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Hazard perception in emergency medical service responders

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ABSTRACT

The perception of on-road hazards is critically important to emergency medical services (EMS) professionals, the patients they transport and the general public. This study compared hazard perception in EMS and civilian drivers of similar age and personal driving experience. Twenty-nine EMS professionals and 24 non-professional drivers were given a dynamic hazard perception test (HPT). The EMS group demonstrated an advantage in HPT that was independent of simple reaction time, another indication of the validity of the test. These results are also consistent with the view that professional driving experience results in changes in the ability to identify and respond to on-road hazards. Directions for future research include the development of a profession-specific hazard perception tool for both assessment and training purposes.

1. Introduction

Hazards are defined as either an object (e.g. vehicle merging into a lane) or condition (e.g. a construction zone) that increases the risk of injury. In the traffic safety literature, *hazard perception* is operationalized as the ability to identify and respond to hazardous elements in the roadway environment (Horswill and McKenna, 2004). Efficient hazard perception allows individuals to anticipate a hazard from situational cues and respond appropriately and has been identified as a skill that is related to safe driving (e.g., Mills et al., 1998).

Spicer initiated the investigation of hazard perception (1964, as cited in Horswill and McKenna, 2004) in a study asking drivers to identify important elements from a series of driving videos. Younger, collision-involved drivers were found to be less accurate than those who were collision-free. Similarly, Pelz and Krupat (1974) found a significant difference in response latency; drivers with no collision history revealed faster responses to road hazards presented in video clips than those who reported collisions (by 500 ms) and those with reported convictions (by 1200 ms). Those without a collision history are also better at correctly identifying when it is safe to maneuver a vehicle (Hull and Christie, 1992). Additionallly, scores on brief, standardized, dynamic hazard perception tests (HPTs) have been associated with collision involvement (Deery, 1999; McKenna and Crick, 1991 Quimby and Watts, 1981).

Although the body of literature on hazard perception has grown considerably over the past several decades, theoretical treatment of its development and manifestation has been relatively sparse. Several authors have discussed the "mental model" that is required for efficient hazard perception (Underwood et al., 2002; Scialfa et al., 2011), which is deficient in novice drivers and those with a greater propensity for collisions. More recent treatments (e.g., Vaa, 2013) incorporate hazard perception as the result of stimulus-driven and experience-based inputs that combine with emotional states and task goals to influence driving behaviors, including the allocation of attention and scanning that sub-serve safe driving.

Many of these elements are central to the Salience, Effort, Expectancy and Value (SEEV) model, which asserts that the allocation of visual attention to an area of interest, such as a hazard, is dependent on those factors (Horrey et al., 2006). In the continuously changing driving environment, there are multiple areas and stimuli to which drivers must attend in order to detect hazards. Within the SEEV model, experience provides the driver with an expectancy of the location of potential hazards and their associated value (i.e., the consequences of not performing an evasive maneuver). This, in turn, allows the driver to expend less effort to allocate attention appropriately within and around the roadway.

Hazard perception is a skill and, as such, develops with and is influenced by practice (Crundall and Underwood, 1998; Crundall et al., 2005; Fisher et al., 2003). Compared to their more experienced counterparts, novice drivers are often relatively poor at perceiving on-road hazards (Fisher et al., 2006; McKenna et al., 2006). Benefits gained through maneuvering through consistent driving

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scenarios include the less effortful mapping of potential conflicts onto subsequent behaviors (Schneider and Shiffrin, 1997; Logan, 1988), contextual cuing (Jiang and Wagner, 2004; Brockmole and Henderson, 2006), decreased workload (Young and Stanton, 2007), and more efficient scanning behaviour (Mourant and Rockwell, 1972; Deery, 1999; Underwood, 2007; Chan et al., 2010). As would be expected with any skill, training can improve hazard perception, even in those considered to be highly experienced drivers (Horswill et al., 2013).

Given that hazard perception is a skill developed through experience, one might expect that those in occupations requiring a great deal of driving, particularly under demanding conditions, would evidence better performance in tests of hazard perception. Stated differently, a valid test of hazard perception skill will reveal group differences when the groups involved differ in their training and/or driving experience. Thus, HPT deficiencies in novice driers, older drivers and collision-involved drivers attest to the disriminant validity of the HPT.

Crundall et al. (2003, 2005) expanded this line of investigation by including a comparison group with a different level of experience. Experienced police, novice drivers and a civilian group matched on age and time since initial licensure were shown three different series of video clips; pursuit clips of vehicles at high speeds, emergency response drives with lights and sirens, and control drives. Attention was measured by recording participants' eye movements. Novices demonstrated the longest gaze duration towards road hazards. Gaze duration towards the median was similar for the controls and police during the pursuit clip. However, differences were found in the gaze durations between police and matched controls towards the pursuit stimuli (shorter for police), areas where a hazard *may* appear (longer for police), and towards unprotected pedestrians (longer for police).

It is likely that increased exposure to the task for police required fewer attentional resources to be allocated to pursuit, which allowed more resources to be directed toward areas of potential hazards. Consistent with this view, Horswill et al. (2013) assessed the hazard perception of experienced drivers compared to police using a dynamic hazard perception test of civilian driving. Police responded to hazards 1.27 s faster than their experienced civilian counterparts, an advantage that was independent of a measure of simple spatial reaction time. Taking a very different approach to this topic, Borkenhagen et al. (2014) reported that EMS professionals are quite aware of roadway conditions and road users that pose hazards for them and have, in many instances, developed personal strategies to mitigate risk while driving.

The current study compared EMS ambulance operators to civilians on a dynamic HPT that has been used previously (Scialfa et al., 2011) and manifests good psychometric properties. It was used to determine if EMS professionals are, in general, better able to identify and respond to on-road traffic conflicts and thus, is a test of the validity of the HPT.

2. Methods

2.1. Participants

The University of Calgary Conjoint Health Research Ethics Board approved this study. A sample of 53 participants were recruited and tested, 29 Calgary Zone EMS and a control group of 24 civilian drivers. Table 1 presents descriptive statistics for the groups on collected demographics and driving history. EMS participants were recruited through notices distributed within Alberta Health Services (AHS) Calgary Zone Emergency Medical Services. All study advertisements indicated that the session was a study of the University of Calgary and was not a training session run by AHS. This was done to ensure that participants did not feel pressured to participate as a job requirement. EMS participants were paid $25 (CDN) per hour for their time.

The control group was recruited using the University of Calgary undergraduate student participant pool and through "snowball sampling". Students participating were granted course research credit for completing the study. All participants in the control group held a standard driver's license (Class 5 in the province), while EMS held a somewhat more demanding (Class 4) license. There were no significant differences between the EMS and civilian groups' reported age, years of licensure, collision history during civilian driving, or exposure. Within the EMS group, participants reported an average of $M = 6$ years (range 1–17) of professional experience; 67.8% were affiliated with emergency operations (versus Inter-Facility Transportation); 71.4% worked in urban zones.

2.2. Materials and apparatus

2.2.1. Vision tests

Photopic acuity was tested using the Landolt C Near Vision chart at a distance of 40 cm. The test uses a series of broken rings printed in rotations of 90°; participants were asked to indicate which side the gap of the ring faced. Acuity was measured from 20/400 to 20/10 in 0.05 logMAR increments.

Photopic contrast sensitivity was measured using the VISTECH VCTS 6000, which estimates sensitivity at 1.5–18 cpd from a distance of 40 cm (16 in). The chart uses five rows of sine-wave gratings, which increase in spatial frequency from top to bottom and decrease in contrast from left to right. Participants were asked to indicate the orientation of the grating. The reciprocal of the lowest contrast for the row that is correctly reported is the contrast sensitivity for that spatial frequency.

Colour deficiencies were assessed using the Farnsworth D-15 Dichotomous Colour Test. Participants were asked to organize coloured discs in increasing wavelength. The D-15 is considered dichotomous as it distinguishes between severe and mild/normal colour deficiencies. The test was conducted under photopic illumination.

2.2.2. Simple spatial reaction time (SSRT)

Participants completed a simple spatial reaction time test to account for any individual differences in general speed of response. In this test, 16 high-contrast black boxes of differing sizes appear at random intervals and locations on a monitor. The size of the boxes ranged from 2.75 cm × 2.8 cm to 13 cm × 14 cm and were chosen to represent the 25th, 50th, 75th, and 100th percentiles of the height and width of the hazardous objects at onset of the traffic conflicts during the HPT. The task required that they select the center of the black boxes by touching the monitor. A small yellow circle appeared at the selection point to provide visual feedback that participants' responses had been registered. They were informed the test would not give them any information about speed or accuracy of responses

2.2.3. Hazard perception test

The Hazard Perception Test (HPT) is a series of 95 silent driving scenes lasting between 10–62 s filmed in Vancouver, B.C., Canada, and surrounding areas using a Sony Handycam Camcorder, model HDR-SR11 in AVCHD 16 M (FH) format at a resolution of 1920 × 1080/60i. The camera was mounted inside a 2005 Subaru Impreza and secured to the inside door window on the passenger side of the vehicle (Scialfa et al., 2011). An extendable arm allowed the videotaped scenes to give a "driver's eye" view. Filming occurred in March and April 2009, during daylight hours, generally under clear skies and dry roadway conditions in a variety of frequently encountered environments (e.g., residential, limited-access freeway). Each driving scene was edited from original files

Table 1
Descriptive statistics (M, SD) of group characteristics for EMS and civilians. Data exclude outliers.

	EMS *n* = 28	Control *n* = 20	p-value
Age	30.50 (*6.79*)	29.50 (*4.24*)	0.541
Age Range	21–49	24–37	
Gender ratio (M:F)	18:10	9:11	0.184
Years of Licensure[a]	13.96 (*6.79*)	12.70 (*4.65*)	0.475
Avg. driven distance (km/yr)[a]	23,400 (*11,050*)	15,067 (*17,548*)	0.049*
Collisions within last 2yrs.[a]	0.07 (*0.26*)	.16(*0.37*)	0.356
Years of Experience[b]	6 (3.70)		
Less than 5 yrs. Exp. (%)[b]	28		
Urban (%)[b]	71.4		
Emergency Operations (%)[b]	67.8		
Avg. Km/yr. in Ambulance[b]	39,825 (*38,437*)		
Avg. total km/yr.[b]	63,225 (*40,535*)		
Collisions in Ambulance within last 2 yrs[b]	0.36 (*0.68*)		

[a] Refers to non-ambulance driving.
[b] Refers to EMS only.

using Sony Vegas Movie Studio Platinum software (version 9.0a) at a resolution of 1280 × 720 (Scialfa et al., 2011). Only one traffic device found in the scenarios differed from those found in Alberta, a flashing green signal light. Participants were instructed to treat the flashing light as a "solid". The HPT consisted of three 20-min blocks of scenarios that were counterbalanced across participants. They completed a short practice period to familiarize themselves with responding to traffic conflicts similar to those occurring during the experimental trials. They were instructed to select the traffic conflicts as quickly and accurately as possible. A yellow circle appeared at the point of contact to provide visual feedback that participants' responses had been registered but they did not receive feedback about accuracy or speed.

Of the 95 driving scenes, 64 (67%) contain a *traffic conflict*, defined as a situation in which the camera car would be required to take evasive action such as slowing, stopping, or steering to avoid a collision with a road user or stationary object. Examples of the traffic conflicts include a braking lead vehicle, pedestrian incursion, and construction equipment in the driving lane. A more complete description of the scenes can be found in Table 2.

At onset of the traffic conflict the object in the scene had a height ranging between 1 and 10 °(M = 3.0°) and a width between 1.6 and 14.8° (M = 4.4°) at a nominal viewing distance of 50 cm. The eccentricity of the objects relative to screen center ranged between −0.9 and 3.4° on the vertical axis (M = 1.0°) and between −16.2 and 10.9° on the horizontal axis (M = −1°). Thus, objects in traffic conflicts were quite varied in their size and location but, on average, did not require excellent acuity or peripheral vision. Thirty-one scenes (33%) did not contain a traffic conflict and were included in the series to increase uncertainty about hazard presence, as would be the case in normal driving.

Custom software was used by the researchers to define (before data collection) the onset, offset, and spatial extent of the traffic conflicts of each scene (see Marrington et al., 2008). Briefly, at conflict onset, the object that produced the conflict (e.g., a suddenly turning vehicle) was enclosed by a rectangular space that was then changed in size and location on a frame-by-frame basis until the end of the video sequence. This spatial information was saved to a separate file and that file was then convolved with a participant's time-stamped responses to determine response latency and accuracy.

A 17-in. Elo 1729 L touch-screen LCD desktop monitor with a resolution of 1280 × 1024 set at a viewing distance of approximately 50 cm was used to present the HPT and collect responses.

The test has been shown to be reliable (Cronbach's alpha = 0.75) and sensitive to levels of experience. It discriminates novice from experienced drivers with a classification accuracy of 84% (Scialfa et al., 2011). In brief form, it also predicts which older adults will fail and which will pass an on-road examination (Ross et al., 2014).

2.3. Procedure

Participants were tested in a session lasting approximately 2 h. The control group was tested at the Perceptual and Cognitive Aging Lab at the University of Calgary. Most EMS were tested at their operations headquarters, however they were also given the option to complete the session at the University of Calgary. Upon arrival at the facility, participants were asked to read and sign the consent form. A researcher also verbally described the details of the study and what would be expected of them. After obtaining consent, participants completed the vision tasks. Only those participants who demonstrated better than 20/40 near acuity with corrective lenses and no colour deficiencies continued.

For the SSRT and HPT tasks participants were seated at a viewing distance of 50 cm. The monitor height was adjusted to a viewing angle of −10°. If participants required corrective lenses they were asked to wear them. Next, they were asked to complete a short demographic questionnaire. At the end of the experimental trials, they were debriefed on the purpose of the experiment and compensated for their time.

3. Analysis and results

3.1. Outliers

Analysis of the simple spatial reaction time (SSRT), hazard perception reaction time (HPRT), false alarm, and miss rate data revealed five participants (1 EMS, 4 civilian) whose scores were more than 2.5 SD from the mean for their group. In addition to this, two of the civilian participants had difficulty understanding what the hazard perception test task required.

Analyses were completed once including the outliers and again excluding them. Although there was no effect on significance levels, the outliers were found to influence the magnitude and direction of the correlations (not included here) between HPRT, false alarms and miss rates. Reported results are those excluding outliers.

3.2. Simple spatial reaction time (SSRT)

SSRT was calculated as the mean reaction time for SSRT trials in which participants responded to the target (see Table 3). Missing data were excluded from analysis, but only 3 trials were missed out of all trials and all participants. EMS (M = 684 ms) had a shorter SSRT than civilians (M = 708 ms), however the difference was non-significant (p = 0.467).

Table 2
Classification of traffic conflict type and scenes included in analyses.

Type	All TC scenes 64 n (%)	TC Subset scenes 42 Included n (%)	22 Excluded n (%)
Moving vehicle in same direction as the camera car			
Signal/turn right	7 (10.9)	5 (7.8)	2 (3.1)
Signal/turn left	5 (7.8)	2 (3.2)	3 (4.7)
Parking	3 (4.7)	3 (4.7)	0 (0)
Slowing	12 (18.8)	6 (9.4)	6 (9.4)
Turning/merging into CC* lane	9 (14.1)	9 (14.1)	0 (0)
Stopped in CC lane	6 (9.4)	5 (7.8)	1 (1.6)
Moving vehicle in different direction of the camera car			
Crossing CC path from the left	2 (3.1)	2 (3.1)	0 (0)
Crossing CC path from the right	1 (1.6)	1 (1.6)	0 (0)
Head-on	2 (3.1)	1 (1.6)	1 (1.6)
Miscellaneous			
Pedestrians	5 (7.8)	3 (4.7)	2 (3.2)
Cyclists	8 (12.5)	5 (7.8)	3 (4.7)
Road Work	3 (4.7)	1 (1.6)	2 (3.2)
Object on the road	1 (1.6)	0 (0)	1 (1.6)

Table 3
Average dependent variable scores in relation to driver group.

	EMS Mean (SD)	Control Mean (SD)	p-value
SSRT (ms)	684.3 (130.26)	708.9 (87.55)	0.467
False alarms (%)	3.9(7.5)	3.3 (.5)	0.772
Miss rate (%)	4.4 (4.5)	4.0 (5.9)	0.800
HPRT (s)	1.80 (36)	2.14 (.49)	0.010
Adjusted mean HPRT (s) based on covariance analysis	1.80 (.36)	2.14 (.49)	0.034

3.3. Hazard perception

3.3.1. Scene selection

Although the 64 traffic conflict scenes were previously identified to contain a hazard, participants did not identify them all consistently. This can complicate the interpretation of hazard perception data. Therefore, exclusion criteria used in previous studies (Scialfa et al., 2011) were applied to eliminate problematic scenes. Traffic conflict scenes were included only if the hit rate corresponding to the identification of a hazard in its defined spatial-temporal window, was at least 85%. Of the 64 traffic conflict scenes, 42 were included in the analysis (See Table 2 for a description of the excluded and included scenes). Missing data for each scene were replaced by the group mean for the scene. Cronbach's alpha for the resulting 42-item hazard perception test was 0.86. Hazard perception reaction time was calculated from these scenes.

For similar reasons, if 15% or more of the participants identified a hazard in a non-traffic conflict scene, the scene was excluded from analyses. Of the 31 scenes that did not contain a traffic conflict, 9 were included; false alarm rate was calculated from these scenes.

3.3.2. Comparison of EMS and civilians

3.3.2.1. Total touches. The total number of touches was recorded for participants. This included the total number on trials resulting in hits or false alarms, as well as additional touches made to traffic conflict scenes outside the predefined parameters of the hazard. The touches were included only for traffic conflict and non-traffic conflict scenes that met the inclusion criteria. Analysis revealed a significant, negative correlation between total touches and HPRT for the entire sample ($r = -387$, $p = 0.007$), suggesting that those who made more touches responded faster. However, there was no significant difference in the number of touches made by each group (EMS $M = 115.29$, $SD = 23.18$; civilians $M = 108.2$, $SD = 18.26$), $t(46) = 1.11$, $p = 0.271$.

3.3.2.2. Misses. A miss was recorded when a participant failed to touch the hazard within the spatio-temporal window defined pre-experimentally. There were no significant differences in miss rate between EMS and civilians.

3.3.2.3. False alarms. A false alarm was recorded when a participant responded during a non-traffic conflict scene. There were no significant differences in false alarms between EMS and civilians (see Table 3). However, because of the significant correlation obtained ($r = -0.327$, $p < 0.05$) between false alarms and HPRT, the variable was incorporated as a covariate in analyses of HPRT data.

3.3.2.4. HPRT. EMS were significantly faster than civilians on average HPRT $F(1, 46) = 7.32$, $p = 0.01$, $\eta^2 = 0.754$. Because the civilian group reported significantly less yearly distance driven than EMS, it is possible that group differences in HPRT are due to individual differences in experience as measured by distance driven. Although mean SSRT was not significantly different, because the direction of differences favored EMS, it is possible that group differences in HPRT may be related to differences in SSRT. To examine this possibility, an analysis of covariance (ANCOVA) was completed comparing the groups' average HPRT while controlling for total touches, exposure, SSRT, false alarms and miss rate. The ANCOVA revealed a significant effect of total touches $F(1,41) = 4.54$, $p = 0.039$, non-significant effects for false alarms $F(1,41) = 0.007$, $p = 0.932$, miss rate $F(1,41) = 2.76$, $p = 0.104$, SSRT $F(1,41) = 0.199$, $p = 0.658$ or for distance driven yearly $F(1,41) = 0.436$, $p = 0.513$. Importantly, the group effect was still significant $F(1,41) = 4.79$, $p = 0.034$, $\eta^2 = 0.105$, with EMS revealing faster HPRTs.

4. Discussion and conclusions

Driving is a complex task that requires a number of perceptual and cognitive skills. Included among these skills is hazard perception, the ability to identify and respond to a hazard to allow collision avoidance (Horswill and McKenna, 2004). Hazard perception deficiencies in novice drivers have been widely reported (Crundall et al., 2003; Garay-Vega, and Fisher, 2005; McKenna et al., 2006; Fisher et al., 2006; Patten et al., 2006; Horswill et al., 2013). Additionally, there is a growing body of evidence suggesting that differences also exist between experienced civilian drivers and emergency service responders (Horswill et al., 2013; Crundall et al., 2005). This research suggests that those in the roles of "first responders" have acquired greater experiences that affect their driving, specifically their hazard perception.

To evaluate the discriminat validity of hazard perception tests, a dynamic HPT was used to assess the differences in hazard perception between EMS and civilians. It was predicted that the EMS would respond faster to hazards than experienced, civilian drivers. As hypothesized, EMS revealed a shorter latency to hazards than civilians, independent of general response latency. At a speed of 60 km/h, their 340-ms advantage translates to a stopping distance advantage of 5.6 m. Clearly then, such a difference in HPRT may be critical in collision avoidance.

This study is the first to assess hazard perception in emergency medical service professionals. The findings are consistent with previous work evaluating the hazard perception skills of police (Crundall et al., 2005; Horswill et al., 2013) in that police spend more time observing areas where a hazard may emerge (Crundall and Chapman, 2005) and have an advantage in response latency (Horswill et al., 2013). Thus, there is consistent evidence that HPTs show good discriminant validity.

The advantages that EMS demonstrate in their response latency to hazards may be attributed to the experiences gained through emergency vehicle operations, either those due solely to greater driving or those that are specific to the profession (e.g., driving with lights and sirens, at speed, against a red light or stop sign). It is likely that these experiences contribute to the development of a more diverse mental model to detect and predict hazards (Horrey et al., 2006) and facilitate a more automatized detection of hazard features (Schneider and Shiffrin, 1977). Given the nature of the study sample and the non-random selection of them for data collection, it is also possible that self-selection played a role in generating the obtained group differences.

This research has laid groundwork for a number of future studies. Hazard perception differences resulting from experiences garnered through emergency vehicle operations have been demonstrated in a test of civilian driving. In addition to a civilian driving HPT, studies examining police have produced job-specific tests using videos filmed during police driving (Crundall et al., 2005; Horswill et al., 2013). The next logical step for this study is the development and validation of an EMS-specific hazard perception test.

Despite the observed superiority of EMS professionals in hazard perception, there are good reasons to develop training modules for both novice and experienced EMS. The nature of Emergency Service Response professions, such as emergency medical service providers (EMS), police, and fire fighters, means increased exposure to high-risk encounters on the road and greater risk of injury and death. For example, between 2003 and 2007, the fatality rate among Emergency Medical Technicians was 6.3 per 100,000 individuals, 1.4 times greater than other professions (Reichard et al., 2011). These professionals often are involved in either speedy pursuit or travel to and from a scene, they are exposed more frequently to traffic conflicts and thus, as with any driver, the probability of collision increases.

Like their civilian counterparts, ambulance operators are particularly susceptible to collisions at intersections, where potentially conflicting road users interact and the EMS driver may violate civilian law. The largest percentage of collisions between ambulances and other vehicles occur at intersections; the reported values range from 43% to 46% (Custalow and Gravitz, 2004; Sanddal et al., 2010). Of particular relevance for the current study, in 32% of the reports, the ambulance drivers were at fault, having struck another object or vehicle (Sanddal et al., 2010).

The benefits of hazard perception training are well documented for novice drivers (Garay-Vega and Fisher, 2005; McKenna et al., 2006; Fisher et al., 2006). Within the context of emergency vehicle operations, novice EMS may also be considered novice drivers. They may therefore display similar benefits to EMS-based hazard perception training. As well, assessments of the effect of training on hazard perception found that even experienced drivers demonstrate improvement (Horswill et al., 2013).

The greater reported collision risk among EMS drivers (e.g., Reichard et al., 2011), despite the hazard perception advantages found here, may be explained by the violation of traffic norms and overall greater exposure to driving experience by EMS. However, this study examined only civilian driving. It is unknown what differences exist in hazard perception during emergency vehicle operations. Due to these unique experiences that occur during ambulance operations, there may be benefit in embedding the hazard perception training modules within on-road training with the ambulance. Through this, EMS may strengthen their ability to detect hazards while performing additional tasks. These may include operating the vehicle, communicating with dispatch, and communicating with their shift partner while they care for a patient.

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References

Borkenhagen, D., Johnston, K., Scialfa, C., 2014. Hazard perception in EMS operations: a focus group study. Can. Paramed. 37 (4), 20–22.

Brockmole, J.R., Henderson, J.M., 2006. Using real-world scenes as contextual cues for search. Visual Cognit. 13 (1), 99–108, http://dx.doi.org/10.1080/13506280500165188.

Chan, E., Pradhan, A., Pollatsek, A., Knodler, M., Fisher, D., 2010. Are driving simulators effective tools for evaluating novice drivers' hazard anticipation, speed management, and attention maintenance skills? Transp. Res. Part F: Traffic Psychol. Behav. 13 (5), 343–353, http://dx.doi.org/10.1016/j.trf.2010.04.001.

Crundall, D., Underwood, G., 1998. The effects of experience and processing demands on visual information acquisition in drivers. Ergonomics 41 (4), 448–458, http://dx.doi.org/10.1080/001401398186937.

Crundall, D., Chapman, P., Phelps, N., Underwood, G., 2003. Eye movements and hazard perception in police pursuit and emergency response driving. J. Exp. Psychol. Appl. 9 (3), 163–174, http://dx.doi.org/10.1037/1076-898x.9.3.163.

Crundall, D., Chapman, P., Phelps, N., Underwood, G., 2005. What attracts attention during police pursuit driving? Appl. Cognit. Psychol. 19 (4), 409–420 http://dx.doi.org/10.1002/acp.1067.

Custalow, C., Gravitz, C., 2004. Emergency medical vehicle collisions and potential for preventive intervention. Prehosp. Emerg. Care 8 (2), 175–184, http://dx.doi.org/10.1080/31270300279x.

Deery, H., 1999. Hazard and risk perception among young novice drivers. J. Saf. Res. 30 (4), 225–236, http://dx.doi.org/10.1016/s0022-4375(99)00018-3.

Fisher, D.L., Pradhan, A.K., Hammel, K.R., DeRamus, R., Noyce, D.A., Pollatsek, A., 2003. Are younger drivers less able than older drivers to recognize risks on the road? Inj. Insights 1, 2–7.

Fisher, D., Pollatsek, A., Pradhan, A., 2006. Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? Inj. Prev. 12, 25–29, http://dx.doi.org/10.1136/ip.2006.012021.

Garay-Vega, L., Fisher, D., 2005. Can novice drivers recognize foreshadowing risks as easily as experienced drivers? In: Proceedings of the Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Rockport, Maine June 27–30.

Horrey, W., Wickens, C.D., Consalus, K., 2006. Modeling drivers' visual attention allocation while interacting with in-vehicle technologies. J. Exp. Psychol. Appl. 12 (2), 67–78, http://dx.doi.org/10.1037/1076-898x.12.2.67.
Horswill, M., McKenna, F., 2004. Drivers hazard perception ability: situation awareness on the road. In: Banbury, S., Tremblay, S. (Eds.), A Cognitive Approach to Situation Awareness. Ashgate, Aldershot, UK, pp. 155–175.
Horswill, M.S., Taylor, K., Newnam, S., Wettin, M., Hill, A., 2013. Even highly experienced drivers benefit from a brief hazard perception training intervention. Accid. Anal. Prev. 52, 100–110.
Hull, M., Christie, R., 1992. Hazard perception test: the Geelong trial and future development. In: Proceedings of the National Road Safety Seminar, Wellington, NewZealand.
Jiang, Y., Wagner, Y., 2004. What is learned in spatial contextual cuing—configuration or individual locations? Percep. Psychophys. 66 (3), 454–463, http://dx.doi.org/10.3758/bf03194893.
Logan, G.D., 1988. Toward an instance theory of automatization. Psychol. Rev. 95 (4), 492–527, http://dx.doi.org/10.1037/0033-295x.95.4.492.
Marrington, S., Horswill, M., Wood, J., 2008. The effect of simulated cataract on drivers' hazard perception ability. Optometry Vision Sci. 85, 1121–1127, http://dx.doi.org/10.1097/opx.0b013e31818e8d00.
McKenna, F.P., Crick, J.L., 1991. Hazard perception in drivers: a methodology for testing and training (No. CR313). In: Final Report, Behavioural Studies Unit. Transport and Road Research Laboratory, Crowthorne, UK.
McKenna, F.P., Horswill, M.S., Alexander, J.L., 2006. Does anticipation training affect drivers' risk taking? J. Exp. Psychol. Appl. 12 (1), 1–10, http://dx.doi.org/10.1037/1076-898x.12.1.1.
Mills, K.L., Rolls, G.W.P., Hall, R.D., McDonald, M., 1998. The effects of hazard perception training on the development of novice driver skills (No. 00735328). In: Road Safety Research Report No. 4. Department of the Environment, Transport & the Regions, London, UK.
Mourant, R., Rockwell, T., 1972. Strategies of visual search by novice and experienced drivers. Hum. Factors 14, 325–335.
Patten, C., Kircher, A., Ostlund, J., Nilsson, L., Svenson, O., 2006. Driver experience and cognitive workload in different traffic environments. Accid. Anal. Prev. 38 (5), 887–894, http://dx.doi.org/10.1016/j.aap.2006.02.014.
Pelz, D.C., Krupat, E., 1974. Caution profile and driving record of undergraduate males. Accid. Anal. Prev. 6, 45–58, http://dx.doi.org/10.1016/0001-4575(74)90015-3.
Quimby, A.R., Watts, G.R., 1981. Human Factors and Driving Performance (No 00348578). Transport and Road Research Laboratory, Crowthorne, UK.
Reichard, A., Marsh, S.M., Moore, P.H., 2011. Fatal and nonfatal injuries among emergency medical technicians and paramedics. Prehosp. Emergency Care 15 (4), 511–517, http://dx.doi.org/10.3109/10903127.2011.598610.
Ross, R., Cordazzo, S., Scialfa, C., 2014. Predicting on-road driving performance and safety in healthy older adults. J. Saf. Res. 51, 73–80, http://dx.doi.org/10.1016/j.jsr.2014.09.005.
Sanddal, T.L., Sanddal, N.D., Ward, N., Stanley, L., 2010. Ambulance crash characteristics in the U.S. defined by the popular press: a retrospective analysis. Emergency Med. Int., 1–7, http://dx.doi.org/10.1155/2010/525979.
Schneider, W., Shiffrin, R.M., 1977. Controlled and automatic human information processing: I. Detection, search and attention. Psychol. Rev. 84 (1), 1–66, http://dx.doi.org/10.1037//0033-295x.84.1.1.
Scialfa, C.T., Deschenes, M.C., Ference, J., Boone, J., Horswill, M., Wetton, M., 2011. A hazard perception test for novice drivers. Accid. Anal. Prev. 43 (1), 204–208, http://dx.doi.org/10.1016/j.aap.2010.08.010.
Underwood, G., Chapman, P., Bowden, K., Crundall, D, 2002. Visual search while driving: skill and awareness during inspection of the scene. Transp. Res. Part F Traffic Psychol. Behav. 5 (2), 87–97, http://dx.doi.org/10.1016/s1369-8478(02)00008-6.
Underwood, G., 2007. Visual attention and the transition from novice to advanced driver. Ergonomics 50 (8), 1235–1249, http://dx.doi.org/10.1080/00140130701318707.
Vaa, T., 2013. Proposing a Risk Monitor Model based on emotions and feelings: exploring the boundaries of perception and learning. In: Regan, M., Lee, J., Victor, T. (Eds.), Driver Distraction and Inattention: Advances in Research and Countermeasures, Vol 1. Ashgate Publishing Ltd, Surrey, UK, pp. 103–112, http://dx.doi.org/10.1080/00140139.2013.824153.
Young, M.S., Stanton, N.A., 2007. What's skill got to do with it? Vehicle automaticity and driver mental workload. Ergonomics 50 (8), 1324–1339, http://dx.doi.org/10.1080/00140130701318855.