Elsevier Editorial System(tm) for
Transportation Research Part F: Traffic Psychology and Behaviour
Manuscript Draft

Manuscript Number: TRF-D-14-00170R6

Title: Are Situation Awareness and Decision-Making in driving totally conscious processes? Results of a Hazard Prediction task.

Article Type: Full Length Article

Section/Category: Regular Issue

Keywords: Hazard perception, driving skills, risk estimation, situation awareness, decision making, offender, non-offender, learner, novice, inexperienced, experienced drivers, visual search, object recognition, traffic scene, training,

Corresponding Author: Dr. Candida Castro,

Corresponding Author's Institution: University of Granada

First Author: Andres A Gugliotta, Ph.D. Student

Order of Authors: Andres A Gugliotta, Ph.D. Student; Petya Ventsislavova, Ph.D. Student; Pedro Garcia-Fernandez, Dr. Electronic Engineering; Elsa Peña-Suárez, Post Doc. Research Fellow; Eduardo Eisman, Ph.D. Student; David Crundall, Professor Psychology; Candida Castro

Manuscript Region of Origin: SPAIN

Abstract: Detecting danger in the driving environment is an indispensable task to guarantee safety which depends on the driver's ability to predict upcoming hazards. But does correct prediction lead to an appropriate response? This study advances hazard perception research by investigating the link between successful prediction and response selection. Three groups of drivers (learners, novices and experienced drivers) were recruited, with novice and experienced drivers further split into offender and non-offender groups. Specifically, this works aims to develop an improved Spanish Hazard Prediction Test and to explore the differences in Situation Awareness, (SA: perception, comprehension and prediction) and Decision-Making ("DM") among learners, younger inexperienced and experienced drivers and between driving offenders and non-offenders. The contribution of the current work is not only theoretical; the Hazard Prediction Test is also a valid way to test Hazard Perception. The test, as well as being useful as part of the test for a driving license, could also serve a purpose in the renewal of licenses after a ban or as a way of training drivers. A sample of 121 participants watched a series of driving video clips that ended with a sudden occlusion prior to a hazard. They then answered questions to assess their SA ("What is the hazard?" "Where is it located?" "What happens next?") and "DM" ("What would you do in this situation?"). This alternative to the Hazard Perception Test demonstrates a satisfactory internal consistency (Alpha=0.750), with eleven videos achieving discrimination indices above 0.30. Learners performed significantly worse than experienced drivers when required to identify and locate the hazard. Interestingly, drivers were more accurate in answering the "DM"

question than questions regarding SA, suggesting that drivers can choose an appropriate response manoeuvre without a totally conscious knowledge of the exact hazard.

Acknowledgments

We are grateful to the Spanish participants who volunteered for the tests as well as to the two anonymous reviewers whose comments enabled us to improve the manuscript and to our English editor Barbara Lamplugh for revising and improving the English. We are also indebted to the Junta de Andalucía (Proyecto Motriz P11-SEJ-7404), the BS-14-164 I+D+I Research project from the CEI-Biotic, University of Granada and the Spanish Government, MICINN (PSI2013-42729-P), all of whom gave us financial support. This research was supported by the Spanish Dirección General de Tráfico – DGT (0100DGT21263 and SPIP2015-01782) and the three driving schools in Granada (Autoescuelas la Victoria, Luna and Genil) from whom we obtained our sample of participants. We much appreciate their contribution to the study. We gratefully acknowledge financial support from the computational resources supplied by the Centro de Servicios de Informática y Redes de Comunicaciones (CSIRC-Universidad de Granada). Its design, data collection, analysis and interpretation were carried out independently of the funding bodies, as were the writing up of the experiment and the decision to seek publication. "

Highlights

- The contribution of the current work is not only theoretical, Hazard Prediction is also a practical alternative to Hazard Perception testing in European countries.
- This study will be pioneering in exploring how drivers react by making decisions related to their Situation Awareness of the driving environment.
- Interestingly, drivers were more accurate in answering the decision-making question than questions regarding situation awareness.
- Then, drivers can choose an appropriate response maneouvre without a totally conscious knowledge of the exact hazard.
- Learners were significantly worse than experienced drivers when required to identify and locate the danger.

Are Situation Awareness and Decision-Making in driving totally conscious processes? Results of a Hazard Prediction task

Andrés Gugliotta[a], E., Petya Ventsislavova[b], Pedro Garcia-Fernandez[a], Elsa Peña-Suarez[a], Eduardo Eisman[a], David Crundall[b], and Candida Castro[a]

[a]CIMCYC. Mind, Brain and Behavior Research Center. Faculty of Psychology.

University of Granada

[b]Nottingham Trent University. UK

Email addresses: candida@ugr.es

Corresponding author: Cimcyc Centro de Investigación Mente, Cerebro y Comportamiento. (Mind, Brain and Behaviour Research Centre)

Facultad de Psicología. Universidad de Granada.

Campus Cartuja, 18011.

Granada. Spain.

Phone: + 34 958 240663 +34 655 99 40 59 Fax:+34 958 246239

Abstract

Detecting danger in the driving environment is an indispensable task to guarantee safety which depends on the driver's ability to predict upcoming hazards. But does correct prediction lead to an appropriate response? This study advances hazard perception research by investigating the link between successful prediction and response selection. Three groups of drivers (learners, novices and experienced drivers) were recruited, with novice and experienced drivers further split into offender and non-offender groups. Specifically, this works aims to develop an improved Spanish Hazard Prediction Test and to explore the differences in Situation Awareness, (SA: perception, comprehension and prediction) and Decision-Making ("DM") among learners, younger inexperienced and experienced drivers and between driving offenders and non-offenders. The contribution of the current work is not only theoretical; the Hazard Prediction Test is also a valid way to test Hazard Perception. The test, as well as being useful as part of the test for a driving license, could also serve a purpose in the renewal of licenses after a ban or as a way of training drivers. A sample of 121 participants watched a series of driving video clips that ended with a sudden occlusion prior to a hazard. They then answered questions to assess their SA ("What is the hazard?" "Where is it located?" "What happens next?") and "DM" ("What would you do in this situation?"). This alternative to the Hazard Perception Test demonstrates a satisfactory internal consistency (Alpha=0.750), with eleven videos achieving discrimination indices above 0.30. Learners performed significantly worse than experienced drivers when required to identify and locate the hazard. Interestingly, drivers were more accurate in answering the "DM" question than questions regarding SA, suggesting that drivers can choose an appropriate response manoeuvre without a totally conscious knowledge of the exact hazard.

Keywords
Hazard perception, driving skills, risk estimation, situation awareness, decision making, offender, non-offender, learner, novice, inexperienced, experienced drivers what, where, what happens next, visual search, object recognition, traffic scene.

1. Introduction

Situation Awareness (SA) can be a useful term to describe drivers' understanding of the relationship between themselves and other objects within the driving environment, with the ultimate aim of avoiding hazards on the road (e.g. Wetton, Hill and Horswill, 2013). These authors define hazard perception as 'the ability to predict dangerous situations on the road' (p65), which elegantly encapsulates the final output of the linear, three-stage model of Situation Awareness popularised by Endsley (e.g. Endsley, 1988a, 1995; Bolstad et al., 2010). In this model, *perception* of the environmental elements precedes *comprehension* of their qualities and relevance to oneself, which allows one to project their future status (e.g. predicting their future locations). While good SA is not *sufficient* to guarantee an appropriate response, it could be argued that SA is at least necessary in order to decide upon the most suitable manoeuvre: whether to brake sharply, make a turn to avoid a hazard, or overtake. While the necessity of good SA seems obvious in support of selecting the correct behavioural response, this has not been tested in the field of driving. Furthermore, while there is much evidence to suggest that hazard prediction discriminates between drivers on the basis of experience, there is no research that has followed these predictions through to the response selection. It is a possibility that adding response selection to a hazard prediction test may enhance (or even degrade) the discriminative function of such tests. For this reason, the current study explores the link between SA and Decision-Making ("DM") using a hazard prediction methodology.

Pradhan and Crundall (2016) have defined hazard prediction as the extraction of hazard evidence from the potential hazard precursors in the scene, and then prioritising these precursors for iterative monitoring. They argue that this is a vital sub-process in the whole behaviour chain (from hazard searching to response selection) which they term *hazard avoidance.* In contrast they argue that the term *hazard perception* is often imprecisely used to refer to varying collections of sub-processes within the *hazard avoidance* process (including both perceptual and post-perceptual processes).

Despite the inexact terminology of *hazard perception*, the majority of research over the last five decades has focused upon the use of *hazard perception tests*. Traditionally these tests require participants to watch video clips from a driver's perspective and press a button as soon as they spot a developing hazard (though some also include a measure of location-based accuracy; e.g. Wetton et al., 2011). Evidence suggests that safer and more experienced drivers respond faster to such hazards (e.g. McKenna and Crick, 1991; Horswill and McKenna, 2004, Wetton et al., 2011), and that performance on these tests can be linked to likelihood of collision (e.g.

Horswill, *et al,* 2010, Boufous, et al., 2011). Indeed the introduction of the UK hazard perception test in 2002 has been directly linked to a significant decrease in on-road crashes (Wells et al., 2008). It should be noted however that not all studies have had success separating safe from less-safe drivers (Chapman and Underwood, 1998; Sagberg and Bjørnskau, 2006; Borowsky et al., 2010, Underwood, Ngai and Underwood, 2013).

The Hazard Prediction Task (also known as the "What happens next?" test) is a variant on the traditional Hazard Perception task that assesses the predictive component of situation awareness for on-road hazards, asking participants to answer three questions that probe SA: "*What* is the hazard?" "*Where* is the hazard?" "What happens next?" *(WHN)*. Following the methodology of Jackson et al., (2009), these questions are asked following occlusion of the video clip, which occurs just as the hazard begins to develop. In comparison with a traditional hazard perception methodology, evidence suggests that this hazard prediction test format is also good at discriminating between experienced, safer drivers and inexperienced, less-safe drivers (e.g. Castro et al., 2014, Crundall 2016). However, one benefit of the hazard prediction test over the hazard perception test is that it removes post-perceptual biases from the measure, such as response criterion (where participants may delay responding to a perceived hazard because they feel it falls within their skill level to avoid it). Thus this prediction test is a potentially purer measure of one's ability to spot hazards. It is presumed that a correct prediction of the hazard is needed in order to make appropriate decisions about the manoeuvres to be performed (Endsley's, 1995, Horswill and McKenna, 2004; Jackson, Chapman and Crundall, 2009), but to date this has yet to be tested in a hazard prediction paradigm.

1.1. In-time critical Decision-Making processes and Situation Awareness

Individuals' ability to acquire SA has an impact on their decision-making. According to Smith (2013), making the right decision in a short period of time is crucial in driving. The accuracy of the decision made by the driver is based on his/her knowledge of the driving environment applied to the present context. However, the role that SA plays is not constant even in time-critical situations (SA). That is, it seems more crucial in non-standard situations or when anticipating hazards to have good SA, such as a high level of information about traffic, extraneous activity and unforeseeable events. Therefore, the analytical process of quantifying and qualifying SA should involve integrating "DM", and equally, SA should be analysed in order to discover in what form it could be used at the critical time, in order to make the right decisions.

Making a decision whether to keep the same speed and trajectory or make an avoiding manoeuvre may be considered a simple aspect of the driving task that could be carried out in a controlled way but also be primed by automatic processing. However, Groeger and Clegg (1998, page 145) stated that they were very doubtful indeed that the performance of any complex aspect of the driving task (e.g. changing gear) was automatic.

1.2. Driving Experience, Offender status and Hazard Prediction

It has been widely documented that differences in Hazard Prediction are found between different groups of drivers on the basis of experience and crash record (see Horswill, 2016, for a review). There is less evidence however regarding the impact of offender status on traditional hazard perception tests. We know that offenders are more likely to be involved in a collision (Simon and Corbett, 1996; Laapotti *et al,* 2001; Yahya and Hammarstroöm, 2011), and repeat offenders are especially dangerous (Lapham et al., 2006). There has been some suggestion that drivers with multiple convictions score worse in Hazard Perception than non-offenders (e.g. Pelz and Krupat, 1974), but it seems more likely that the increased crash risk of offenders is driven mostly by high level of risk propensity (e.g. Hatfield and Fernandes, 2009) and perhaps alcohol/drug intake (e.g. Beirness, Simpson and Mayhew, 1991; Fell, 1993, 1995; Solnick and Hernenway, 1994). So why might violators have worse HP skills? It is possible that this could reflect a risk estimation bias: Perhaps violators see the obstacles but decide they are not hazardous to them because they overestimate their own skills. In other words, violators' poorer skills in hazard estimation could be due to a criterion bias, which the hazard prediction test should remove. This provides an additional potential benefit for using the prediction-based variant of the hazard perception test.

1.3. Research aims

The purpose of this study is to assess the relationship between drivers' SA and "DM" when performing a Hazard Prediction task, with the ultimate aim of further developing our Spanish Hazard Prediction Test (Castro et al., 2014), modified to suit the different driving context found in Spain and to determine its psychometric properties. We are hoping to improve the internal consistency of the test and to evidence validity, by discriminating between groups Specifically we predict that learner and novice drivers should perform worse on this prediction test than experienced drivers, and this difference may become greater when one considers their decision making in regard to response selection. We may also find that offenders are worse at hazard prediction than non-offenders, though if previous results from hazard perception studies are due to criterion bias in their responding, we may find that offenders are equally good at predicting hazards as non-offenders.

2. Method

2.1. Participants

The number of participants in the current study was 121: 69 male and 52 female. They were divided into three experience groups: (a) 20 young learner drivers (16.5%), aged between 18 and 37, taking lessons in order to pass their driving test, (b) 62 novice drivers (50.4%) aged between 18 and 39, already qualified but with no more than eight years' driving experience and (c) 40 drivers with experience (31.1%), aged between 26 and 53, who had driving licenses of various kinds. Of those already possessing driving licenses, 20 in the novice group and 20 in the experienced group were repeat offenders.

The average age of the novice drivers was 23 years, with between 3 and 7 years of post-licensure driving experience (mean = 4.54 years, SD = 2.75). All novices reported driving on a weekly basis. In contrast, experienced drivers' average age was 38 years, with 8 or more years of post-licensure experience (mean = 20.97 years, SD = 8.14).

Significant differences were found in number of kilometres driven between learners (280.20 km/year), younger inexperienced drivers (11318.82 km/year) and experienced drivers (27975.67 km/year), taking into account the complete sample $F(2, 95)= 5.578$., $p=0.004$ (with repeated contrasts showing differences between all levels) . Also, significant differences were found in years of driving experience between learners (1 year), younger inexperienced drivers (4.54 years) and experienced drivers (20.97 years) taking into account the complete sample, $F(2, 103)=108.353$ $p=0.001$, with repeated contrasts again confirming differences at each level comparison). In the current research, the experienced group of drivers was recruited from beyond the student population to ensure sufficient experience, though learner and novice drivers included students.

Offender drivers were recruited from different driving schools in Granada (La Victoria and Genil, Granada, Spain). These participants were attending a driving education course following a succession of violations, resulting in a loss of license points (opposite to the UK system where drivers gain points due to violations).

2.2. Design

Mixed ANOVAs were performed. The repeated measures factor was the type of question (4) (SA questions ["What", "Where", "WHN"] and the "DM" question). The between subjects factors were: driving experience (3) and offender status (2). As the assumption of sphericity was violated, we used the Greenhouse-Geisser correction. Here the *dependent variable* is the accuracy mean for the 4 questions (ranging from 0 to 2 points).

2.3 Equipment

2.3.1 Videos

During late 2012 and early 2013, a total of 300 videos, recorded from the driver's viewpoint, were made in the city of Granada, Spain, by two members of the research team who were also experienced drivers. Recording conformed with the Nottingham protocol (Jackson et al., 2009; Crundall 2016). Sixteen of the 300 high definition (HD) video-clips, with a resolution of 1920 X 1080, were selected for use in the test. Hazards consisted of cars, motorcycles, trucks and pedestrians that entered the path of the film car and would have caused a collision without the driver making an avoidance manoeuvre. The film clips were edited to cut to a black screen just as the hazard began to develop. In Table 1 can be seen a description of the videos used.

<Table 1>

It is worth noting that the participant's point of view was passive (as the driver of the car from which the videos were recorded). There was no active involvement of the driver in the unfolding hazard situation. All hazards, therefore, could be considered passive hazards. There were no accidents during the video recording of naturalistic driving. This research followed the ethical principles required for researching with human beings (Declaration of Helsinki).

Participants were shown the videos in the following way: a blank screen with the corresponding numerical code was presented initially and then immediately replaced by the driving scene, which lasted for between 6 and 25 seconds.

2.3.2 Questionnaire

For the study, a questionnaire was used to collect participants' answers to the three SA questions and the "DM" question. Following initial pages for instructions and demographic questions, 16 pages repeated the four questions for each clip: (SA Q1) "What is the hazard?" (SA Q2) "Where is it located?" (SA Q3) "What happens next?", and (DM Q) " What would you do in this situation?".

Scoring was as follows. For "What is the hazard?" two points were obtained if the description of the hazard was correct (e.g. "The green car!"), one point if the answer was partially correct but lacking detail about its characteristics that might distinguish it from other exemplars in the scene (e.g. "A car…?"), and zero if the answer given was incorrect.

For “Where is the hazard?” participants were asked to mark a cross on a pictorial representation of the last frame (but without any hazard elements included). This picture was similar to a line-drawing of the scene in blank ink, though it was actually created using an artistic filter in Adobe Photoshop, and then edited to remove all potential hazards, (see the drawing in Figure 1). The sketch contained enough detail to enable the participants to identify the location without hesitation if they had correctly spotted the imminent hazard before occlusion. Each answer sheet had a picture that was specific to a particular clip. Participants drew an X on the picture where they anticipated the hazard to be immediately after the video was cut. If this cross fell within an invisible target square that matched the extreme boundaries of the hazard, the participant was awarded two points. If the cross fell within a one cm boundary around the target square, the participant was awarded a single point. Zero points were obtained if the cross was drawn in any other position.

For the “What happens next?” question, participants obtained two points if they described exactly what would happen, e.g. “The car ahead will have to brake sharply to avoid colliding with the red car merging from the right”, one point if the answer was incomplete but pointed towards the answer, and zero if the description was incorrect.

The fourth question regarding their decision of how to respond (“What would you do in this situation?”) was presented with eight possible answers, of which the first seven were possible manoeuvres (i.e. “sharp brake”, “gradual brake”, “maintain same speed and direction”, “speed up”, “move forward”, “swerve to the left” and “swerve to the right”) and the last alternative was left as an open answer (i.e. other), where the participant could suggest an alternative manoeuvre.

For the “DM” question, two points were given if the exact manoeuvre performed by the film driver was provided, e.g. “gradual brake”, one point if the description was incomplete or referred to another avoiding manoeuvre and zero points if the answer was incorrect. Expert drivers’ judgments were taken into account to establish the correct, partially correct and incorrect answers. The manoeuvres are described in the right-hand columns of Table 1.

In order to distinguish the question about what would happen next in the driving environment from the “DM” process, a clarification was added to the “What happens next?” question (SA Q3) explaining that this answer should be independent of what the participant would actively do if he/she was the driver of the car filming the traffic scene.

2.4. Procedure

The 121 participants in this experiment comprised drivers from different experience groups (learners, novices and experienced drivers) and profiles of offending (offenders/non-offenders), grouped accordingly. Before beginning, a researcher gave them instructions on how to follow the task and respond to the questionnaire and they filled in the demographic information form. The time required to carry out the entire study was around 90 minutes. The task was performed in groups (with group size averaging 15). Participants sat between 3 to 5 m from a projection screen measuring 1.53 y 2.44. All video clips were presented in a fixed (though initially random) order, matching the order of the answer sheets in the response booklet.

2.5. Data Analysis

The participants' answers were corrected by a first evaluator, but 50% of the questionnaires were corrected by a second evaluator, independently. The degree of agreement between the two was assessed for each question. Cohen's Kappa was calculated. The level of agreement between the two evaluators was considered high s: κ = .95 for "What is the hazard?" and κ = .94 for "What happens next?" These data confirmed the consistency of the corrections

The scores were subjected to classic item analysis, calculating the discrimination indices; and reliability analyses, estimated with Cronbach's (1951) Alpha coefficient. All group comparisons were based on mixed between- and within-subjects analysis of variance.

The differences that achieved a level of .05 were considered statistically significant (Cohen, 1988; Richardson, 2011).

Levene's test was calculated to evaluate the assumption of homogeneity of variance and the KS test to check assumption of normality. All the post-hoc analyses (i.e. planned and pairwise comparisons) were subjected to Bonferroni's adjustment. The program used for the statistical analyses was SPSS (version 19), IBM Statistics.

Finally it should be noted that the same participants also contributed data to a recent publication (Castro et al., 2016), though the other paper was concerned with the impact of a training intervention (listening to a driving commentary) on hazard prediction scores. The current paper reports a novel focus and analysis.

3. Results

3.1. *Internal consistency*

This Hazard Prediction Test was first tested with 16 videos and the initial value obtained for Cronbach's alpha coefficient was 0.73. Following this, 5 of the videos were removed because they showed a low index of discrimination (less than 0.30). The final test was composed of eleven videos, that showed indices of discrimination higher than 0.30 and the final Cronbach's Alpha Coefficient of the test was 0.75.

3.2. *Main Results*

3.2.1. *Non-offender drivers: Analysis of type of question (SA and "DM") and experience*

A 4×3 mixed ANOVA was performed: 4 questions ("What?", "Where?", "WHN?" and "DM") X 3 levels of driving experience in the non-offender drivers' sample, with question type being the within groups factor. Question type produced a main effect [$F(3,75)=31.726$ $p<.001$ η^2 p=.559]. Pairwise comparisons showed significant differences between all questions, except between the "What?" and "DM" ones. The "What?" question (M=.89) (SA Q1) was more correctly answered than both the location question ("Where?") (M=.77) (SA Q2) or the prediction question ("What happens next?") (M=.56) (SA Q3). Interestingly, the "DM" question (M=.87) was answered correctly more often than the "Where?" and "What happens next?" questions (see Figure 2).

A main effect of experience was also found [$F (2,77)=6.20$ $p=.003$ η^2 p.=.14], though the interaction was not significant [$F (6,150) =1.27$ $p=.27$ η^2 p. =.05]. Planned comparisons between groups indicated that experienced drivers outperform learners [$t(78)=3.01$ $p=.003$] in "What?" and "Where?" [$t(77)=4.29$ $p=.001$]; and experienced drivers outperform younger inexperienced drivers in "What?" [$t(78)=2.89$ $p=.01$] and "Where?" questions [$t(77)=2.83$ $p=.01$] (see Figure 2).

<Figure 2>

3.2.2. *Offender drivers: Analysis of type of question (SA and "DM") and experience*

A 4×3 mixed ANOVA was performed: 4 questions ("What?", "Where?", "WHN?" and "DM") X 3 levels of driving experience in the offender drivers' sample. Question type was the only repeated measures factor manipulated. Question type was found significant [F(3,369=27.019 $p<.001$ η^2 p.=.692]. Paired comparisons revealed the same pattern of results to those in previous analyses with a decrease in mean accuracy across the three SA questions (M=.96 Vs. M=.83 vs M=.55 respectively), while mean accuracy to the "DM" question (M=.94) was significant better than both the "where?" question (SA Q2) and the "what happens next?" question (SA Q3).

While the experience effect was not significant [$F(1,38)=.285$ $p=.597$], a significant interaction between the two factors was noted [$F(3,38)=5.56$ $p=.02$ η^2 p.=.13]. Planned comparisons identified that inexperienced offenders (M=0.83) only differed to the experienced offenders (M=1.07) in the “DM” question [$t(97)=2.83$ $p=0.01$].

3.2.3. *Analysis of the type of question by experience and offender status*

A 4x2x2 mixed ANOVA was performed across the 4 questions (“What?”, “Where?”, “WHN?” and “DM”) X 3 levels of driving experience X 2 offender status of drivers (non-offender and offender). Question type was the only repeated measures factor manipulated.

Question type produced a significant main effect [$F(3,94=50.33$ $p<.001$ η^2 p.=.62]. Paired comparisons revealed the same pattern of results to those in previous analyses with a decrease in mean accuracy across the three SA questions (M=.92 vs. M=.79 vs M=.57 respectively), while mean accuracy to the “DM” question (M=.90) was significantly better than both the “where?” question (SA Q2) and the “what happens next?” question (SA Q3). In addition, a significant experience effect was found [$F(1,96)=3.99$ $p=0.04$ η^2 p.=0.04]. Experienced drivers (M=.88) obtained higher scores than younger inexperienced drivers (M=.79). No significant effect of offender status was found.

3.3. *Subjective estimates of driving skills*

Participants estimated their driving skills, their awareness of other drivers and their confidence in driving. They used a 6-point scale (1=null, 6=excellent). Significant differences in the three questions were found between the experience groups (learners, novice and experienced drivers). In fact, learners showed significantly lower scores than experienced drivers in all the questions. In addition, younger inexperienced drivers showed significantly lower scores than experienced drivers in self-rated driving ability (see Table 2). Differences were also found between non-offenders and offenders, excluding learner drivers, particularly in the self-reported measures of driving ability and confidence in driving, where the offender group showed higher scores than the non-offender group.

<Table 2>

These self-reported measures were correlated with the SA questions. A Pearson correlation between these variables showed that self-reported measures were correlated with each other ($p<.001$), as were the SA questions ($p<.001$). Only the “What?” question was correlated with self-rated driving ability and confidence in driving ($p<0.05$) (see Table 3).

<Table 3>

1.4. Socio-demographic and driving variables

In addition to the above analyses we analysed whether socio-demographic variables affected the answers provided by the participants to the four questions for each clip. Regarding gender, it was found that men were more likely to be correct (M=9.31 S.D.=2.81) than women (M=8.02 S.D.=2.73) when answering “Where is the hazard?” [$t(116)=2.493$ $p=.014$ $\eta^2=.12$]. However, age and educational level did not show significant differences in test performance.

Among the participants, 17.5 % (N=21) worked as professional drivers. This sample obtained better results than the rest in the “Where is the hazard?” question (M=8.56 S.D.=2.82 for non-professional drivers; M=9.57 S.D.=2.87 for professional drivers) [t(1189=-2.411 p=.017 η^2=.05] and for “What would you do in this situation?” (M=9.53 S.D.=2.97 for non-professional drivers; M=11.38 S.D.= 3.61 for professional drivers) [$t(118)=-2.487$ $p=.014$ $\eta^2=.05$]. Additionally, people whose work involved driving (N=36) showed significantly better results in both identifying [$t(117)=-3.06$ $p=.003$ $\eta^2=.08$] and locating [$t(116)=-2.63$ $p=.010$ $\eta^2=.06$] the hazard, when compared with other groups. Finally, no relationships were found between the efficacy of test performance and type of accident or near misses, nor for withdrawal of license or fines.

Regarding subjective estimates of driving skills, the socio-demographic characteristics in these variables were compared. Results indicated that men (M=5.10 S.D.=1.42) obtain higher scores in driving ability than women (M=4.25 S.D.=1.93) [$t(115)=3.924$ $P<.001$ η^2=,12] and men show more confidence in driving than women [$t(112)=3.004$ $p<.003$ η^2=,07]. Furthermore, age is correlated with the three driving skills (driving ability: $r=.335$ $p<.001$; awareness of others: $r=.257$ $p<.001$; confidence in driving: $r=.242$ $p<.001$,] and there are statistically significant differences between educational levels in confidence in driving [$F(5,114)=2.337$ $p=.047$ $\eta^2=.10$]. Tukey tests isolated these differences between two educational levels: drivers with Higher Education (non-compulsory) studies show higher levels of confidence in driving than drivers with a vocational degree (M=4.69 S.D=1.34).

Professional drivers gave higher ratings of their driving ability (M=4.57 S.D.=1.38) than non-professional drivers (M=5.29 S.D.=.644;t(116)=-2.320 p=.022 η^2=.04). Additionally, people whose work involves driving gave significantly higher ratings on all three subjective scales. People whose work involves driving gave a mean of 5.50 (SD= .56), while people whose work does not involve driving gave an average of 4.34 (SD=1.39) in driving ability [t (116)=-4.823 p<.001 η^2=0.18]; people whose work involves driving (M=5.42 SD=.77) present higher scores than people whose work does not involve driving (M=4.83 SD=1.21) in awareness of others [t (115)=-2.683 p=.008 η^2=.06]; and people whose work involves driving (M=5.47 SD=.61) present higher scores than people not involved in driving for work (M=4.70 SD=1.39) in confidence in driving [t (115)=-3.191 p=.002 η^2=.08]. In addition, the driving experience (nº years with driving license) correlated with the driving skills (*r* =.358 p<.001; *r* =.295p<.001; *r*=.244 p=.013, respectively). Finally, no relationships were found between the efficacy of test performance and types of accident or near misses, nor for withdrawal of license or fines.

4. Discussion

4.1 Experience affects hazard prediction

The target of this research was to further develop our Hazard Prediction test for driving in a Spanish setting and to determine its psychometric properties, exploring the effect of driver experience and driving profile on the detection and prediction of various hazardous situations displayed on video, and to assess the relationship between SA and DM. The test showed sufficient psychometric reliability and discrimination indices. An acceptable Cronbach's alpha coefficient was achieved (α =0.750). Cronbach's alpha coefficient is dependent on the items' sample size. While the current study only used a small sample of video-items, the test still achieved good internal consistency.

The skill of correctly predicting "What will happen next?" in a hazardous situation was found to depend on the driver's experience. This extends beyond research that has previously compared novice and experienced drivers (Crundall, 2016, Jackson *et al,* 2009; Lim, Sheppard and Crundall, 2014) and demonstrates that this skill develops across a wider spectrum of experience than we may have first thought, from learner, through to highly experienced (see also Castro *et al,* 2014; Ventsislavova *et al,* 2016). As this predictive skill underlies the whole hazard avoidance process (Pradhan and Crundall, 2017), and is therefore crucial to safe driving (Horswill and McKenna, 2004), it follows that authorities should make efforts to improve hazard prediction in novice and learner drivers.

Spanish government needs to bring in a test to encourage training. Hazard prediction assessment and training is essential to detect hazards that appear abruptly at the driving environment. In addition, performance in gradual-onset obstacles can be improved after training, teaching drivers where to look, identifying and prioritising potentially hazardous areas of the visual scene.

4.2 Offender status does not affect hazard prediction

In relation to offender and non-offender status, there were no significant differences between them, which supports the previous results of Castro *et al.,* (2014). This previous study suggested that multiple driving offenders obtained similar results to non-offender drivers in the Hazard Prediction test. Thus the source of their increased crash risk does not appear to come from offenders' inability to perceive hazardous precursors and predict imminent hazards. It is more likely that their increased crash propensity derives from risk taking which is, at least partly, linked to their confidence in their own driving skills. Perhaps their over-confidence decreases safety margins in responses to hazardous stimuli? If this is the case, one might expect an effect of offender status upon accuracy to the "DM" question, yet no effect was found. It remains possible however that the options provided for the "DM" question were not sensitive enough to detect risky behaviours in hazard responding. For instance both offenders and non-offenders may choose the "swerve to the right" option for a particular clip, but these responses do not identify the fact that offenders might choose to swerve to the right at the very last instant, whereas non-offenders might swerve much sooner. It remains an interesting research challenge to develop future options that might have a greater chance of discriminating between offenders and non-offenders.

4.3 Complete SA is not required to select the most appropriate response

Perhaps the most striking result of the current study comes from comparing the scores for the three SA questions to response accuracy for the "DM" question, with the latter introduced for the first time on comparable scales of measurement. While the three SA questions appear progressively more difficult (as predicted by a linear SA process, and as noted by Jackson et al., 2009, though see Endsley 2015), the results suggest that drivers are more accurate in identifying the most appropriate manoeuvre to be performed than in locating the hazard and predicting what happens next in the driving environment. It seems that it is possible to ascertain how to behave appropriately without having complete SA to support the decision. This could be a useful survival mechanism. While drivers are able to use controlled processes to make the decisions necessary to perform accurate manoeuvres, in time-critical moments unconscious processing, or automatic responding, could also influence their performance. In support of this, other researchers (Creswell, Bursley, and Stapute, 2013; Langsford and Mckenzie, 1995) have suggested that decision making tasks can be influenced by both implicit (unconscious) and explicit (conscious) processes.

Inference processes vary. Some of them are more automatic, rapid and easier, while others seem controlled, slower, more difficult and demanding (Evans, 2008 and Sloman, 1996, 2002). They depend on different cognitive systems: automatic vs. controlled. In addition, the number of alternatives to think about (or "the contrast class") affects the grade of difficulty in reasoning (Barrouillet and Lecas, 1998, Oaksford and Stenning, 1992, Schroyens, Schaeken and Y'dewalle, 2001; and Wason, 1961). That is, different conclusions are reached when we negate a binary class such as 'it is not a man' than when we negate a non-binary class, e.g., 'it is not red'.

In our case, initial mental models can be considered easy for the questions "What is the hazard?" and "Where is it?" but they may also be important when asked '*"What would you do in this situation?".* We believe that all the potential alternatives can be encapsulated in just two ways of manoeuvring. The two main alternatives available after perceiving a hazardous driving situation are: a) keeping the same speed and direction (when an almost-hazard is perceived), b) performing an avoidance manoeuvre (when a hazard is perceived; e.g. braking progressively or abruptly or changing direction).

Those inferences that require thinking of a greater number of alternatives (see Johnson-Laird, 2006 and 2008), such as with the "What happens next?" question, could be considered harder and more time-consuming. They require a prediction to be made about the future of the driving situation, based on the information previously processed, which involves considering a greater number of alternatives.

While the conclusion that complete SA is not necessary for "DM" is appealing, there is a caveat. The fact that the "DM" question provided 8 options to choose from meant that there was a 12.5% chance that the participants could guess the answer without even seeing the accompanying video, let alone correctly predicting the hazard. Furthermore, some answers are more likely than others (e.g. 'braking' might appear a more natural answer than 'swerving'), and if these popular answers matched the correct answers this could inflate the "DM" score over and above the free response required for the SA questions. This possibility needs to be explored in future research.

4.4 Modest novices and boastful offenders

Participants were asked to estimate their driving skills, such as driving ability, awareness of others and confidence in driving. According to Horrey, Lesch, Mitsopoulos-Rubes and Lee (2015) drivers estimations of their abilities are often inflated or erroneous. They also state that such misjudgments in calibration result in poor decision making, or risky behavior (e.g. younger inexperienced drivers may over-estimate their misperceived their skills and drive too fast on slippery surfaces).

In the current study, significant differences were found between those with different driving experience in all three self-rated scales relating to driving skills, though in the current study our inexperienced drivers claimed less driving ability and confidence than experienced drivers, as well as less awareness of others. This apparent contradiction of Horrey *et al,* suggests that if younger inexperienced drivers travel at high speed on a slippery surface, it could have more to do with their ability to judge the demands of the roadway. Thus inexperience in calibrating their perceived skills to the apparent demand of the roadway, rather than overconfidence in their skills per se, may be a greater cause of collision.

Furthermore, significant differences were found between offender and non-offender drivers: the offender group showed higher scores than the non-offender group in all three driving skills when self-reported. It is the offender group who shows greater overconfidence. If we assume that at least experienced offenders are as good at predicting hazards as non-offenders, then any miscalibration between perceived skill and roadway demands is more likely to come from the former rather than the latter (i.e. they may accurately judge the danger in a situation, but mis-judge their ability to deal with it).

In regards to other demographic factors, age and educational level showed no significant differences in test performance. Conversely it was found that professional drivers, and people whose work involved driving, performed significantly better at both identifying and locating the hazard when compared with other groups. Therefore, we can conclude that when it comes to differences, only experience can be considered as a determining variable.

Finally, the results showed relationships between socio-demographic characteristics and subjective driving skills (driving ability, awareness of others and confidence in driving). In the main, men showed greater confidence in driving than women; there were positive correlations between age and the three subjective driving skills, and also in the number of years since passing the driving test. Professional driving and work that involves driving are significant indicators of higher subjective driving skills.

4.5 Future Research and implications

As this is the first attempt to link hazard prediction with decision making regarding response selection, it is inevitable that future research questions will be raised. While, the SA questions have been used several times previously (e.g. Jackson et al., 2009), this is the first time that a

“DM” question has been used in this context. Accordingly while we feel confident in the (albeit null) conclusion that the current study does not suggest a difference between offender and non-offender hazard prediction, we are less confident that offenders might choose the same response option as non-offenders. As noted above, this may be affected by the sensitivity of the response options to the underlying dimensions in which offenders differ in their real world behaviour (e.g. offenders may choose the same response as non-offenders but may choose to trigger this response later than non-offenders when in the real world. Alternatively one could argue that the location of testing (during a driver re-education course), and the nature of the tasks, may have led to demand characteristics contaminating the measure. Further research varying the nature of the “DM” question and response method is required.

Another route for future research is to compare offenders’ performance to non-offenders performance across both a hazard prediction test and a hazard perception test. If the traditional hazard perception methodology suggests offenders to be worse than non-offenders, but the hazard prediction test does not, then we can conclude that the hazard perception group differences are more likely due to post-perceptual processes, such as criterion bias, rather than perceptual problems.

While correct “DM” may not be entirely dependent on the ability to articulate SA completely within this current methodology, the strong correlations between SA questions and “DM” demonstrate a significant relationship which benefits from driving experience. The implications are clear. If hazard prediction is a key element in avoiding collisions, policy makers need to provide the conditions under which inexperience drivers can develop their prediction skills in safe environment. Two options are possible. First, governments might opt for a graduated licensing system which gently increases exposure to difficult driving situations, rather than the step-change in difficulty that many new drivers face after passing their test. This would allow them to develop their predictive powers in relative safer environments, before moving to more demanding types of driving. A more targeted intervention however might be for governments to introduce a hazard perception (or hazard prediction task) as part of the national licensing procedure as has happened in the UK, the Netherlands, and in some states of Australia. Wells et al (2008) reported the beneficial effects of having introduced the UK hazard perception test, with a significant reduction in collisions. This was presumably due to a mixture of preventing the worst drivers from obtaining a license, and from a change in training practices, with driving instructors focusing more upon the higher order skills relating to the detection of hazards, in order to ensure that their pupils pass the test. On this basis we recommend that policy makers in different countries consider the introduction of some form of hazard perception test as a requirement for all learner drivers to pass. This will hopefully accelerate the usual experiential development of drivers' predictive powers, and help reduce collisions involving inexperienced drivers.

5. References

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

Barrouillet, P. and Lecas, J. F. (1998). How can mental models account for content effects in conditional reasoning? A developmental perspective. *Cognition, 67,* 209–253. DOI: 10.1016/S0010-0277(98)00037-7

Beirness, D.J., Simpson, H.M., Mayhew, D.R. (1991). *Diagnostic assessment of problem drivers: review of factors associated with risky y problem driving*. Report to Transport Canada. TP11549E. Road Safety y Motor Vehicle Regulation, Transport Canada, Ottawa.

Brown, I.D. and Groeger, J.A. (1988). Risk perception and decision taking during the transition between novice and experienced driver status, *Ergonomics, 31,* 587-597.

Benda, H.G. and Hoyos, C.G. (1983). Estimating hazards in traffic situations. *Accident Analysis and Prevention, 15(1),* 1-9.

Carreiras, M., Armstrong, B. C., Perea, M. and Frost, R. (2014). The what, when, where, and how of visual word recognition. *Trends in Cognitive Sciences*, *18*(2), 90-98.

Castro, C., Padilla, J. L., Roca, J., Benitez, I, Garcia-Fernandez, P., Estevez, B., Lopez-Ramon, M.F. and Crundall, D. (2014). A first development and validation of the Spanish Hazard Perception Hazard Prediction Test. *Traffic Injury and Prevention, 15(8), 817-826.* DOI:10.1080/15389588.2013.879125

Castro, C., Ventsislavova, P., Peña-Suárez, E., Gugliotta, A., García-Fernández, P., Eisman, E., & Crundall, D. (2016). Proactive Listening to a Training Commentary improves hazard prediction. *Safety Science, 82,* 144-154. DOI:10.1016/j.ssci.2015.09.018

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Creswell, J. D., Bursley, J. K. and Satpute, A. B. (2013). Neural reactivation links unconscious thought to decision-making performance. *Social cognitive and affective neuroscience*, *8*(8), 863.

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16,* 297-334.

Crundall, D. andrews, B., Van Loon, E. and Chapman, P. (2010). Commentary training improves responsiveness to hazards in a driving simulator. *Accident Analysis and Prevention, 42,* 2117-2124.

Crundall, D., Chapman, P., Trawley, S., Collins, L., van Loon, E., Andrews, B. and Underwood, G. (2012). Some hazards are more attractive than others: drivers of varying experience respond differently to different types of hazard. *Accident; Analysis and Prevention*, *45*, 600–9. DOI:10.1016/j.aap.2011.09.049

Crundall, D. (2016). Hazard prediction discriminates between novice and experienced drivers. *Accident Analysis & Prevention*, 86, 47-58. DOI: 10.1016/j.aap.2015.10.006

Deery, H. A. (1999). Hazard and Risk Perception among Young Novice Drivers. *Journal of Safety Research*, *30*(4), 225–236. DOI: 10.1016/S0022-4375(99)00018-3

Endsley, M.R. (1988). Situation awareness global assessment technique (SAGAT). Proceedings of the National Aerospace and Electronics Conference (NAECON), 789–795. New York: IEEE. DOI:10.1109/NAECON.1988.195097

Endsley, M.R. (1995). *Toward a theory of situation awareness in dynamic-systems. Human Factors, 37(1),* 32-64.

Endsley, M.R. (2000). Theoretical underpinnings of situation awareness: A critical review. In M.R. Endsley and D.J. Garland (Eds.), *Situation awareness analysis and measurement* (pp 3-32). Mahwah, NJ: LEA

Endsley, M.R. (2015). Situation Awareness Misconceptions and Misunderstandings. *Journal of Cognitive Engineering and Decision Making, 9(1) 4-32* DOI: 10.1177/1555343415572631

Evans, J. St. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology, 59,* 255–278.

Fell, J.C., (1993). Repeat DWI offenders: their involvement in fatal crashes. In: Utzelmann, H-D., Berghaus, G., Kroj G. (Eds.), 12th International conference on Alcohol, Drugs and Traffic Safety-T92. Cologne, Germany, National Highway Traffic Safety A"DM"inistration.

Fell, J.C. (1995). Repeat DWI Offenders in the United States, Washington, DC. National Highway Traffic Safety A"DM"inistration, NHTSA Traffic Tech. No. 85.

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

Flach, J. (1995). Situation Awareness: Proceed with caution. *Human Factors, 37,* 149-157.

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

Groeger, J. A. and Clegg, B. A. (1998). *Automaticity and driving*: *time to change gear conceptually* In J. A. Rothengatter and E. Carbonell Vaya (Eds), *Traffic and transport psychology: Theory and application (pp. 137-146*). Elsevier, Amsterdam.

Horrey, W.J., Lesch, M.F., Mitsopoulos-Rubens, E. and Lee, J.D. (2015). Calibration of skill and judgement in driving : Development of a conceptual framework and the implications for road safety. *Accident, Analysis and Prevention, 76,* 25-33.

Horswill, M. and McKenna, F.P. (2004). Drivers hazard perceptionHazard Prediction ability: Situation awareness on the road. In S. Bandury and S. Tremblay (Eds.). *A Cognitive approach to situation awareness: Theory and application* (pp.155-175). Aldershot, England: Ashgate.

Horswill, M., Anstey, K.J., Wood, J. and Hatherly, C. (2010). The crash involvement of older drivers is associated with their hazard perception latencies. *Journal of the International Neuropsycholocial Society, 16(5),* 939-944.

Horswill, M. S. (2017). Hazard perception tests. In D. L. Fisher et al. (Ed.s) *Handbook of teen and novice drivers: Research, Practice, Policy and Directions.* CRC Press: Boca Raton, FL.

Jackson, L., Chapman, P. and Crundall, D. (2009). What happen next? Predicting other road users' behavior as a function of driving experience and processing time. *Ergonomics, 52 (2),* 154-164.

Johnson-Laird, P. N. (2006). *How we reason.* Oxford: Oxford University Press.

Johnson-Laird, P. N. (2008). How we reason: a view from psychology. *The Reasoner, 2,* 4—5.

Laapotti, S., Keskinen, E., Hatakka, M. and Katila, A. (2001). Novice drivers accidents and violations. A failure on higher or lower hierarchical levels of driving behavior. *Accident Analysis and Prevention, 33,* 759-769.

Langsford, P.B. and McKenzie, B.D. (1995). Unconscious influences on direct-test performance. *Psychological Research, 58 (2),* 134-143

Lapham, S.C., Ring-Kapitula, L. C'de la Baca, J. and McMillan, G.P. 2006. Impaired-driving recidivism among repeat offenders following an intensive court-based intervention. *Accident, Analysis and Prevention, 38* (1), 162-169.

Leibowitz, H.W. and Owens, D.A. (1997). Nighttime accidents and selective visual degradation. *Sience, 197*, 422-423.

McGowan, A.M. and Banbury, S.P. (2004). Evaluating interruption-based techniques using embedded measures of driver anticipation. En Banbury, S., Tremblay, S. (Eds.). *A cognitive approach to situation awareness: Theory and application.* Ashgate, Aldershot, UK, pp. 144-175.

McKenna, F.P. and Crick, J.L. (1991). *Hazard perception in drivers: a methodology for testing and training.* Transport and Road Research Laboratory. Crowthorne, UK.

Norman, J. (2002). Two visual systems and two theories of perception. An attempt to reconcile the constructivist and ecological approaches. *Behavioral and Brain Sciences, 25*, 73-144.

Oaksford, M. and Stenning, K. (1992). Reasoning with conditionals containing negated constituents. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 835-854.

Pelz, D.C. and Krupat, E. (1974). Caution profile and driving record of undergraduate males. *Accident, Analysis and Prevention, 6,* 45-58.

Pradhan, A. K., and Crundall, D. (2017). Hazard avoidance in young novice drivers: definitions and a framework. In D. L. Fisher et al. (Ed.s) *Handbook of teen and novice drivers: Research, Practice, Policy and Directions.* CRC Press: Boca Raton, FL.

Richardson, J.T.E. (2011). Eta squared and partial eta squared as measures of effect size in educational research. *Educational Research Review, 6,* 135–147.

Schroyens, W., Schaeken, W. and d'Ydewalle, G. (2001). The processing of negations in conditional reasoning: a meta-analytic case study in mental model and/or mental logic theory. *Thinking and Reasoning, 7,* 121–172.

Simon, F. and Corbett, C. (1996). Road traffic offending, stress, age and accident history among male and female drivers. *Ergonomics, 39* (5), 757-780.

Sloman, S.A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119,* 3–22.

Sloman, S.A. (2002). Two systems of reasoning. In T. Gilovich, D. Griffin, and D. Kahneman (Eds.), *Heuristics and biases: the psychology of intuitive judgment* of th(pp. 379–398). Cambridge: Cambridge University Press.

Smith, K.T. (2013) *Building a human capability decision engine*. Contemporary Ergonomics and Human Factors 2013 Proceedings of the international conference on Ergonomics and Human Factors 2013, 395–402.

Solnick, S.J. and Hemenway, D., (1994). Hit the bottle and run: the role of alcohol in hit-and-run pedestrian fatalities. *Journal of Studies Alcohol 55*, 679–684.

Spicer, R.A. (1964). Human factors in traffic accidents. Final Report (Research Grand No AC-55). United States Public Health Service. Quoted in Pelz, D.C. and Krupat, E. (1974). Caution profile and driving record of undergraduate males. *Accident, Analysis and Prevention, 6,* 45-58.

Stanovich, K. E. (2004). *The Robot's Rebellion: Finding meaning in the age of Darwin.* Chicago: University Press.

Underwood, G., Ngai, A. and Underwood, J. (2013). Driving experience and situation awareness in hazard detection. *Safety Science, 56, 29–35.*

Ventsislavova, P., Gugliotta, A., Peña-Suarez, E., García-Fernandez, P., Eisman, E., Crundall, D. and Castro, C. (2016). What happens when drivers face hazards of the road? *Accident, Analysis and Prevention*, http://dx.doi.org/10.1016/j.aap.2016.013

Wason, P. C. (1961). Response to affirmative or negative binary statements. British. *Journal of Psychology, 52,* 133–142.

Wells, P., Tong, S., Sexton, B., Grayson, G. and Jones, E. (2008). *Cohort II: A Study of Learner and New Drivers.* Department of Transport (UK), London.

Wetton, M.A., Hill, A. and Horswill, M.S. (2011). The development and validation of a hazard perception test for use in driver licensing. *Accident, Analysis and Prevention,* 43(5), 1759-1770.

Yahya, M. and Hammarstrm, U. (2011). *The offender's drink-driving as accident cause in traffic – An analysis of data in the register of legal proceedings*. VTI. Rapport 710

Video Code	Length (Sec)	Discrimination (inclusion)	Vehicle	Type of road	Visibility	Description of the video content	Expected Driver Response to the Decision Making Question	
							Manoeuvres performed by the real driver: **2 points Score**	Other appropriate avoiding manoeuvres **1 point Score**
9	16.09	Yes	Car	Highway	Clear	A car stops in the middle of a junction between two exits, and changes direction	Swerve to the left	Move forward Speed up
28*	11.49	Yes	Car	Highway	Clear	The red car in the left lane suddenly invades our lane while trying to dodge another car that has stopped	Sharp brake	Gradual brake
31*	12.04	Yes	Car	Minor Road	Less clear	A car is joining the road at an intersection	Sharp brake	Gradual brake
32	15.08	Yes	Car	Urban Road	Less clear	A car suddenly joins the road and moves into the left lane	Gradual brake	Sharp brake
84	12.04	Yes	Car	Urban Road	Less clear	A car is approaching an intersection in reverse	Maintain same speed and direction	-
95	20.27	Yes	Car	Urban Road	Hindered by other vehicles	A car that was parked is reversing into the road	Gradual brake	-
103	24.48	Yes	Car	Urban Road	Hindered by other vehicles	A car hidden behind other cars in a car park is reversing into the road	Gradual brake	-
118	11.02	Yes	Car	Urban Road	Clear	A car, that suddenly starts indicating, is moving into our lane from the left-hand lane	Gradual brake	Sharp brake
130*	20.48	Yes	Car	Urban Road	Hindered by other vehicles	A towed car has moved into our lane in front of us	Sharp brake	-
169	19.04	Yes	Motorcycle	Urban Road	Clear	A motorcycle appears in front of us and performs a manoeuvre that is not allowed in order to join the left lane, invading our lane	Gradual brake	Move forward Swerve to the left
197	18.05	Yes	Pedestrian	Urban Road	Hindered by other vehicles	A pedestrian is about to cross the road	Gradual brake	Sharp brake
205*	19.54	No	Car	Highway	Clear	The car that is ahead of us slows down due to the heavy traffic	Swerve to the right	Gradual brake
215	14.08	No	Truck	Minor Road	Less clear	A butane truck suddenly appears in the opposite lane, heading towards us	Gradual brake	Sharp brake
216	6.11	No	Car	Urban Road	Hindered by other vehicles	A car suddenly joins the road at an intersection	Sharp brake	Gradual brake
226	15.04	No	Car	Urban Road	Hindered by other vehicles	Overtaking a double-parked ambulance is another car that is trying to reverse into its lane	Sharp brake	Swerve to the right
230*	19.46	No	Pedestrian	Urban Road	Hindered by vegetation	A pedestrian is about to cross on a zebra crossing	Gradual brake	-

Table 1. Description of these hazard situations.

*Videos that does not discriminate (alpha value under 0.30)

Top	Learner M (S.D.)	Novice M (S.D.)	Experienced M (S.D.)	F (d.f)	*p.*	η^2
Driving Ability	2.94 (1.73)	4.79 (1.02)	5.33 (.66)	31.93 (2.12)	<.001	.36
Awareness of Others	3.56 (1.59)	5.10 (.91)	5.45 (.68)	22.61(2.12)	<.001	.28
Confidence in Driving	3.38 (1.82)	5.05 (1.06)	5.40 (.63)	20.68(2.11)	<.001	.27
Bottom		Non-offender M (S.D.)	Offender M (S.D.)	t	*p.*	η^2
Driving Ability		4.82 (.99)	5.28 (.75)	-2.474	.015	.06
Awareness of Others		5.20 (.77)	5.30 (.94)	-.604	.55	.00
Confidence in Driving		5.02 (.95)	5.45 (.85)	-2.337	.021	.05

Note: M= Mean; S.D.= Standard Deviation; F = One-way between-groups ANOVA (top) t= Independent Samples t-test (bottom); d.f.= degrees of freedom *p*= significance level ; η^2= Size Effect.

Table 2. Comparisons of driving skills for experience condition and offender status.

	What	Where	WHN	“DM”	Driving ability	Awareness of others	Confidence in driving
What	1	.62**	.39**	.30**	.23*	.11	.19*
Where		1	.55**	.35**	.17	.08	.10
WHN			1	.19*	.12	.01	.07
“DM”				1	.16	.14	.077
Driving ability					1	.72**	.81**
Awareness of others						1	.78**
Confidence in driving							1

Note. **=The correlation at p< 0.1 (2-tailed) was considered significant. *=The correlation at p<0.5 (2-tailed) was considered significant

Table 3. Correlations between the Hazard Prediction questions and driving skills (self-estimations)

Figure 1. Example of an edited sketch of the last photogram (with all the relevant obstacles removed) displayed in each video, printed on each answer sheet (Figure 1a). The original schematic drawings of the road frame with all the relevant objects and possible obstacles (pedestrians, cars, bicycles, etc.). This was not used (Figure 1b). An example of the restricted and the near-restricted areas on the photogram is provided (Figure 1c). This was used for correction of the “Where is the hazard?” question.

		
Figure 1a. Example of the sketch that was used (the relevant objects and possible obstacles (pedestrians, cars, bicycles, etc.) were removed)	Figure1b. The sketch that was not used.	Figure1c. Example of the restricted areas. Restricted area Near-Restricted area

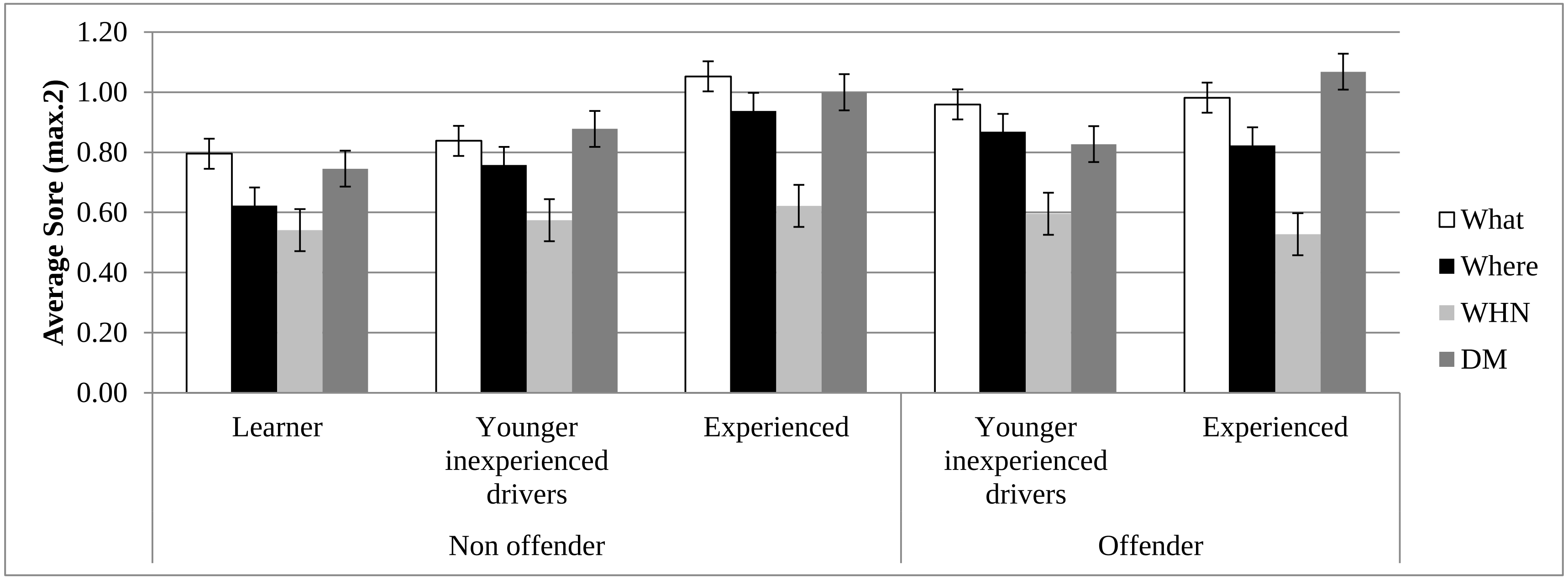

Figure 2. Accuracy mean total for the 4 questions: SA [Q1“What is the hazard?” (What?), Q2 “Where is it?” (Where?) “What happens next?” (WHN?)] and Decision-Making (“DM”); by non-offender (learner, younger inexperienced and experienced) drivers and offender (younger inexperienced and experienced) drivers; and showing error bars.