Exploring the effects of driving experience on hazard awareness and risk perception via real-time hazard identification, hazard classification, and rating tasks

Avinoam Borowsky*, Tal Oron-Gilad

Ben-Gurion University of the Negev, Department of Industrial Engineering and Management, Israel

ABSTRACT

This study investigated the effects of driving experience on hazard awareness and risk perception skills. These topics have previously been investigated separately, yet a novel approach is suggested where hazard awareness and risk perception are examined concurrently. Young, newly qualified drivers, experienced drivers, and a group of commercial drivers, namely, taxi drivers performed three consecutive tasks: (1) observed 10 short movies of real-world driving situations and were asked to press a button each time they identified a hazardous situation; (2) observed one of three possible sub-sets of 8 movies (out of the 10 they have seen earlier) for the second time, and were asked to categorize them into an arbitrary number of clusters according to the similarity in their hazardous situation; and (3) observed the same sub-set for a third time and following each movie were asked to rate its level of hazardousness. The first task is considered a real-time identification task while the other two are performed using hindsight. During it participants' eye movements were recorded. Results showed that taxi drivers were more sensitive to hidden hazards than the other driver groups and that young-novices were the least sensitive. Young-novice drivers also relied heavily on materialized hazards in their categorization structure. In addition, it emerged that risk perception was derived from two major components: the likelihood of a crash and the severity of its outcome. Yet, the outcome was rarely considered under time pressure (i.e., in real-time hazard identification tasks). Using hindsight, when drivers were provided with the opportunity to rate the movies' hazardousness more freely (rating task) they considered both components. Otherwise, in the categorization task, they usually chose the severity of the crash outcome as their dominant criterion. Theoretical and practical implications are discussed.

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1. Introduction

A large body of evidence suggests that young-novice drivers are more likely to be involved in a crash than experienced drivers (e.g., Pradhan et al., 2009; Shinar, 2007). In addition to age-related factors such as attitudes and personality traits which contribute to young-drivers' over involvement in traffic crashes (e.g., Heino et al., 1996; Ulleberg and Rundmo, 2003; Shinar, 2007) there are experience-based factors that contribute to their over involvement (e.g., Maycock et al., 1991). Of the many skills acquired with accumulated driving experience, hazard awareness (usually termed Hazard Perception, see Oron-Gilad and Borowsky, in press) is perhaps the most explored (e.g., Pelz and Krupat, 1974; Horswill and McKenna, 2004; Pollatsek et al., 2006; Sagberg and Bjørnskau, 2006; Wallis and Horswill, 2007; Borowsky et al., 2010b; Crundall

et al., 2010). Another related concept that is often confounded with hazard awareness is risk perception (e.g., Benda and Hoyos, 1983; Matthews and Moran, 1986; Jonah, 1986; Finn and Bragg, 1986; Brown and Groeger, 1988; Armsby et al., 1989; Borowsky et al., 2009). Although both of these skill-based processes relate to drivers' ability to anticipate the hazardousness in a situation and evaluate the risk associated with it, they are conceptually different and their evaluation measures are different as well (Oron-Gilad and Borowsky, in press). The purpose of the present study was to investigate hazard awareness and risk perception concurrently in typical driving-related paradigms in order to identify the components of each construct and ascertain where each of these processes is more dominant. Furthermore, by comparing tasks and measures that are typically considered depicting either hazard awareness related or risk perception related processes, the cross dependencies between these two constructs could be more thoroughly examined.

Hazard awareness, the ability to read the road (Mills et al., 1998) and identify potentially hazardous situations is a multidimensional and complex cognitive process (Benda and Hoyos, 1983). In this

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* Corresponding author.
E-mail address: avinoam.bor@gmail.com (A. Borowsky).

process, the driver must identify all hazards at any given moment and consider a maneuver that reduces the likelihood of a crash in light of other maneuver-related hazards. Hazards can therefore be defined as sources of danger that exist in the environment. Drivers are not always aware of their existence. Risk perception on the other hand, may be regarded as a subjective evaluation of how well the driver thinks he or she is able to handle the situation and apply an appropriate action. Consistently, evidence suggests that different types of hazard awareness and risk perception driving-related evaluation tasks provide distinctive (but complementary) knowledge. That is, when participants' task is to identify hazards in real-time (i.e., by responding to or reporting on) with minimal judgment, then it is more likely that the major process involved is hazard awareness and not risk perception. When, however, a participant is asked to evaluate the risk for being involved a crash in a certain situation, then the participant is likely to include a subjective evaluation of his or her skills and thus such tasks are related to risk perception.

The literature on hazard awareness has mainly focused on paradigms where participants are asked to observe short movies of real-world traffic situations from a driver's perspective and press a response button each time they identify a hazard (see Horswill and McKenna (2004) for a review). Typically, when using this type of paradigm, young-novice drivers identify fewer potential hazards than experienced drivers (e.g., Underwood et al., 2005; Borowsky et al., 2010b) and they are also slower (e.g., McKenna and Crick, 1994; McKenna et al., 2006; Wallis and Horswill, 2007). However, some studies did not find differences in response time (e.g., Chapman and Underwood, 1998; Sagberg and Bjørnskau, 2006; Borowsky et al., 2010b). Furthermore, eye scanning pattern analyses show that young-novice drivers do not accommodate their scanning behavior to the situation at hand (Chapman and Underwood, 1998) and they tend not to scan areas that embed potential risks (e.g., Pollatsek et al., 2006; Borowsky et al., 2010b). Recent evidence also suggests that young-novice drivers have difficulties in processing hazards once they are identified (Huestegge et al., 2010). Such evidence suggests that a portion of young-novice drivers' risk taking behavior can be attributed to their inability to identify the sources of dangers embedded in the environment and as a result selecting inappropriate actions (e.g., Jonah, 1986; McKenna et al., 2006) rather than to personal characteristics. One typical example relates to lead vehicles: a shorter gap from a lead vehicle may lead to a narrower field of view due to the lead vehicle obscuring other road hazards. Indeed, young-novice drivers tend to adopt shorter headways (Evans and Wasielewski, 1983). As such, when examining the development of these skills among drivers, it is necessary to capture both hazard awareness and risk perception abilities concurrently.

Differences in hazard awareness and risk perception skills between experienced and young-novice drivers can also be examined via rating-retrospective tasks in which drivers rate hazard- or risk-related variables (e.g., evaluating one's own ability to handle certain situations), or categorization tasks in which drivers categorize traffic scenes according to various criteria (e.g., Benda and Hoyos, 1983; Borowsky et al., 2009). Yet, retrospective tasks tend to confound hazard with risk. That is, when a driver is asked to rate the level of hazardousness in a given situation, he or she cannot abstain evaluating, to some degree, his or her own abilities to handle the situation. These tasks complement hazard identification tasks because they delve into drivers' conceptual knowledge regarding hazards and risks and they reveal the extent to which drivers relate to various attributes of the traffic environment (see also Endsley, 1995), elements that cannot be examined in real-time identification tasks. Benda and Hoyos (1983), for example, developed a categorization methodology in which drivers were asked to categorize traffic scene photos into an arbitrary

number of groups according to the similarity in their hazardousness. They reported that experienced drivers built a ranking order of groups, thus dealing with hazardousness as a quantity (e.g., "This is most. least hazardous group", etc., p. 5). On the other hand, drivers with half the driving experience, used a nominal scale for classifying the pictures into groups of equal quality of hazardousness ("The situations in this group are similarly hazardous because of the intersections in each", "all wet road situations", etc., p. 6). Also, although the task was originally designed to measure an objective evaluation of hazard awareness skills, participants could not avoid estimating their own abilities to handle the situation at hand. Thus, categorization tasks indeed involve both hazard awareness and risk perception.

Differences between young-novice and more experienced driver groups were also found in hindsight tasks. Applying a similar paradigm to Benda and Hoyos (1983), Borowsky et al. (2009) asked young-novice, experienced and elderly-experienced drivers to observe six traffic scene movies (of residential and urban driving situations) and to categorize them. They found two dominant categorization criteria: (1) categorization according to similarity in *hazard instigators* (the source of danger, e.g., pedestrians, vehicles, or no hazard–movies without materialized hazards). The hazard instigator criterion was dominant among young-novice drivers and less among more experienced drivers. (2) Categorization according to similarity in the *environmental characteristics* (the nature of the driving environment, e.g., urban or residential). Notably, the environmental characteristics criterion was more dominant among experienced and elderly experienced drivers than among young-novice drivers pointing to the fact that experienced drivers tend to be more aware of hidden hazards. Fig. 1 presents examples for criteria 1 and 2, respectively.

Despite their evidence, Borowsky et al. (2009) argued that there might be other categorization dimensions that were not observed in their study because it did not control for all possible hazard-related and risk-related dimensions (e.g., there was no urban exemplar where a pedestrian was crossing the road). In a later study, Borowsky et al. (2010a) examined the effect of hazard perception training of young-novice drivers on categorization of similar hazardous situations to the one reported by Borowsky et al. (2009), but included an urban exemplar where a pedestrian was crossing the road. Indeed they found that the addition of this one exemplar revealed a third categorization criterion – the perceived time to collision (perceived TTC; immanency of the hazard) criterion. This criterion suggested that drivers can categorize traffic scenes according to their similarity in the imminence of the situation or the amount of time left to prevent a crash. Thus, drivers may categorize a vehicle-related and a pedestrian-related hazard in the same group when both situations require an imminent response. As such, the current study was aimed to further explore these three possible classification criteria. In order to do so, the traffic scene set for the current study was selected in a more controlled, pre-structured manner.

Categorization tasks typically induce drivers to select a single categorization criterion which may implicate their limitations. In order to allow more flexibility the present study also included a rating task. Ratings provide drivers with more flexibility to base their judgment on multiple criteria (e.g., Armsby et al., 1989). Retrospective rating tasks complement the former two paradigms as they can also provide information regarding experience-based differences with respect to hazard awareness and risk perception. In a typical rating task a driver is asked to rate the level of hazardousness in a given situation on a continuous scale (e.g., Armsby et al., 1989; Matthews and Moran, 1986). Usually, young-novice drivers rate potentially hazardous situations and more complex situations as less hazardous than experienced drivers (Finn and Bragg, 1986; Armsby et al., 1989; De Craen et al., 2009).