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Hazard perception as a function of target location and the field of view

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ABSTRACT

A typical hazard perception test presents participants with a single-screen view of the road ahead. This study assessed how increasing this field of view would affect hazard perception abilities. Drivers were shown video clips of driving situations containing at least one hazard either on a single screen, or with the addition of side views on two separate but adjacent screens that extended the perceived worldview to approximately 180°. Mirror information was also included to allow information from behind the vehicle to be attended. Participants were instructed to press a button as soon as they saw a hazard. Faster response times were found for hazards that appeared in the centre of the central screen, than in the periphery of the central screen, with hazards that first appeared in the lateral screens responded to slowest. Additionally, responses to the hazards were faster and were more likely to occur in the three-, as compared to the single-screen condition. These results suggest that providing participants with a wider field of view, which includes more environmental cues that are related to the relevant hazardous situation increases their ability to detect hazards, and some limited support to that providing them with a wider view increases this ability even when all hazard-relevant information appear only in the central screen. A number of reasons for the three-screen advantage are discussed. This study suggests that even responses to central hazards may be under-estimated in a typical single-screen hazard perception test, and that improvements can be made for new hazard perception tests, by including visual information from the side and from behind the driver. This new methodology not only allows testing hazard perception skills in a potentially more immersive and realistic environment, but also enables to create hazard perception clips that cannot be realised in a typical single-screen test.

1. Introduction

With most crashes occurring due to human error (Lewin, 1982; West et al., 1993), drivers' abilities, to anticipate road events, to detect hazardous traffic situations and to respond to them appropriately are considered to be substantial characteristics of cautious driving and major contributors to traffic safety. These abilities are often termed hazard perception (HP). Although definitions for HP vary, researchers have usually focused on either the above-mentioned components (i.e., the abilities to anticipate road events etc.; e.g., Deery, 1999; Elander et al., 1993; Horswill and McKenna, 2004; Jackson et al., 2008; Sagberg and Bjørnskau, 2006), or on the subjective experience of risk in potential traffic hazards (Adams-Guppy and Guppy, 1995; Brown and Groeger, 1988; DeJoy, 1989; Finn and Bragg, 1986; Gregersen, 1996; Harre, 2000; Jessor, 1987; Matthews and Moran, 1986; Rosenbloom et al., 2008). Studies focusing on the subjective experience of risk in potential traffic hazards, namely risk perception, typically concentrate on an expected negative correlation between risk perception and risky behaviour. In other words, the general notion pointed out in these studies is that in a given situation, perceiving low crash risk would lead to less cautious driving.

In fact, it has been argued that HP more than any other driving component has been found to predict accident involvement (Horswill and McKenna, 2004). Studies showing a relationship between HP performance and accident involvement typically demonstrate that drivers who have not had an accident respond more quickly to hazards than drivers who have (e.g., McGowan and Banbury, 2004; McKenna et al., 2006; Wallis and Horswill, 2007). In addition, a number of studies have found experiential differences in HP performances. These include studies which discriminated between learner drivers and novices (Sexton, 2000), novices and experienced drivers (e.g., Jackson et al., 2008; McKenna and Crick, 1991, 1994; Sexton, 2000; Wallis and Horswill, 2007) as well as between experienced and expert drivers (McKenna and Crick, 1994). Apparently, such differences between novice and experienced drivers are related to the fact that novices are less willing to classify situations as hazardous and require higher thresholds of risks to be present before doing so (Wallis and Horswill, 2007), hence they are related to lower risk perception. Experienced drivers

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seem to perceive more – and generally be more sensitive to – potential hazards than novice drivers, and therefore they recognize elements missed by novices (Borowsky et al., 2009).

Among the different methods used to assess detection and response to hazards, the presentation of short video clips is probably the most common. In a typical video-based HP test participants are asked to watch clips taken from a driver's perspective through the windscreen of a moving vehicle, and to respond by pressing a button or a foot pedal to the appearance of hazards. Hit rates and response times are normally recorded and these measures are used to reflect HP skill. Based on such evidence and on the related assumption that with practice individuals learn to correctly identify hazards, the HP test has been incorporated into the UK driving test since 2002.

In spite of the evidence presented above for both accident liability related HP differences and experiential related HP differences, there have also been failures to replicate both types of findings. Specifically, some studies have failed to discriminate between experienced and inexperienced drivers (e.g., Crundall et al., 1999; Groeger et al., 1998), and between accident-involved and accident-free drivers (e.g., Groeger et al., 1998). These failures to demonstrate the expected negative correlation between HP performance and accident involvement and the expected positive correlation between HP performance and driving experience raise some questions about the validity of HP tests (for a review see Horswill and McKenna, 2004; Groeger, 2000). Briefly, poor face validity (button presses in response to filmed hazards may be considered quite different than real driving; Groeger, 2000), low internal consistency, and different thresholds to defining hazards (Horswill and McKenna, 2004) are all potential factors in limiting the consistency of HP tests. It has also been argued that the complexity of hazard perception skill may not be reflected by the most commonly used push-button measure of reaction times (Jackson et al., 2008). Also as noted previously (e.g., Sagberg and Bjørnskau, 2006; Sexton, 2000), not all clips are capable of demonstrating experiential differences.

The current study dealt with yet another characteristic, which we believe reflects a substantial drawback inherent to the typical HP test. While the standard HP test is presented on a single screen, presenting *only* the front view from a driver's perspective (approximately 60–80° of visual angle depending on which camera the clips were filmed with, and where the camera was mounted on the car), real driving involves detecting and processing information from the sides as well as from behind the vehicle. Pedestrians who intend to cross the road, overtaking and undertaking vehicles, and vehicles which do not maintain a safe distance are just few examples of the many occurrences of potential hazards outside the frontal view of a driver, with substantial implications to safety of road users. With respect to McKenna and Crick's (1991) argument that the most important aspect of the hazard perception test was viewing the visual scene (and that it therefore was not necessary to simulate being in a car to watch the clips), we suggest that the typical HP test lacks not only the interactivity found in a driving simulator (which we agree is not necessarily required for assessing some types of hazard perception), but also the full range of visual cues that compete for attention when actually driving a car in the real world. As the side views and mirror information, which in real driving often provide information which can be critical to preventing accidents, are not present in the typical HP tests, we may be underestimating or overestimating drivers' HP skill.

For instance, by adding mirror and side view information we may increase the likelihood that drivers are looking in the wrong place when the hazard appears, thus decreasing hazard perception (suggesting that typical single-screen tests overestimate real HP skill). In this sense the additional information from the sides and from behind the vehicle also builds up additional mental load. Decremental effects of increased mental load upon driving performance have been demonstrated, often with respect to use of mobile phones (Alm and Nilsson, 1994; Consiglio et al., 2003; McKnight and McKnight, 1993; Patten et al., 2004; Strayer and Drews, 2004), but also with other, both visual and non-visual related tasks (Recarte and Nunes, 2000, 2003). However while increases in localised visual demand tends to narrow the attentional focus, prolonging fixations (Chapman and Underwood, 1998) and impairing peripheral processing (Miura, 1990; Crundall et al., 1999; Crundall et al., 2002), increased visual complexity instead tends to increase the sampling rate of a search strategy, resulting in a greater number of shorter fixations (e.g., Crundall and Underwood, 1998). Such short fixations are likely to occur with a wider field of view, and may therefore reduce the processing power of any individual fixation, potentially increasing the possibility of Look But Failed To See errors (Brown, 2002). This is encapsulated in Findlay and Walker (1999) model of saccade generation which describes a reciprocal inhibitory relationship between the urge to fixate and the urge to move the point of gaze. With more stimuli in the visual field, the urge to move the eyes may be increased, thus reducing the time spent at any particular fixation point, which in turn increases the possibility that the eyes move away from their current location before they have fully processed whatever they were looking at.

This explanation assumes however that a decrease in fixation durations would reduce the level of attention at the point of regard to below that which is required for an optimum level of processing (thereby interfering with hazard perception skills). By encouraging wider scanning of the visual scene and a higher sampling rate with shorter fixations without reducing fixations to below that required for successful processing, the provision of a wider visual field could in fact lead to improved hazard detection. There are a number of other possible reasons why a wider available visual field would result in better hazard detection.

One might argue that a wider field of view could provide a more immersive experience (Allen et al., 2005). This may encourage more realistic scanning of the scene (a more realistic search pattern), focusing the participants in the most vital areas and directing them to the most relevant sources of information thus improving HP scores (suggesting that that the typical single-screen test underestimates HP skill). Allen et al. (2005) undertook studies of novice drivers across three simulator platforms; a single-screen, three-screens and a large three-screen display with participants sat inside an instrumented car cabin. One of the findings they reported was that the novice drivers tended to behave differently in the single-screen simulator to the other two platforms, with more aggressive behaviour (faster speeds, harsher braking), reduced time-to-collision estimates and more accidents. Allen et al. (2005) put these differences down to the greater information provided across three screens which may have increased the immersive qualities of the simulator, encouraging more realistic behaviour. If this is indeed the case then it is also possible that the greater immersion with the three-screen platforms encouraged different scanning patterns. This is potentially of great importance to the hazard perception literature, especially if a wider field of view induces a more realistic scan pattern. If scanning a single-screen HP test is not a reflection of visual behaviour during real driving, then not only can we suggest that this might lead to single-screens over-estimating HP skill, but also the alternative argument could be made for an underestimation: a narrow field of view might be so far removed from real driving that participants would view it without feeling immersed in the driving situation, resulting in greater temptation to look at objects in the scene that are less relevant (e.g., searching shop fronts for emerging customers), and spending much of their time not inspecting relevant aspects of the scene. Even if drivers are consciously searching for hazards, the lack of realism