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The effects of driving experience on responses to a static hazard perception test

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ABSTRACT

Novice drivers exhibit deficits in hazard perception that are likely to increase their risk of collisions. We developed a *static* hazard perception test that presents still images to observers and requires them to indicate the presence of a traffic conflict that would lead to a collision. Responses to these scenes were obtained for young adult novice ($N = 29$) and experienced drivers ($N = 27$). Additionally, participants rated the hazard risk and clutter of each scene. Novice drivers rated traffic conflicts as less hazardous and responded more slowly to them. Using a subset of 21 scenes, we were able to discriminate novice and experienced young adult drivers with a classification accuracy of 78% and a scale reliability (Cronbach's alpha) of .91. The potential applications of this research include the development of standardized hazard perception tests that can be used for driver evaluation, training and licensure.

1. Introduction

Driving is one of the more risky behaviors in which people engage in terms of injury, death or related costs. While many drivers are quite safe, there are some driver groups, particularly novice drivers, that are at greater risk (McKnight and McKnight, 2003). Wells et al. (2008) found that almost 20% of new drivers had a self-reported collision in the first 6 months of driving and that fully 70% had at least one "near-accident" (p. 131). In the attempt to increase driving safety, several measures have targeted this group including graduated licensing, more systematic training, and more rigorous examinations for licensure. Included in this latter category are tests assessing a person's ability to identify and respond to road hazards.

Hazard perception is a critical component to safe driving (Insurance Institute for Highway Safety, 2010; McKnight and McKnight, 2003). Awareness of hazards protects against collision involvement in the early stages of driving (Wells et al., 2008), yet inexperienced drivers are less able to identify and respond to them (McKenna and Crick, 1994; Pollatsek et al., 2006a,b; Quimby and Watts, 1981; Renge, 1998; Wallis and Horswill, 2007; Whelan et al., 2002) and hazard response times are slowed in this group (Horswill et al., 2008; Quimby and Watts, 1981; Scialfa et al., 2011; Wetton et al., 2010, but see Crundall et al., 2003; Sagberg and Bjornskau, 2006).

There are both methodological and psychometric problems associated with investigating the association between crash risk and hazard perception (Horswill et al., 2010a,b), such as the poor psychometric properties of crash involvement measures and the fact that crash involvement is typically due to many factors including chance. Despite these limitations, hazard perception has been found to be associated with crash risk in multiple studies (e.g. Congdon, 1999; Horswill et al., 2010a,b; Darby et al., 2009; McKenna and Crick, 1994; Quimby et al., 1986; Watts and Quimby, 1979; Wells et al., 2008). For example, Pelz and Krupat (1974) found that there was a 1.2 s difference in HPT between those without a collision or conviction and those having both. Watts and Quimby (1979), McKenna and Crick (1994) and Darby et al. (2009) reported small but significant relationships between HPT scores and retrospective collision involvement. Similarly, Congdon (1999) observed that the VicRoads Hazard Perception Test was a successful predictor of more serious collisions and Wells et al. (2008) found that the UK Hazard Perception Test could predict certain crash types.

Because of their face validity and utility in identifying at-risk drivers, tests of hazard perception have been incorporated into the licensure process in both Australia and the U.K., generally in the form of a video-based series of dynamic scenes of roadway hazards. Dynamic HPTs are also being used for training purposes as in Driver ZED, developed under the AAA Foundation for Traffic Safety (see http://www.driverzed.org/home/), which has been shown to produce improvements in hazard perception of young, inexperienced drivers (Fisher et al., 2002). Training benefits have been found under several other platforms (Chapman et al., 2002).

Despite their promise, dynamic HPTs can be difficult to develop and administer, and some investigators have suggested that HPTs consisting of still images may offer an effective assessment or training alternative (e.g., Huestegge et al., 2010; Whelan et al., 2002).

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There are several advantages to using still images. In still images it is often easier to select a moment in time containing one unambiguous hazard, whereas a temporally extended scene may contain multiple hazards, which can create problematic response variability. Because hazard onset is synchronous with image onset in a static image, there is no uncertainty about determining the onset of the hazard, a factor that can complicate the calculation of response latency in dynamic scenes. In addition, a test containing still images can be completed in substantially less time or, alternatively, include a larger number of stimuli, because a typical dynamic scene lasts 30–60 s whereas a still image can have a fixed and much shorter display duration.

Still images of driving scenes have been used frequently in the assessment of driving performance including examinations of speed adaptation to increasing environment complexity (De Craen et al., 2008), change blindness (Velichkovsky et al., 2002) and search for traffic signs (Ho et al., 2001). For example, Huestegge et al. (2010) required observers to monitor and react to still images of typical traffic scenes under distracted and non-distracted conditions. Participants responded when they felt a speed reduction would be required. Experienced drivers responded faster than novice drivers to situations that demanded a braking action. Similarly, Whelan and colleagues (2002) asked novice and experienced drivers to view 25 photographs of roadway scenes and respond as quickly and accurately as possible to the most important hazard within them. Hazard reaction times for experienced drivers were significantly faster than novice drivers under both non-distracted and distracted conditions.

There are several reasons why novice drivers are thought to be deficient in hazard perception whether tested using dynamic sequences or still images. For instance, inexperienced drivers do not scan the roadway environment efficiently (Chapman et al., 2002; Falkmer and Gregersen, 2005; Pradhan et al., 2005; Underwood et al., 2002a,b) and so hazards that are identified by a more experienced driver may go unnoticed. Inadequate search behavior could be particularly problematic for hazards presented in the periphery (Shahar et al., 2010), in unexpected locations (Pradhan et al., 2005; Sagberg and Bjornskau, 2006) or in the presence of additional visual clutter (Ho et al., 2001).

Because hazard perception is based in experience, another possible explanation for novice deficits is that they have not driven sufficiently to acquire a "data base" of hazards they might encounter. Groeger (2000) has proposed, following Logan's instance theory (2002), that hazards are encoded as separate memory traces and that rapid and accurate hazard perception is mediated by the fast, automatic retrieval of these previous instances and subsequent match to the current information. Novices have fewer instances to retrieve and, probabilistically, fewer will be retrieved quickly. As a result, they will be slower at hazard perception, both on the road and in the lab.

Alternatively, novice drivers may have an impoverished mental model of the hazards that are present in the driving environment (Deery, 1999; Horswill and McKenna, 2004). A mental model is a well-defined, often dynamic set of knowledge structures that are relevant for task performance. For example, a mental model of social greetings could include knowledge of common salutations, body position, "chit chat", and contextual variables such as gender, marital and social status.

Underwood (2007) has invoked Endsley's (1995) situation awareness theory to describe a mental model of the roadway environment that includes perception, integration of isolated perceptions into an awareness of current driver actions and positions, and finally, prediction of future behaviors, speeds, trajectories, etc. Because Crundall and Underwood (1998) found that novice and experienced drivers' scanning behavior differed even when vehicle control was unnecessary, they suggested that an impoverished mental model, particularly at the third level of situation awareness, was responsible for novice deficits in hazard perception.

A mental model of driving hazards must include some assessment of the level of risk that includes the likelihood of an undesirable event (Laughery and Hammond, 1999) that each hazard poses. It is possible that inexperienced drivers perceive scenarios as less hazardous and so do not respond to them appropriately. Several studies have determined that less experienced drivers rate hazardous driving situations as possessing less hazard risk than do more experienced drivers (Finn and Bragg, 1986; Matthews and Moran, 1986; Renge, 1998). On the other hand, Wallis and Horswill (2007) presented novice and experienced drivers with 23 dynamic traffic scenes, which were occluded at selected points (chosen to yield a range of low, moderate, and high hazard potential in the moments after the occlusion occurred, according to a panel of experts). There were no differences between novices and experienced drivers in ratings of whether a hazard was likely to occur after the occlusion point.

Thus, there is inconsistent evidence regarding novices' abilities to judge the hazard level in driving scenarios. Even if inexperienced drivers are deficient in judging hazards, it is not necessarily the case that this deficit produces slower responses to hazards when they occur. There have been relatively few attempts to measure both the perception of hazard and response latencies to those hazards in the same individuals. Huestegge et al. (2010) gathered RT data from inexperienced and experienced drivers who saw still images of driving scenes that had been rated pre-experimentally as being of low, moderate or high urgency for braking. Inexperienced drivers were slower to respond and the more hazardous scenes yielded shorter RTs, but there was no interaction between hazard level and driving experience, as might be expected if the hazard was perceived inaccurately by those who were new to driving.

Wallis and Horswill (2007), in addition to obtaining subjective ratings of hazard potential, gave their participants a validated hazard perception test using a variety of dynamic driving scenarios. Even though response latencies were longer for novice than experienced drivers, there was no correlation between perceived potential hazard ratings and hazard perception time. Importantly, however, the scenes used for the latency measures were not those used for the hazard ratings. It is unclear if novices would have produced lower ratings of hazard in the scenes for which latency was the outcome measure.

In the current study, we presented 120 still images of driving scenes to similarly aged, young adult drivers who were either very new to driving or had more driving experience. They were asked to quickly identify traffic conflicts, and then rate the level of hazard and the level of visual clutter in the scene.

There were four goals to this research. First, there has not been a demonstration to date that novice drivers are deficient in the perception of static hazards found in North American driving environments. Even in those studies conducted outside of North America, previous novice/experienced driver comparisons tend to confound age with experience (where more experienced drivers are older), which limits the interpretation of findings. In the current study, we avoided this confound by recruiting drivers that differed only in experience and not age. This allowed us to make stronger assertions as to the effect of experience on hazard perception. Second, because there is some evidence that novices are not capable of accurately estimating hazard risk and that level of hazard risk may be associated with speed of response, we hypothesized that hazard ratings would be lower in the novice driver group and that hazard ratings would be correlated negatively with response times to those hazards. Third, because often it is the cluttered scenes that are most demanding for hazard perception (e.g., Ho et al., 2001) and may be more problematic for novice drivers (Pradhan et al., 2005), we examined the relationships between driving experience, subjective