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Late detection of hazards in traffic: A matter of response bias?

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ABSTRACT

In this study, results from two different hazard perception tests are presented: the first one is a classic hazard-perception test in which participants must respond – while watching real traffic video scenes – by pressing the space bar in a keyboard when they think there is a collision risk between the camera car and the vehicle ahead. In the second task we use fragments of the same scenes but in this case they are adapted to a signal detection task – a 'yes'/'no' task. Here, participants – most of them, University students – must respond, when the fragment of the video scene ends, whether they think the collision risk had started yet or not. While in the first task we have a latency measure (the time necessary for the driver to respond to a hazard), in the second task we obtain two separate measures of sensitivity and criterion. Sensitivity is the driver's ability to discriminate in a proper way the presence vs. absence of the signal (hazard) while the criterion is the response bias a driver sets to consider that there is a hazard or not. His/her criterion could be more conservative – the participant demands many cues to respond that the signal is present, neutral or even liberal – the participant will respond that the signal is present with very few cues. The aim of the study is to find out if our latency measure is associated with a different sensitivity and/or criterion. The results of the present study show that drivers who had greater latencies and drivers who had very low latencies yield a very similar sensitivity mean value. Nevertheless, there was a significant difference between these two groups of drivers in criterion: those drivers who had greater latencies in the first task were also more conservative in the second task. That is, the latter responded less frequently that there was danger in the sequences. We interpret that greater latencies in our first hazard perception test could be due to a stricter or more conservative criterion, rather than a low sensitivity to perceptual information for collision risk. Drivers with a more conservative criterion need more evidences of danger, thus taking longer to respond.

1. Introduction

Hazard perception is understood as a high skill that plays an important role in driving. This is a learned skill which develops as a driver gains experience, but supposedly reaches an asymptotic level when the driver acquires a sufficient level of driving experience. Its function is to provide the driver with a mental model or knowledge that enables him/her to anticipate the presence of hazard cues or signals in the dynamic traffic environment in order to react to and avoid accidents. Mills et al. (1998) defined it as the "ability to identify potentially dangerous traffic situations" (p. 10). For McKenna and Crick (1991), hazard perception can be interpreted as the ability to "read" the road. That is, the ability to extract information from the road environment (understood as a set of constantly changing stimuli), that is vital to anticipating the appearance of circumstances that could cause an accident, and therefore take some precautionary response.

The relevance of investigating this skill is due to the relationship between hazard perception and accidents, an aspect discussed below. For now, the evidence suggests that those drivers with the worst hazard perception skills also have more accidents. Therefore, this skill could be taught in order to prevent them.

An important question in this type of research is the methodology used in evaluating hazard perception (for a review of the subject see Egea-Caparrós, 2012). Different kinds of hazard-perception studies are video-sequences presentations, simulator studies and hazard-perception in photographs. For example, Pollatsek, Fisher, Pradhan and collaborators (Fisher et al., 2007; Garay-Vega and Fisher, 2005; Pradhan et al., 2005; Pradhan et al., 2009) have developed training procedures for novice drivers, based on their

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findings about attention allocation while driving. Dixit et al. (2014) performed a study with a driving simulator in which a monetary incentive enhanced motivation for the participants to focus their attention on those cues relevant for completing the tasks. Through several gap acceptance tasks for performing a left-hand turn, they showed that as drivers completed more successful turns the more optimistic they were about their probabilities of success with smaller gaps. While estimating a structural simple model to explain success in those tasks (including probabilities estimations of success in performing the tasks and attitudes towards risk), they found that the only parameter that distinguished those drivers who crashed and those who do not crashed was optimism towards smaller gaps. That is, independently of skill, those who crashed were more confident in their success than those who did not crash. The authors concluded that, while attitudes towards risk do not seem to explain accident involvement, differences in risk perception do. Nevertheless, in this part of the paper we will focus on those laboratory studies which used real traffic video-sequences.

The perception of traffic hazards in laboratory tasks using real traffic footage is a topic that has received attention since the mid – 60 s (see Currie, 1969; Spicer, 1964), through various methodologies. In the work of Spicer (1964; cited in Pelz and Krupat, 1974) traffic situations were presented using film footage and after viewing, participants were asked to choose a series of characteristics which described these films. Young drivers who had accidents were less sensitive in identifying the most essential characteristics related to safety in those scenes than those who had not been involved in accidents. Other studies pointed to the same conclusion (Quimby et al., 1986).

McKenna and Crick (1991) begun to use video footage of traffic situations, a research that links with the pioneering work already mentioned. These authors argue that hazard perception can be accurately evaluated, just using video footage of real traffic situations and measuring the response latency to hazards, without necessarily simulating driving behavior through vehicle control. Latency is the time between the moment a hazard appears in the sequence (defined as any action by other user forcing the camera car to take an evasive action such as braking or swerving to prevent a collision) and the driver's – observer's – response. This line of work continues today and has produced some mixed results. On the one hand, McKenna and Crick (1991) found that drivers who had a high number of accidents in the previous two years performed a worse hazard perception test, even partialling out the effects of age and mileage ($r = 0.11$, $n = 398$, $p = 0.03$). These same authors (McKenna and Crick, 1997) showed that young, novice drivers were significantly slower in their responses to detect dangerous situations. Hull and Christie (1992) carried out a test in which participants viewed traffic scenes and, on considering what appeared to be a maneuver involving a collision hazard were required to press a touchscreen. The results showed that there was a significant response time difference between those participants who had been involved in accidents and those who had not: the former took longer to react to danger than the latter.

Subsequent studies focused on how driving experience modulate hazard perception skills. It was found that response latency could discriminate between novice and expert drivers (Huestegge et al., 2010; Isler et al., 2009; McKenna et al., 2006; Scialfa et al., 2011; Smith et al., 2009; Sümer et al., 2007; Wallis and Horswill, 2007; Wetton et al., 2010; Whelan et al., 2002). In these, expert drivers responded more quickly to danger than novice drivers. However, some studies did not achieve the same results (e.g. Chapman and Underwood, 1998; Crundall et al., 1999; Sagberg and Bjørnskau, 2006; Underwood, 2000).

Many explanations for this inconsistency of results have been suggested. For example, Sagberg and Bjørnskau (2006) argue that perhaps the type of hazard perception skills that differentiate a novice from an expert is more related to certain types of traffic situations than others, and that the distinguishing features of these situations would be complexity, surprise and requirements of anticipation.

Also mentioned is the fact that the type of hazards presented is not equivalent in the sense that one type may be more obvious than another. Those dangers of abrupt occurrence (such as pedestrians or cyclists who suddenly enter the path of the vehicle from which the scene is filmed) arouse a quick response in both expert and novice drivers. However, other more subtle dangers (or showing a 'gradual' appearance, see Jackson et al., 2009) are responded to more efficiently by expert drivers than by novices, which suggests that while abrupt dangers cannot discriminate the responses of experts and novices, the 'gradual onset' ones can.

However, there remains a question regarding exactly what the measure of latency represents. That is, the results of research employing this methodology cannot explain what causes an increased latency of response to danger. For example, perhaps those subjects who most frequently delay response in sensing danger in traffic scenes do so because they do not perform fast and accurate discrimination of the cues that distinguish the appearance of such danger. It could be more a matter of "Sensitivity" to perceptual information in the scenes in terms of Signal Detection Theory.

Another alternative would be to consider that the greatest response latency could be caused by the "Criterion", i.e. the result, not of a lack of sensitivity to perceptual information but the "response tendency" or "Bias" of the driver. For Horswill and McKenna (2004), individual differences found in hazard perception tests, especially among novice and expert drivers, could be due to a different criterion rather than the ability to detect dangerous situations. This means that in this case, the driver is capable of detecting potential danger, but their judgment of what constitutes the "danger" of a particular traffic sequence makes them wait until enough evidence has been accumulated; that is, to wait until a certain level of 'threshold' have been reached before deciding that there is a danger of collision. A result that supports this interpretation is by Farrand and McKenna (2001), who found that, by using alternative instructions, the response bias of participants changed and this influenced the response latencies in a hazard perception test.

The relevance of adapting the hazard perception task to Signal Detection Theory (hereafter SDT) is shown by the fact that this provides two independent measures of these factors; Sensitivity and Criterion. SDT not only takes into account the sensory and motor aspects of our response to stimuli, but also the aspects of judgment that subjects made based on their expectations of the situation and possible consequences of their actions (Blanco Rial, 1996). Therefore, this provides an attitudinal and motivational dimension to the problem of hazard perception expressed in Criteria or response tendencies that participants show when responding to the task.

A precedent in trying to adapt the SDT to hazard perception tests is the work of Wallis and Horswill (2007). According to these authors:

While hazard perception test scores are typically based on reaction times, hazard perception is nonetheless a detection task and therefore issues related to Signal Detection Theory are relevant (p. 1178).

In their article, Wallis and Horswill adapt the "fuzzy" Signal Detection Theory (Parasuraman et al., 2000; Masalonis and Parasuraman, 2003) to hazard perception. The starting point is the idea that, lacking objective criteria to determine what is a Signal and what is Noise in this task, i.e. what is "Danger" and what is "Not danger", can be considered a continual in the appearance of the Signal (from 0 = completely "No Signal" and 1 = completely "Signal"), as well as the subject's response (from 0 = completely "No" and 1 = completely "Yes"). Each test is assigned to one of four categories considered in the SDT ("Hit", "Miss", "False Alarm" and "Correct