Alternative methods of measuring hazard perception: Sensitivity to driving experience

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ABSTRACT

Drivers' ability to perceive and react to hazards has been a focus of much research over the past two decades, and hazard perception testing is an increasingly important part of the driver licensing process world-wide. Hazard perception appears to be sensitive to crash-involvement and driving experience. However, the methodological approach and conceptual basis of these experiments has varied considerably. This may account for why the effects observed in some studies have not always been replicated in others, and why development of truly parallel versions of hazard perception tests has proven difficult. Comparison of different methods to test hazard perception is theoretically important – to gain a better understanding of the psychological processes which underpin hazard perception, and practically important – to driver training, education, and licensing.

Outcomes of various methods of assessing hazard detection with still and moving images of traffic scenes are presented here. Novice (*N*=86) and Experienced (*N*=20) drivers were asked to detect any hazards or potential hazards, tested under distraction and non-distraction conditions, in photographed traffic scenes. Objects identified as hazards and the time taken to make such responses were the basis of several different analytical approaches. Comparisons were made between experienced and novice drivers using experts' ratings.

Experienced drivers detected hazards significantly faster than Novice drivers. Whilst no significant effect was found for hazard perception accuracy as a function of driving experience, qualitative analysis indicated that lane type and whether the object was fixed or moving did show differences. Implications of these results for understanding hazard perception are discussed.

INTRODUCTION

The role of hazard perception in the development of safe driving has become increasingly important. In an analysis of police reports, failing to search the roadway was the single most common factor in crashes, especially amongst the young novice driver group (Lestina & Miller 1994, cited in Underwood, Crundall, & Chapman, 2002). It is not surprising then that the importance of hazard perception has led to its introduction into many driver-licensing systems world-wide. In Australia, hazard perception tests are a part of the licensing process in Victoria, New South Wales, and Western Australia.

Hazard perception can be defined as the process of identifying hazards and quantifying their potential for danger (Brown & Groeger 1998). There have been a variety of methodologies used to test this complex skill, including the identification of hazards encountered on a test drive (Soliday, 1974), the ranking of photographed traffic scenes on a scale of hazardousness (Armsby, Boyle, & Wright, 1983), the presentation of video scenes requiring various ratings including the danger and difficulty involved in the scene (Groeger & Chapman, 1996), rating of risk presented in video or photographed traffic scenes (Finn & Bragg, 1986), and the measurement of visual search patterns whilst driving a test route (Mourant & Rockwell, 1972; Underwood, Crundall, & Chapman, 2002) or when watching video traffic scenes (Chapman & Underwood, 1998).

The most common hazard perception test in studies, and indeed driver licensing, presents traffic scenes on a computer using videos or photographs. Participant's are required to make a response as soon as they detect a hazard. The ability of drivers with varying crash involvement (Quimby, Maycock, Carter, Dixon & Wall, 1986) and those with differing amounts of driving experience (e.g., McKenna & Crick, 1994) are compared on the test which records reaction times and/or accuracy in detecting hazards. This paper focuses on differences between novice and experienced drivers on the detection of hazards. Whilst studies comparing novice and experienced drivers show that experienced drivers react faster to hazards, assumptions underlying hazard perception tests, validity of the tests, and the implications for education/training hazard perception are not clear (see Groeger, 2000). There is, therefore, a need to conduct some background research in the area of drivers' hazard perception.

Whilst many studies have shown differences between novices and experienced drivers, very few studies have investigated which features of hazards that drivers misperceive. Two studies have shed some light on this problem. Firstly, Soliday (1974) recorded participants' roadway comments during a 12.1-mile test drive. Drivers were aged from 16 to 70 years. Results indicated that older and more experienced drivers perceived moving objects as more dangerous than fixed objects. Secondly, Mourant and Rockwell (1972) investigated the eye movement of novices and experienced drivers and found that the novices' search area was smaller and closer to the front of the vehicle compared to that of experienced drivers. Interesting results from a more recent study from Chapman and Underwood (1998) on the vertical search patterns of novices and experienced drivers. They found that novices' vertical search patterns were more variable than experienced drivers, and that generally novices fixated further ahead of the vehicle.

The current study examines in more detail the features of hazards identified by a group of novice and experienced drivers. The results presented here are part of a longitudinal study concerned with the development of cognitive skills in novice drivers. This longitudinal design aims to assess novices' driving skills at three separate times before gaining their full licence. The first is at baseline when they have little or no driving experience, they will be assessed again once they have gained some driving experience as a Learner driver, and finally when they have obtained their Probationary licence. The results of the baseline assessment session are reported here. The novice and experienced drivers identified hazards in photographed traffic scenes under two conditions, non-distraction and distraction. Their accuracy was based on hazards identified by a group of experts and reaction times were also recorded. The focus was on a quantitative comparison of the types of hazards that novices and experienced drivers identified and a qualitative investigation of "false alarms" or non-hazards; that is, aspects of images identified by novices and experienced drivers that were not rated as hazards by the experts.

METHOD

Participants

Eighty-six young Novice drivers and 20 Experienced drivers participated in the study. Novices having little or no driving experience were recruited from secondary schools. Thirty-one novices who had recently obtained a learners permit (approximately within 2-4 weeks of recruitment) reported little on-road driving. They comprised 41 males and 45 females aged between 15-18 years. Experienced drivers were recruited from acquaintances and comprised 9 females and 11 males. They were aged between 28-35 years and had an average of 10 years driving experience. The five expert raters were Monash University Accident Research Centre staff with expertise in the field of novice drivers and/or driver licensing. Three were male and two were female.

Materials and Procedure

For the assessment task, Novice and Experienced drivers used a laptop-based, mouse-driven computer program. A digital camera was used to take photographs of everyday traffic scenes from the driver's perspective. The images were presented on the screen and participants were instructed to identify hazards or potential hazards with the cursor by clicking with the mouse. The co-ordinates of the click and response times were recorded. Assessments were conducted individually on school premises for Novices and at home for Experienced drivers.

Participants completed the hazard perception task under two conditions; non-distraction and distraction. In the non-distraction condition, participants viewed 25 photographs. They were restricted to three clicks for each photograph, after which the photograph would disappear. If participants did not click more than twice, the photograph disappeared after five seconds. They were also instructed to click on the worst hazard first. Novices and Experienced drivers viewed the same set of 25 photos presented in random order for each individual.

For the distraction condition, circles coloured either red, blue or green (approximately 15mm in diameter) were presented randomly in a central position below the photograph. Again, 25 photographs were presented. Participants were instructed to count and recall the number of circles by colour whilst identifying any hazards or potential hazards in the photographs, with each task equally important. After each photograph was displayed, participants were prompted to enter the number of red, blue, and green circles. A different set of photographs was used for the non-distraction condition, again presented in random order for each individual.

For the expert ratings, a grid was superimposed over each photograph, which were displayed without time limits. The experts were asked (separately) to determine whether a hazard or potential hazard was present in each square of the grid and to identify the most hazardous object or primary hazard. Responses from each of the experts were collated and the primary hazard in each photograph was determined from the sum of the most hazardous object in each photograph across the raters. Secondary hazards were then identified from the sum of the raters' responses to the remaining hazards in each photograph. A program (ViewData) was developed which highlighted the primary and secondary hazards that all experts identified, and the hazards that novice and experienced drivers identified, for qualitative analyses.

RESULTS & DISCUSSION

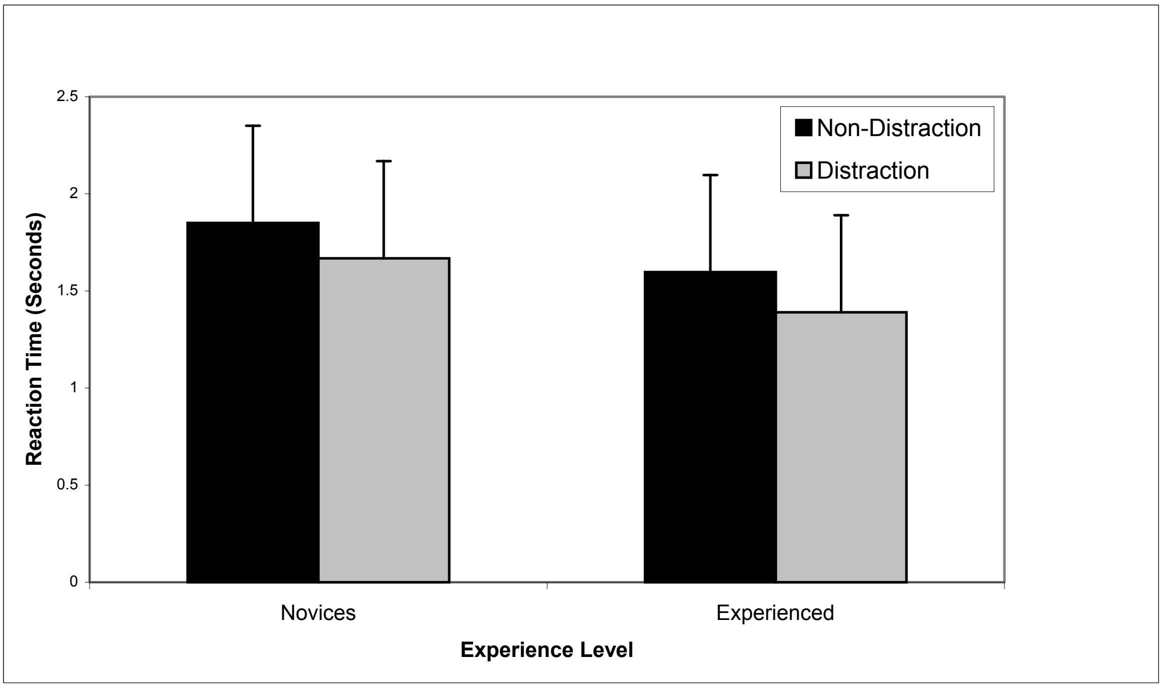
Quantitative Analyses

The analysis discussed here addresses the following questions: Firstly, what is the difference in the accuracy to detect hazards between experience levels, what differences are found in the reaction time to detect hazards between Novice and Experienced drivers, and thirdly what effect does the task condition (non-distraction versus distraction) have on both accuracy, and reaction time to detect hazards.

Accuracy in detecting hazards was measured by the hit proportion which is the total number of primary and secondary hazards correctly identified by each participant (in comparison with expert ratings), divided by the total number of photographs (25) for each condition. Hit proportions for the non-distraction and distraction condition were calculated for each participant. There were no significant differences between the mean hit proportion across levels of experience for the non-distraction (t_{104}=1.1, p=0.27) and the distraction condition (t_{104}=1.1, p=0.27). However, Experienced drivers were significantly faster than Novices to detect the primary hazard in both the non-distraction (t_{104}=2.7, p=0.01) and distraction conditions (t_{104}=3.1, p=0.00). No effect of experience was found in performance on the secondary task.

Figure 1 displays the mean reaction time to detect the primary hazard across experience level and task condition. The mean reaction time to detect the primary hazard for Novices in the non-distraction condition was 1.85 seconds and for the distraction condition 1.67 seconds. The equivalent figures for Experienced drivers were 1.6 and 1.4 respectively. For both levels of experience the mean reaction time was *less* for the distraction condition than the non-distraction condition, indicating that participants were faster at detecting the primary hazard when under dual-task conditions.

Figure 1. Mean reaction time to detect the primary hazard by driving experience and task condition



The trend showing that experienced drivers were significantly and consistently faster at detecting the primary hazard has similarly been found on video hazard perception tasks (McKenna & Crick, 1994; Quimby, Maycock, Carter, Dixon & Wall, 1986). However, only one other study has found such a trend using photographed traffic scenes (Whelan, 2000). In the present study participants were significantly faster to detect the primary hazard in the distraction condition, which was unexpected. Several interpretations are offered, but further evidence is required to be conclusive. The first is that there was a practice effect on the hazard perception task, as the distraction condition always followed the non-distraction condition. However statistical analyses used to assess this make such an interpretation unlikely. It is possible that people may have been more motivated in the distraction condition. The likelihood of this explanation will be re-examined when further data is available. A further possibility is that as the stimuli in the two conditions were different, that is, the photographs were not consistently matched for the presence and type of hazards. Comparison of the experts' data shows comparable *number* of hazards identified in each category; however, it is possible that the hazards were qualitatively different. This possibility was investigated further.

Qualitative Analyses
The aim of the qualitative analyses was twofold; first, to gain a better understanding of the patterns of hazards identified by Novice and Experienced drivers' based on the expert ratings; second, to investigate aspects of the images participants identified as hazards that were not considered such by the expert raters; hereafter referred to as *non-hazards*. The following seven categories and varying subcategories were devised to code the location and type of object that participants clicked on (Table 1.).

Table 1. Definition of categories and subcategories used to classify hazards and non-hazards

Category	Subcategory	Definition
Road Location	Left	objects off the road from the left of the driver's own lane
	Joining	objects appearing in a lane intersecting with the driver's lane
	Side Road	any object in a slip lane, or road separated by a median strip that is not the oncoming lane
	Median	includes any object on the median strip (ie: grass/concrete)
	Own Lane	objects in the driver's own lane or other lanes in the same direction of multi lane road
	Oncoming Lane	objects appearing in the driver's oncoming lanes
	Right	objects appearing off the road past the oncoming lanes
General Location	On Road	objects appearing in any lane (median, own, side, etc)
	Off Road	objects appearing to the 'left' or 'right' of the road layout
Distance	Near	objects in the bottom half of photograph (defined as the length of the driver's own car to the end of visible roadway)
	Far	as above, but objects in the top half of the photograph
Size	Small	any object that could be moved/picked up
	Large	objects not able to be picked up or moved
Movement	Fixed	all objects that are not vehicles
	Moving	vehicles located on the road and not parked, and pedestrians
	Semi-fixed	parked vehicles (vehicles with the potential to move)
Vehicle Type	Car	all cars including 4WDs
	Truck/Bus	all trucks and buses
	Motorcycle	all motorcycles
Miscellaneous	1	clicks on the driver's own car (approximately 17 in total, all Novice drivers)
	2	clicks in the sky (6 Novice drivers, 1 Experienced driver)

Each click was coded into one or more of the above categories. For example, if a participant clicked on a traffic light on a median strip which was located far away from the driver's position, it would be categorised as: median, on road, far, large, fixed. Alternatively, if participants clicked on a car immediately in front of them in the same lane, it would be categorised as: own lane, on road, moving, near, car.

The total numbers of clicks in each of these categories were then calculated and compared between Novices and Experienced drivers. Clicks on hazardous features (as identified by the experts) were analysed separately to clicks on non-hazardous features. The sum of the Novice and Experienced drivers' clicks in each category was obtained, separated for the non-distraction and distraction conditions, in addition to proportions of clicks within each major category (location, moving, size, and distance). This allowed for comparisons of moving/fixed objects, near/far objects and so on to be made across groups, and secondary task conditions.

Using the categories in Table 1, binomial distribution tests were used to compare the proportion of clicks on primary and secondary hazards for Novice and Experienced drivers, and to assess the proportion of clicks in the various categories on objects that were non-hazards.

Novice and Experienced Drivers' Clicks on Hazards Identified by Experts
In the non-distraction condition, the proportion of correct responses to moving objects for Novices was 57%. The equivalent figure for Experienced drivers was 78% (p=0.00, binomial test) was reliably different. For the distraction condition Novice drivers identified 60% of moving hazards. The equivalent figure for Experienced drivers was 83% (p=0.00, binomial test), again reliably different.

For on road hazards in the non-distraction condition, the proportion of correct responses for Novices was 55%. The equivalent figure for Experienced drivers was 75% (p=0.00, binomial test), a significantly different finding. In the distraction condition, the proportion of correct responses to on road hazards from the Novice driver group was 59%. For the Experienced drivers this figure was 81% (p=0.00, binomial test), again significantly different. Table 2 presents the proportion of clicks in each category for the different road lanes.

Table 2. Proportion of Clicks for Location Category for Novices and Experienced Drivers

Category	Novices		Experienced	
	ND	**D**	**ND**	**D**
Own lane	46%	56%	72%	83%
Oncoming lane	67%	61%	82%	85%
Joining lane	80%	72%	84%	78%
Median	12%	8%	5%	8%

Note: ND = Non-distraction condition; D = Distraction condition. There were no side road hazards.

It can be seen that when hazards were present in the joining lane Novice drivers were highly accurate. However, their accuracy for hazards in the joining lane was not matched in the other categories, particularly in their own and median lanes. Interestingly, some 67% of all the hazards that the experts identified were in the driver's own lane whereas the equivalent proportion for joining lane hazards was 19%. Experienced drivers were accurate across all categories except for hazards in the median lane. These latter types of hazards only made up 3% of all the hazards that the experts identified. Differences in the proportion of joining and own lane hazards identified by Novice and Experienced drivers across both conditions were significantly different (p=0.00, binomial test). In addition significant differences between Novices and Experienced drivers on the proportion of hazards identified in the own and oncoming lanes were also found (p=0.00, binomial test).

Novice and Experienced Drivers' Clicks on Non-Hazards

Results now turn to a focus on non-hazards. Regardless of driving experience and task condition over 80% of clicks on non-hazards were located on the road. Thus, when participants were not clicking on primary or secondary hazards as identified by experts, they were predominantly identifying objects on the road as hazards.

Clicks in the driver's own lane and oncoming lanes were combined to assess the proportion of non-hazards identified in this area of the road. Comparison revealed that for the non-distraction condition, 57% of non-hazards identified by Novices were on the driver's own or oncoming lane. The equivalent figure for Experienced drivers, 78% (p=.00, binomial test), was reliably different. For the distraction condition, some 71% of non-hazards identified by Novices were in the driver's own or oncoming lane, reliably different to the equivalent figure for Experienced drivers: 80% (p=0.00, binomial test).

Differences were also found between the proportion of clicks on the joining and drivers own lane: 17% of non-hazards identified by Novices, while only 9% (p=.00, binomial test) for Experienced drivers, a reliably different result. For the distraction condition, 8% of non-hazards identified by Novices were on the drivers joining lane, while the equivalent figure for Experienced drivers was reliably different at 13% (p=0.00, binomial test). The tendency for novices to click on hazards in the joining lane relates to their accurate detection of hazards in this lane compared to other areas of the road.

Summary of Qualitative Analyses

Novices were less accurate than Experienced drivers overall. Whilst Novices were accurate at detecting hazards in the joining lane their performance on hazards in their own lanes was quite poor. Importantly, expert raters identified substantially more hazards in the driver's own lane compared to the joining lanes, which increases the impact of the finding that novices were poor at detecting hazards in their own lane. Novices consistently clicked on non-hazards in the joining lane in comparison to Experienced drivers. Novices also fared consistently worse on moving primary and secondary hazards compared to experienced drivers. However this was not significant in the analysis of non-hazards.

Notably, Soliday's (1974) findings, whereby more danger was found stemming from moving objects for experienced drivers whereas novices tended to report fixed objects as more dangerous, are similar to the pattern of results found here in that novices performed worse at detecting moving hazards in comparison with experienced drivers. Interestingly, results showing that Novices detected less hazards in their own lane compared to the joining lane is somewhat inconsistent with the findings of Mourant and Rockwell (1972). Results do lend support to Chapman and Underwood's (1998) finding that novices fixate further ahead of their own vehicle.

IMPLICATIONS AND CONCLUSIONS

The major finding of the current study is that Novices focus attention on hazards in the joining lane and subsequently are significantly poorer than Experienced drivers at detecting hazards in their own lane. This may partly contribute to the finding that novices have a tendency to be involved in rear-end collisions (Evans, 1991). This may be as they expect hazards to arise from joining lanes and pay less attention to potential conflicts ahead.

Studies such as this provide richer support for the notion that novices misperceive particular hazards. The findings provide direction for developments in education and training programs for novices before licensure. Education and training by instructors could include clearer specification and identification of different types of hazards and areas of the road and road environment to search when driving. In the long run, findings such as these may assist in reducing the crash involvement of novice drivers.

Further results from this longitudinal study, including a similar hazard perception task using digital videos and repetition of the tasks during differing stages of driving experience, will help further clarify the findings in this paper. It is hoped that the project will provide further insights into the role that practice at the driving task has on the development of hazard perception skills.

The current study has been successful in identifying clues to explain the notion that novice drivers perceive hazards differently to more experienced drivers. It has been the message of this paper that more background research is required on hazard perception, particularly on qualitative features of hazards, and this message should be heeded when interpreting the results and considering their implications.

REFERENCES

Armsby, P., Boyle, A.J., & Wright, C.C (1989). Methods for assessing drivers' perception of specific hazards on the road. *Accident Analysis and Prevention, 21,* 45-60.

Brown I.D., & J.A., Groeger, (1988). Risk perception and decision taking during the transition between novice and experienced driver status. *Ergonomics, 31,* 585-597.

Chapman, P.R., & Underwood, G. (1998). Visual search of driving situations: Danger and experience. *Perception, 27,* 951-964.

Evans, L. (1991). *Traffic safety and the driver.* New York: Van Nostrand Reinhold.

Finn, P. & Bragg, B.W.E. (1986). Perception of risk of an accident by young and older drivers. *Accident Analysis and Prevention, 18*, 289-298.

Groeger, J.A., & Chapman, P. (1996). Judgement of traffic scenes: The role of danger and difficulty. *Applied Cognitive Psychology, 10,* 349-364.

Groeger J.A. (2000). *Understanding driving: Applying cognitive psychology to a complex everyday task*. Hove, UK: Psychology Press.

McKenna, F.P., & Crick, J.L. (1994). Hazard perception in drivers: A methodology for testing and training. TRL CR 313, Transport Research Laboratory, Crowthorne, Berkshire.

Mourant, R.R, & Rockwell, T.H. (1972). Strategies of visual search by novice and experienced drivers. *Human Factors, 14,* 325-335.

Quimby, A.R., Maycock, G., Carter, I.D., Dixon, R., Wall., J.G. (1986). Perceptual abilities of accident-involved drivers. TRL RR27, Transport and Road Research Laboratory, Crowthorne, Berkshire.

Soliday, S.M. (1974). Relationship between age and hazard perception in automobile drivers. *Perceptual and Motor Skills, 39,* 335-338.

Underwood, G., Crundall, D., & Chapman, P. (2002). Selective searching while driving: The role of experience in hazard detection and general surveillance. *Ergonomics, 45,* 1-12.

Whelan, M.I. (2000). *Hazard perception, driving experience, and driving style.* Unpublished Honours Thesis, School of Psychological Science, La Trobe University, Bundoora, Australia.

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