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The influence of image valence on visual attention and perception of risk in drivers

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ABSTRACT

Currently there is little research into the relationship between emotion and driving in the context of advertising and distraction. Research that has looked into this also has methodological limitations that could be affecting the results rather than emotional processing (Trick et al., 2012). The current study investigated the relationship between image valence and risk perception, eye movements and physiological reactions. Participants watched hazard perception clips which had emotional images from the international affective picture system overlaid onto them. They rated how hazardous or safe they felt, whilst eye movements, galvanic skin response and heart rate were recorded. Results suggested that participants were more aware of potential hazards when a neutral image had been shown, in comparison to positive and negative valenced images; that is, participants showed higher subjective ratings of risk, larger physiological responses and marginally longer fixation durations when viewing a hazard after a neutral image, but this effect was attenuated after emotional images. It appears that emotional images reduce sensitivity to potential hazards, and we suggest that future studies could apply these findings to higher fidelity paradigms such as driving simulators.

1. Introduction

One of the main contributors of on-road collisions is inattention from drivers. Naturalistic studies of car crashes have found distraction to be the cause in 78% of cases (Neale et al., 2005). What such studies suggest is that many people do not necessarily look at the focus of expansion all of the time, despite the fact that approximately 90% of fixations are supposed to focus at this point (Lansdown, 1997). Drivers may be distracted by internal or external factors, which can take up to two seconds to significantly increase the risk of a crash (Zwahlen et al., 1988). It is therefore important to analyse why drivers decide to divert their attention away from the road for the purposes of road safety.

One significant type of distracter to consider, which is not necessarily in the control of the driver, is road-side advertising. Typically advertising is large, bright and positioned within the driver's central field of view. Self-report measures have also suggested that around 30–50% of driver's attention is given to aspects unrelated to driving, including advertising, whereas only around 20% is given to road signs (Hughes and Cole, 1986). A significant proportion of such drivers can be distracted by advertising, according to a 2006 privilege insurance survey (Lansdown, 2012). Considering that it has previously been suggested that the risk of a crash can significantly increase within two seconds (Zwahlen et al., 1988), advertising can therefore be seen as a significant distracter, and whilst self-report studies do not necessarily indicate real-world data, they do emphasise the need to investigate advertising as a significant distracter. Laboratory studies, using joysticks to point to on-screen arrows, have found that reaction times are significantly slower when advertising is also shown (Johnston and Cole, 1976). Real-world studies have found similar results. Previous research has found that there are more crashes at junctions where there are advertisements (McMonagle, 1952), and correlations have been found between advert frequency, advert size and crashes (Holahan, 1977), suggesting that bottom-up processing is used to analyse the features of the advertisement. However, it may be that there are more crashes at junctions with advertisements simply because the junction itself creates road complexity, and correlation between advert frequency and crashes does not necessarily imply causation by the advertisements. In such cases it could be the physical features of the road, such as road type, weather conditions and even junctions.

Contemporary research within simulators has demonstrated that adverts placed on rural, urban and motorway roads can have negative effects on lateral control and subjective mental workload as well as encouraging a short fixation sampling strategy,

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indicative of the complex environment created by in-car distracters such as mobile phones and iPods (Young et al., 2007). However, research has also suggested that placing advertisements a few feet above the ground, which is out of the way from the typical horizontal search strategy used by drivers, can have beneficial effects (Crundall et al., 2006). So street level adverts, which are typically placed within the driver's horizontal field of view, can be seen as detrimental. Drivers may be fixating on the advertisement instead of any localised hazards, which could result in a near-miss or collision.

However, it may not just be the sensory aspects of advertisements that capture attention. Advertisements often seek to evoke an emotional reaction from the viewer, which may then divert attention away from other real-world stimuli. Emotion has been demonstrated to have an effect on driver behaviour. For example, emotional abilities have been linked to self-reported risky attitudes without becoming correlated with age or driving experience (Arnau-Sabatés et al., 2012), and positive emotion priming has been associated with self-reported reckless driving (Ben-Ari, 2012). Again, this self-report study highlights the importance of studying the effects of emotion. Anxiety, as opposed to other emotions such as happiness or anger has been associated with an increase in perceived risk, as well as an increased heart rate (Mesken et al., 2007).

One example of investigating the relationship between emotion and driving within the context of anxiety and its relationship to driving has been conducted by Briggs et al. (2011). In their study, they found that when participants with arachnophobia ere in a simulator and held what is described as emotionally involving conversations regarding spiders, their cognitive mental workload increased as demonstrated by heart rate, and their spread of eye movements indicated what is known as cognitive tunnelling (Easterbrook, 1959), or a reduction in visual spotlight (Driver and Baylis, 1989). This means that when an anxious participant was placed in what they felt was a threatening situation, it resulted in a case of hyper distractability limiting other sensory processing. In order to safely process the road ahead, the spread of eye movements reduced in order to focus on the central task. Such results are reflective in previous driving literature, where hazards on the road have been shown to capture the attention of a driver and create a cognitive tunnelling effect (Chapman and Underwood, 1998).

Briggs et al. (2011) suggest that the driver is distracted due to the emotional involvement of the task. Whilst this may be true, discussions with a phobic person may result in the development of negative mental imagery and associated memories, thus creating a secondary task which may be the real cause of cognitive tunnelling rather than actual emotional processing. Furthermore, the use of mobile phones as distracters themselves could result in any effects on the road. In car distracters can affect steering precision (Reed and Green, 1999), and result in a greater likelihood of near-misses and collisions (Chisholm et al., 2008). So whilst the proposed effects of emotion are certainly plausible, conclusions such as this need to be investigated further before emotion can actually be considered as a significant on-road distracter.

A good example of studying the effects of emotion on driving behaviour is in the context of music within the car. Pêcher et al. studied the effects of the valence of music and its effects on in-car driving (Pêcher et al., 2009). They found that happy music resulted in a decrease in speed; however, drivers also deteriorated in terms of control and tended to steer towards the hard shoulder. This could have been due to broadening their attention to global aspects of the driving environment, which can happen when using positive valence stimuli (Rowe et al., 2007). It may also have been due to participants reacting to the music and thus creating an unintentional secondary task. On the other hand, sad music resulted in a decrease in driving speed, and an increase in control with a tendency to keep their vehicle in the middle of the lane. This may have been due to the negative valence stimuli resulting in greater control of the vehicle in the, which can be advantageous to the driver in the same way that cognitive tunnelling could be advantageous for spread of search in a hazardous situation (Miyazawa and Iwasaki, 2009). However, whilst differences were found between the two valence levels, the study confounded valence and arousal by not considering the effects of arousal on the speed at which participants chose to drive. They tended to change their speed according to different types of music. Speed is a factor associated with arousal levels of music, which in itself can result in more on-road collisions (Brodsky, 2002).

The previous studies also highlight the fact that emotion and driving attention has not been widely studied within a visual stimuli context. This is important, because it is possible that two tasks using the same sensory modality, for example driving whilst looking at an emotional advert, could result in even greater detrimental consequences. Recent research by Trick et al. has attempted to look at the relationship between emotion and attention whilst driving by using visual stimuli (Trick et al., 2012). Based on previous research and the fact that hazard perception requires the use of search strategies employed by focal vision as opposed to ambient (Previc, 1998) it was hypothesised that positive valence images would create a broadening of attention whilst negative valence images would centralise attention. They used pictures taken from the international affective picture system (IAPS) whilst asking participants to drive around in a simulator. Whilst driving, an image would appear on a GPS device next to the steering wheel. The participants had to indicate whether this image was a positive or negative image whilst driving. It was concluded that steering control was affected by image valence rather than arousal, with negative images producing poorer steering quality. This is complimentary to other contemporary research investigating the effects of emotional visual stimuli and distraction in the context of IAPS stimuli, which suggests negative implications for its effects on increased risk taking within the car and rear-end accidents (Megías et al., 2011).

However, the effect sizes found were small, and there are some methodological concerns. Firstly, the participants had to look down at the device and indicate whether the image was positive or negative. It may have been the act of looking down at the device and pressing a button, rather than whether the image had positive or negative valence, that had an effect on steering quality. Whilst previous research has suggested that in-car devices may not necessarily be disadvantageous to the driver in contexts such as hazard perception (Reed-Jones et al., 2008), other studies have shown that the further away a driver looks from the road, the less they are able to steer (Summala et al., 1996). So in the context of this study, it may have been the in-car distracter affecting the results; this demonstrates the need to fully investigate the role of emotion before making conclusions on in-car distracters, such as the case of Briggs et al.'s spider phobia study. The study also had problems controlling for arousal and valence levels of images, in a similar fashion to Pêcher et al., which once again could be confounding for the experimental results.

Currently there are few studies that observe the relationship between emotion, attention and driving by using visual stimuli. Those that have done so have suffered from various methodological limitations. This study observes the relationship between image valence and driving attention whilst at the same time controlling for arousal levels. In accordance to recommendations from Trick's research (2012), perception of hazard, eye movements and physiological data such as heart rate and galvanic skin response were measured. Such physiological measures have also been recommended as useful in the context of driving by other