30

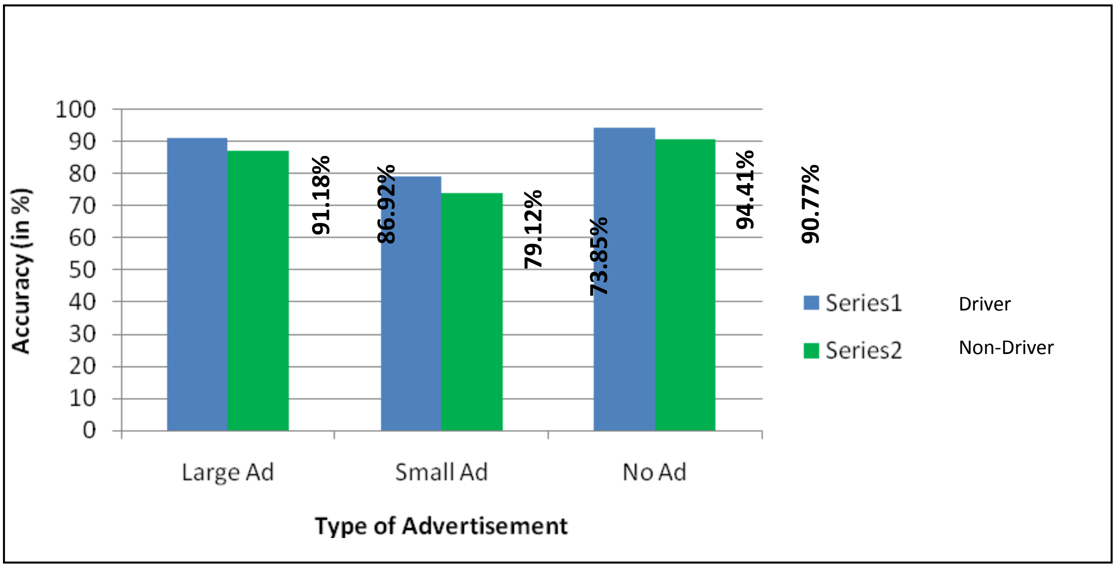


Figure 5: Mean accuracy for 'type of advertisement' condition for drivers and non-drivers.

Mean accuracy for 'type of advertisement was significant, f (2, 56) = 44.708, $p<0.01$. Therefore accuracy between the 3 groups was significantly different. A Bonferroni corrected post hoc test, with a p-value of 0.014 showed there was a significant difference ($p = 0.000$) between mean accuracy scores for the large advertisement and small advertisement conditions, with participants having greater accuracy in the large advertisement conditions. A significant difference ($p = 0.000$) between mean accuracy scores was also found for the small advertisement and no advertisement conditions, with participants having greater accuracy in the no advertisement condition. However, there was no significant difference ($p = 0.015$) between mean accuracy for the large advertisement and no advertisement conditions. The main effect for 'driving experience' was not significant, f (1, 28) = 1.873, $p>0.05$, suggesting accuracy between both drivers and non-drivers was not significantly different.

There was a non-significant interaction between 'type of advertisement' and 'driving experience' for accuracy, f (2, 56) = 0.106, $p>0.05$, which is shown in figure 6. This suggests there was no significant difference in accuracy for the combined 'type of advertisement' and 'driving experience' conditions.

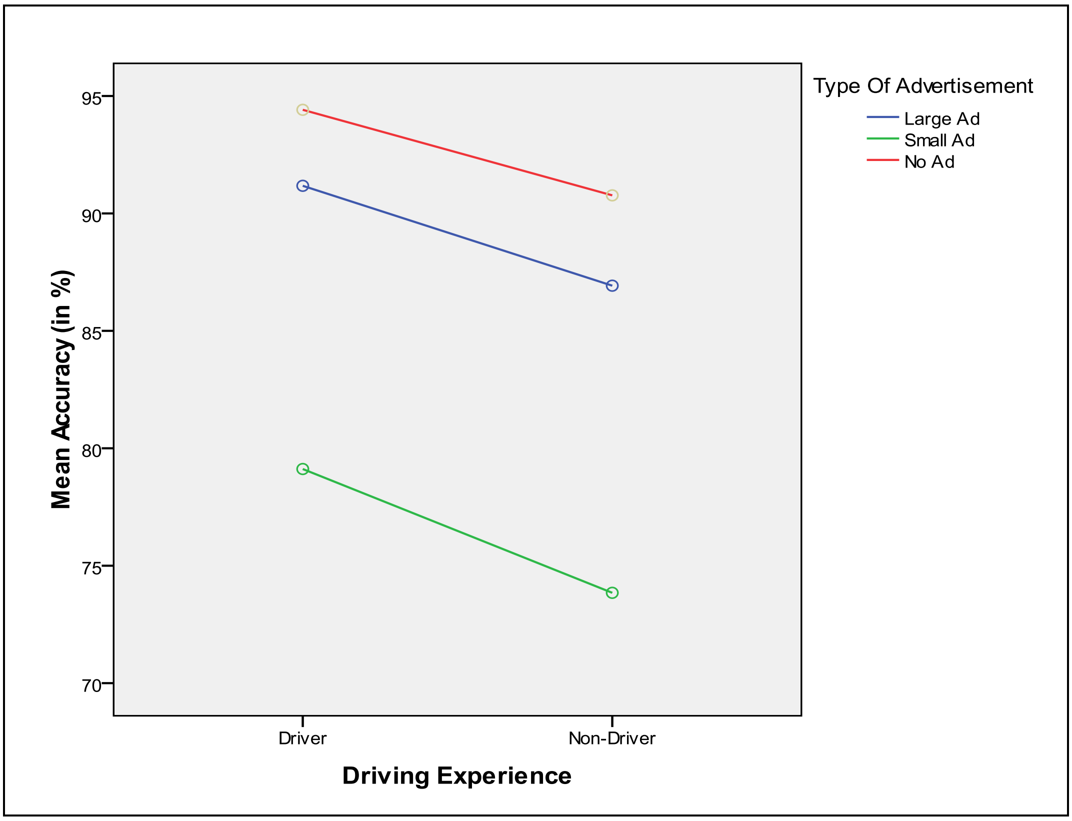


Figure 6: Interaction of type of advertisement and driving experience on accuracy

DISCUSSION

The purpose of this study was to examine the effects of advertisement on the perception of a road scene in both drivers and non-drivers, using a change blindness paradigm. It was discovered that the type of advertisement did influence reaction times. As expected participants responded quicker to the no advertisement conditions (m = 5267ms) compared to the conditions with large advertisements (m = 6889ms) and small advertisements (10011ms) present. However, it was found that participants responded significantly quicker to the conditions with large advertisements compared to the conditions with small advertisements. Overall, there was no significant difference in reaction times for the driving experience condition [drivers: (m = 7459ms), non-drivers: (m = 7296ms)]. Although drivers (m = 5213ms) outperformed non-drivers (m = 6647ms) in the conditions with no advertisements present, these differences were not significant. Also, despite non-drivers outperforming drivers in the large (m = 6647ms vs. m = 7074ms) and small advertisement conditions (m = 9905ms vs. m = 10092ms), these differences too were not significant. It therefore deduces that there was a non-significant interaction between the type of advertisement and driving experience condition for reaction times.

Analysis of accuracy results revealed that the type of advertisement did influence accuracy scores. As expected participants had greater accuracy in the no advertisement condition (m = 92.83%) compared to the small advertisement condition (m = 76.83%). However, such a difference was not experienced between the no advertisement condition and large advertisement condition (m = 89.33%); although accuracy was greatest in the no advertisement condition, this was not significant. As with the reaction time results, accuracy was greatest in the large advertisement conditions compared to the small advertisement conditions. Overall, there was no significant difference in accuracy scores for the driving experience condition [drivers: (m = 88.2%), non-drivers: (m = 83.81%)]. Although drivers outperformed non-drivers in all three types of advertisement conditions, these differences were not significant. A non-significant interaction between the type of advertisement and driving experience was also found for accuracy scores.

As anticipated both reaction times and accuracy were greatest in the no advertisement conditions, findings of which support previous research in the area of advertisements and attention (e.g. Holohan et al, 1978; Johnston & Cole, 1976) and advertisements and accident rates (e.g. Bendak & Al-Saleh, 2010). Such findings signify that the presence of road-side advertisements negatively affect attention and the successful location of a change to a road scene and support the theory of cognitive overload and visual clutter (Wallace, 2003). It therefore appears necessary to reduce the amount of visual clutter on the road in order to increase attentiveness and hazard perception. However, as differences between accuracy for the large advertisement conditions and no advertisement conditions were non-significant, it appears that although changes to road scenes with no advertisement are located quicker, this does not impact on the successful location of such a change. Therefore, the hypothesis that changes to road scenes with no advertisement present would be located more accurately and quickly than roads with advertisements on was only partially supported.

Despite significant differences in reaction times and accuracy between large advertisements and small advertisements, the lack of previous research in the area means such results are difficult to place in context. The finding that changes to the road scene were located in the large advertisement conditions more quickly and accurately than the small advertisement conditions does infer that the smaller advertisements were possibly attended to earlier and for longer, which resulted in the reduced success of locating the change to the scene. With no eye-tracking data to support this though, this is implied with caution. Such a belief would go against the minimal research that there is in the area; that larger advertisements are attended to quicker than smaller ones (Outing & Ruel, 2004).

However, it must be remembered that this was measured on website advertisements, not road-side advertisements and so differences between such types of advertisements might occur. There are a number of reasons why the small advertisements may have been attended to longer than the larger advertisements. One such explanation links to reading and the size of text. It has been found that as the size of the text increases, reading speed also increases (Chung et al, 1998). The larger text therefore required less attention to be successfully perceived and could explain why changes to the road-scenes with large advertisements present were located more quickly and more accurately than road-scenes with small advertisements present. Nevertheless, the hypothesis that differences in reaction time and accuracy in locating changes between road scenes of large versus small advertisements was supported.

In relation to the driving experience condition, a non-significant difference in reaction times and accuracy was found between drivers and non-drivers. A failure to find a significant difference is in line with previous research of change blindness in drivers and non-drivers (e.g. Galpin et al, 2009); however, such findings are against the norm. Typically, expertise within a group equals a better response to changes in domain-related stimuli (Osborn & Owen, 2010; Werner & Thies, 2000). Such findings also go against research into hazard perception, visual scan paths, and attention of novice versus experienced drivers, in which novice drivers are typically inferior to experienced drivers (e.g. Deery, 1999; Underwood, 2007; Vollrath et al, 1999). Therefore, the hypothesis that drivers would be faster and more accurate than non-drivers at recognizing changes to road-scenes was not supported.

Limitations and Further Research

A failure to completely support all of the hypotheses presented within this research means the design of the study may have failed in its function to identify specific differences in change blindness for the driving domain. With this in mind, weaknesses within the experiment, which may have contributed to this outcome, will now be identified.

The effect of driving experience was not apparent in this study. Both drivers and non-drivers had relatively identical reaction times and accuracy totals which could be a result of an insufficient difference in driving experience between drivers and non-drivers. Alternatively, such an effect may be related to the familiarity of the driving situation for non-drivers. Non-drivers may regularly be passengers in a car, and as ascertained by Vollrath et al (2002) passengers provide a protective cover to drivers by identifying hazardous situations. As this change blindness experiment eliminated the effect of in-vehicle demands such as steering or changing gear, non-drivers may have experienced the situation as a passenger who was readily able to recognize hazards or changes in a road scene.

It may have been more beneficial to examine a range of driving experiences and categorised them more definitively or created a secondary cognitive task, similar to that experienced when driving, in order to establish the true effect of driving experience on change blindness. However, it could also be the case that the ecological validity of the study was weak which meant a driving related schema was not activated in the drivers. The use of photographs may have created a situation that was not concurrent with a real-life driving situation. Indeed, in a real-life driving situation drivers are faced with an ever-changing hazardous state, not just a stationary single-change one. Future research could encompass the use of video-clips to eradicate such a problem, and the increasing technological advances of 3D video means the creation of a driving situation comparable to that of a real one may not be far off.

Another limitation of the study relates to the subjective judgement about where the change is made by the experimenter. A result of which may have meant some changes were easier to spot than others. A pilot study in this case would have been advantageous as it would have allowed the removal of changes that were either very easy or very difficult to detect and left changes that were of equal complexity. As well as this, the location of a change has been found to be important in the detection of such change (e.g. Jenkin & Harris, 2001), a variable which was not controlled for in this study. Generally, central items are attended to first which means peripheral changes take a greater amount of time to detect than central (Shore & Klein, 2000). It could therefore transpire that some of the changes in this study were located quicker because they were located more centrally than other changes. Subsequently, further research should aim to incorporate changes in equal quantities of central and peripheral locations, in order to control for such a problem.

The difficulty of assessing why the difference between change detection for road sides with large advertisements versus small advertisements occurred could have been overcome with the addition of eye-tracking data. This would have enabled the measurement of eye fixations and gaze durations to determine if small advertisements were attended to sooner and for longer and could explain why changes to road-scenes with large advertisements were located quicker than road-scenes with small advertisements. If this were to be done in the future, the potential for new theory on the effect size of advertisements have on attention and other cognitive functions could be vast. The data gathered from this study was not enough to establish reasons for the effect size of advertisements have on change blindness but does offer a baseline on which to base additional research.

Conclusion

Overall, this study has applied the change blindness paradigm to the driving domain to investigate the effects of road-side advertisements on change detection in both drivers and non-drivers. Whilst the study has produced findings similar to previous research regarding the adverse effect of road-side advertisements on attention, similar findings were not found regarding a difference in change blindness for those of varying driving experience. The study has opened up the negative effect small road-side advertisements have on change detection, and shows a possible need to reduce the amount of small advertisements on the road-side due to the greater attention they require to be successfully perceived. If the limitations presented within this study are overcome in subsequent research, then a theory regarding the effect of advertisement size on attention could be generated which might provide insight into the practical implementation of road-side advertisements of differing sizes. This would hopefully lend itself to greater driver attention and a reduction in road accidents in the long-term.

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