Education – Hazard perception training

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Please note: The studies included in this synopsis were selected from those identified by a systematic literature search of specific databases (see supporting document). The main criterion for inclusion of studies in this synopsis and the DSS was that each study provides *a quantitative effect estimate*, preferably on the number or severity of crashes or otherwise on road user behaviour that is known to be related to the occurrence or severity of a crash. Therefore, key studies providing qualitative information might not be included in this synopsis.

1 Summary

Katrakazas, C, September 2017

1.1 COLOUR CODE: GREEN

The results from the available literature indicate that hazard perception training/education can significantly improve the hazard perception skills of drivers as well as reduce accident rates and speeds. As most of the studies performed statistical analyses, and the vast majority of the results were statistically significant, there is evidence that hazard perception training brings about enhanced hazard avoidance skills. Consequently, drivers who have undertaken hazard perception training are less likely to cause accidents or drive with high speeds, thus it can be concluded that hazard perception training reduces road safety risk.

1.2 KEY WORDS

Training; Education; hazard perception; hazard avoidance; accidents; speed;

1.3 ABSTRACT

Hazard perception training aims to enhance the ability of road users to detect and avoid hazards through education or additional training, which is not mandatory, as part of licensing or graduate licensing programmes. For this synopsis, the effects of hazard perception training on road safety were investigated based on ten studies in a relatively wide range of countries. In addition to the effects on hazard perception skills, some studies investigated the effect of training on accident rates and vehicle speeds among car drivers, PTW riders and pedestrians. The dominant approaches to derive the effects of training was the use of driving simulators and quasi-experiments. The results demonstrated that the hazard perception ability of road users is significantly enhanced. Furthermore, in three studies regarding accident rates and vehicle speed, it was revealed that drivers who undertook hazard perception training caused less accidents and drove with lower speeds. In conclusion, hazard perception training appears to significantly enhance road safety.

1.4 BACKGROUND

How is hazard perception training defined?

Education and voluntary training is a broad topic area that includes many different methodologies and teaching styles. Hazard perception education/training is defined here as any educational program/activity or training that aims to enhance the ability of drivers to detect and avoid hazards. The primary concern is whether education or voluntary training (i.e. not mandatory as part of licensing or graduate licencing programmes) can improve road users' hazard perception and consequently reduce their involvement in accidents.

What type of education/training has been studied?

A number of different types of education/training have been used in the included studies, for example, driving and riding simulator, practising crossing the road on a virtual road in a simulator, listening to expert or self-generated commentary, viewing visual commentary or field trials.

How are hazard perception skills assessed?

Driving skills are most often assessed by a practical assessment either in a driving simulator or during an on-road test. Hazard perception skills include the ability to avoid hazards, to safely cross the road or to fixate on hazardous areas of the road. It is ethically difficult to assess risky behaviour such as speeding or the involvement in accidents by on-road tests, so changes to these are usually assessed via simulator or self-report methods such as questionnaires.

Which road users are the main focus of hazard perception training and how many of them are killed in road traffic accidents?

The main focus of hazard perception training schemes are novice/young drivers. In Europe, road traffic crashes are the most common single cause of death for 15-24 year olds. Drivers between the ages of 16-24 are over-represented by 2-3 times in crash and fatality statistics and such crashes are associated with greater numbers of fatalities of other road users than crashes involving more experienced drivers (DaCoTA, 2012).

What is the relationship between hazard perception training and accidents?

The majority of studies looking at the relationship between training and hazard perception skills only look at behaviour change and do not examine whether there is a link with accidents. Nevertheless, three studies (DiStasi et al., 2011; Crundall et al., 2010 and Vidotto et al., 2011) investigated the effect of hazard perception training and accident rates. The latter two (Crundall et al., 2010 and Vidotto et al., 2011) found that hazard perception training reduced accident rates, while the former one (DiStasi et al., 2011), demonstrated no significant difference in accident rates between drivers that undertook training and those that did not.

1.5 OVERVIEW OF RESULTS

Overall, the results showed that hazard perception training significantly enhances the ability of car drivers, PTW riders and pedestrians to detect hazards. Road users who undertake such training tend to perform better in hazard perception tests, fixate more on dangerous areas of the roadway and in general behave in a safer way than untrained road users. As a result, trained road users are less likely to cause accidents, but this is only investigated in a limited number of studies. Despite the limited number of studies dealing with accident rates and driving speed, it was still demonstrated that hazard perception training reduced the risk of collisions as well as driving speed. Finally, an analysis of different road users indicated that hazard perception training is more effective on car drivers and pedestrians, whereas results for PTWs were inconclusive.

2 Scientific Overview

2.1 INTRODUCTION

Ten studies were identified as the most appropriate to be included in this synopsis regarding the effect of Hazard Perception (HP) training on road safety. Six of those studies investigated the use of driving simulators for training drivers while the rest followed a quasi-experimental design using visual or commentary training interventions. The majority of the coded studies (6) were concerned with the effectiveness of training on car driving tasks, two of the studies investigated motorcyclists and two investigated road safety effects on pedestrians. Furthermore, two of the studies were conducted in Spain, two in Israel and two in the UK, whereas the USA, Australia, Italy and China were the origin of one study respectively. Most of the studies aimed at improving the hazard perception abilities of novice or learner drivers while one study aimed at improving the anticipation of hazards by child pedestrians.

2.2 METHODOLOGY

As mentioned in the introduction, most of the studies utilized driving simulators (e.g Crundall et al., 2010) and few of them (e.g. Castro et al., 2016) were designed quasi-experimentally. Regardless of the study design, the analyses were almost exclusively carried out using Analysis Of Variation (ANOVA) in order to investigate if and to what extent HP training had affected the skills of trained and untrained drivers. The only exception was the study of Vidotto et al., 2011), who applied Logistic Generalised Linear Models to assess the impact of HP training on driving skills. In the studies applying ANOVA, the effect of training was initially tested for its statistical significance and if it was significant, then the individual effects of training on accident rate, speed and hazard perception skills were explored.

An overview of the methodology for each of the coded studies is given in Table 1.

Table 1: Overview of study methodologies

Author(s), year, country	Study Methodology	Sample	Analysis method/ Effect measure
Crundall et al., 2010, UK	Driving Simulator study aiming to investigate the effect of commentary training on the hazard perception skills of drivers	40 participants, all of them learner (novice) drivers (17-25 years old); 24 assigned to training intervention group and 16 assigned to control group	Multi-level ANOVA (Assignment group as a between-groups factor, assessment type, distance to hazards and hazard type as within-groups factors)
DiStasi et al., 2011, Spain	Driving simulator study aiming to identify the change in riding behaviour of novice motorcyclists as a result of training	33 participants; 17 had never driven/ridden a motorcycle (novice drivers group) 16 were expert riders with more than 10 years of motorcycling experience	Repeated-measures multi-level ANOVA

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Author(s), year, country	Study Methodology	Sample	Analysis method/ Effect measure
Wang et al., 2010, China	Driving simulator study investigating the effectiveness of driving simulation training on hazard perception skills on novice drivers	32 male novice drivers; all undergraduate or graduate university students. 16 randomly assigned to training group and the rest assigned to the control one.	Mann-Whitney U test, Repeated measures multi-level ANOVA
Fischer et al., 2006, USA	The study combines a driving simulator experiment along with a quasi-experimental field trial to assess a PC-based risk awareness and perception training program.	First test: 48 novice drivers; all high school students with learner's permit for 1-5 months. 24 randomly assigned to trained group and 24 to the untrained group. Second test: 12 novice drivers training group; 12 novice drivers control group Third test: 24 drivers (18-21 years old) ; 12 assigned to training group and 12 assigned to control group	Multi-level ANOVA
Castro et al., 2016, Spain	A quasi-experimental study investigating the effect that proactive listening to a training commentary has on hazard prediction performance among drivers with different driving experience	121 drivers (69 male; 52 female; 20 learner, 62 novice, 40 experienced)	Multi-level (mixed-model) ANOVA
Meir et al., 2015, Israel	A quasi-experimental study exploring the formation and evaluation of a new hazard perception training which is based upon exposing young, novice drivers to an array of actual traffic hazards.	61 participants; 21 experienced drivers (23-29 years old), 40 young novice drivers (17-18 years old)	One-way ANOVAs, post hoc comparisons
Rosenbloom et al., 2015, Israel	A quasi-experimental, repeated-measures study aiming to train pedestrians of different age to cross streets safely by successfully detecting on-road hazards.	359 participants; 158 primary school pupils (7-10 years old), 113 volunteer university students and 88 volunteers from elderly community centres	Repeated measures multi-level ANOVAs
Wetton et al., 2013, Australia	A quasi-experimental study investigating the effect that self-generated commentaries and "what happens next" exercises have on hazard perception skills of drivers	233 participants (holders of learner or probationary licenses)	Independent samples t-tests, one-way ANOVAs, Bonferroni-Holm correction comparisons
Vidotto et al., 2011, Italy	A rider-simulator study evaluating the hazard avoidance performance of teen-novice riders	410 participants (14-15 years old, 189 males, 221 females), randomly assigned to experimental or control group	Logistic Generalised Linear Models (Logistic GLMs)

Author(s), year, country	Study Methodology	Sample	Analysis method/ Effect measure
Chapman et al., 2002, UK	A quasi-experimental randomised study exploring the effects of a training intervention on the visual search patterns of drivers with regards to on-road hazards.	143 participants (newly qualified drivers), randomly assigned to the control or intervention group.	Multi-level ANOVAs

2.3 ANALYSIS AND RESULTS

Crundall et al. (2010) found that training with on-road commentaries improved learner drivers hazard perception skills on identifying Behavioural (i.e. hazards which are a-priori visible), Environmental (i.e. hazards which are initially hidden) and Dividing and Focusing attention hazards (i.e. situations where are at least two hazards to anticipate). Foremost, the drivers having undertaken commentary training had fewer accidents than the untrained group. Similarly, Vidotto et al. (2011) using a rider simulator found out that trained drivers avoided 16% more hazards than drivers who did not receive training. However, the results of the study by DiStasi et al. (2011) demonstrated that although novice drivers reduced their number of accidents during the intervention, the total number of accidents for the trained and untrained groups was the same.

Regarding speed, Crundall et al. (2010) found a negative effect. It was demonstrated that trained drivers accelerated slightly more than untrained drivers. Nonetheless, when their analysis focused on specific hazard types (e.g. behavioural, environmental, dividing and focusing attention) it was found that training resulted in lower speeds and increased braking activity. The positive effect of hazard perception training on speed was further justified in Wang et al (2010), where it was indicated that the group of riders that did not receive training rode faster by 2.18 km/h. Results were inconclusive in DiStasi et al (2011). On the one hand, it was found that the riding speed of trained motorcyclists was in general lower than the riding speed of the control group. On the other hand, in locations where accidents had occurred it was found that the trained group rode 11.18 km/h faster than the group of motorcyclists that did not receive training.

The majority of studies investigated the effect of training on the improvement of hazard perception abilities of drivers. Hazard perception skills were evaluated with regards to hazard perception test scores(e.g. Castro et al., 2016; Rosenbloom et al., 2015; Wang et al., 2011; Wetton et al., 2013), fixation on areas of dangers (e.g. Chapman et al.,2002; Fisher et al., 2006), hazard response times (e.g. Wetton et al., 2013) and identification of hazards (e.g. Meir et al., 2015). Using the ANOVA method, the training effect was statistically significant and enhanced hazard perception ability in all the studies which investigated the effect of training on hazard perception skills.

2.4 VOTE COUNT ANALYSIS

Due to variance between individual reported effects in the papers and differences in the types of evaluation of the effect that HP training has on road safety, it was decided the best way to evaluate the coded papers would be through a vote count. Table 2 shows the results of the vote count analysis for the ten studies. Care was taken to ensure that data was not counted twice from the same study.

Table 2: Vote count result of comparing "Hazard perception" studies in terms of accident rate, vehicle speed and hazard perception ability

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Outcome Definition	Included in no. of studies	Result (no. of studies)			Result (% of studies)			Result (no. of effects)			Result (% of effects)		
		↓	-	↑	↓	-	↑	↓	-	↑	↓	-	↑
Accident rate [a]	3	-	1	2	-	33%	67%	-	1	2	-	33%	67%
Vehicle speed	3	-	1	2	-	33%	67%	2	1	10	15%	8%	77%
Hazard perception ability [b]	7			7			100%	-	1	30	-	3%	97%
Total [c]	13		2	11		15%	85%	2	3	42	4%	6%	89%

a: accident rate includes papers providing results on the accident rate and the ratio of crash-prone hazards avoided

b:Hazard perception ability includes papers providing results on hazard perception test scores, fixation, hazard response times and likelihood of pedestrians to safely cross the road

c: Ten studies in total were coded. However, as some papers include results in both accidents and speeds there is an overlap in the number of studies including these outcomes.

↑ = *Significant positive effect on road safety, following hazard perception training (i.e. reduced accident rates and speed, or increased hazard perception ability).*

↓ = *Significant negative effect on road safety, following hazard perception training (i.e. increased accident rates and speed, or reduced hazard perception ability).*

Examining Table 2, it can be observed that in the majority of the studies, HP training has a significant positive effect on road safety. This statement is true for accident rates and vehicle speeds (67% positive results) as well as hazard perception ability enhancement (100% positive results). When analysing the number of effects, it is shown that 89 % of the reported effects lead to a significant enhancement of road safety, whereas only 4% indicate a decrease and just 6% are inconclusive.

By displaying the results using the above mentioned outcomes, it is not possible to investigate the specific effect that hazard perception training has on different road user type. Therefore, Table 3 shows the vote count results for car drivers, PTW riders and pedestrians.

Table 3: Vote count result of comparing "Hazard perception" studies results per road user type

Road user type	Included in no. of studies	Result (no. of studies)			Result (% of studies)			Result (no. of effects)			Result (% of effects)		
		↓	-	↑	↓	-	↑	↓	-	↑	↓	-	↑
Car	6	-		6	-	0%	100%	1	2	35	-	5%	92%
PTW	2	-	1	1	-	50%	50%	1	1	2	25%	25%	50%
Pedestrians	2	-	-	2	-	-	100%	-	-	5	-	-	100%
Total	10		1	9		10%	90%	2	3	42	4%	6%	89%

The results in Table 3 demonstrate that significantly positive results were found for the majority of car drivers (100 % of studies; 92% of effects) and pedestrians (100% of studies and effects), whereas results for PTWs are inconclusive.

2.5 CONCLUSION

Overall, it was found that HP training affects safety in a significantly positive way, and in most of studies, training leads to enhanced hazard perception abilities, as well as reduced accident rates and vehicle speeds.

The noteworthy results were found to be mainly in studies regarding car drivers. Two of the studies investigated the effect of HP training on pedestrians and found a positive outcome regarding all the reported effects, but the results regarding PTWs were not clear enough.

Overall, these results would generally be expected as the main aim of HP training is to increase hazard anticipation skills of drivers for them to be able to react faster and avoid or mitigate collisions. A direct influence of this would be reduced accidents, particularly serious accidents, and there is plenty of existing evidence which highlights this (e.g. Crundall et al., 2010).

As most of the coded studies, however, only consider driving simulator experiments and do not rely on real-world trials, the validity of the results and the actual reduction in speed/accidents must be taken into account.

3 Supporting Document

3.1 DESCRIPTION OF STUDIES

In the following paragraphs, an overview of each coded study is provided, along with a summary of relevant findings. In total, ten studies were identified as being the most relevant for this synopsis on the effects of hazard perception training.

Crundall et al. (2010) describes the differences in hazard perception of drivers between two distinct groups; one that has undertaken training and one that has not. The variables studied, include the number of crashes, the approaching speed and the pressure the drivers put on the braking and accelerator. The effect of hazard perception training on the above-mentioned variables was investigated through an analysis of variation (ANOVA), except for the overall speed of vehicles. The results showed significant changes for the group that undertook the training, especially when the drivers approached the location of a hazard. Therefore, a significant positive effect of training on hazard perception is sufficiently supported and justified.

DiStasi et al., (2011) discussed the effect of experience and training on risk behaviour and mental workload in first time motorcycle riders using a simulator. The performance of first-time motorcyclists was compared to the one of experienced drivers, regarding accidents, speed and steering. Furthermore, the drivers were assessed based on their eye movement and mental workload data. Two sessions took place, namely pre-training and post-training. The experienced drivers did not undertake any training. It was found that first-time motorcyclists, which undertook training, caused less accidents in the post-training session and behaved similarly to the experienced drivers. A safer driving behaviour was further resembled in the speed data. It was found that first-time riders drove in a slower speed than experts who did not undertake training. However, when investigating the speed of riders near location where at least an accident of a first-rider had happened, it was found that first-time riders accelerated near the location, in opposition with experienced drivers.

Wang et al. (2010) investigated the effect that a training intervention based on driving simulation has on the hazard perception performance of novice drivers in China. Eight virtual driving scenarios were tested on two groups; one that received training 6 weeks before the test and one that had no prior training. The drivers were evaluated based on their hazard handling performance (a 5-point scale test regarding their involvement in accidents and their response to hazards), the anticipation of hazards as well as their speeds. Furthermore, their mental workload was analysed. It was found that all hazard perception skills (hazard performance scores, hazard anticipation and driving speed) were significantly enhanced after receiving training. Nevertheless, a limitation of the study is the small sample size.

Fischer et al. (2006) explored the effect of three PC-based training studies on risk awareness and perception of novice drivers in the USA. The first two studies involved testing using a driving simulator, while the third one involved an on-road test. In all tests, drivers were assessed using eye-tracking devices in order to assure if their attention was on the areas of potential crash hazards. Driving scenarios were split into those that had already been seen in PC-based training (near transfer) and those that were not (far transfer). In all tests, it was found that the group that undertook training fixated more on areas containing information that could reduce crash likelihood. Moreover, the performance of trained drivers was similar in far and near transfer scenarios although smaller differences were observed in the field trials.

Castro et al. (2016) discussed the effect that Proactive Listening to a Training Commentary (PLTC) has on hazard prediction in a group of 121 drivers in Spain. The sample included learner, novice and experienced drivers as well as re-offenders and non-offenders. The participants were divided into two groups; a trained and an untrained group. The results describe differences in pre/post test results as well as statistically significant effects or interactions of driving experience and recidivism condition using ANOVA. In general, it was found that training had a positive effect on hazard perception in both the general ANOVA as well as the one taking into account driving experience. However, it was found that the recidivism condition of the drivers (non-offenders, re-offenders) did not result in a significant improvement or decrease of the drivers' scores in hazard perception.

Meir et al. (2015) investigated the effectiveness of training for the enhancement of child-pedestrians' hazard perception abilities in a road-crossing task using a 3D simulator. Two analyses were applied, namely response sensitivity and verbal description analysis. Response sensitivity analysis examined the decision to cross, while verbal description analysis looked at the justification behind the crossing decision in order to identify which dimensions of the traffic environment were considered as dangerous. The participants were twenty-four 7-9 years old child pedestrians, nine of which were chosen as trained and 15 were chosen in the control group. It was found that the trainees were likely to cross more when their field of view was unrestricted or partially obscured by the road curvature. Moreover, trainees justified their crossing decision better than the control group and especially when they decide not to cross. This was prominent in the case when their field of view was obscured by parked cars. However, no such a significant interaction was found when examining the field of view restricted by the road's curvature. Nevertheless, the study has a limited sample size and the allocation of participants to groups was not fully controlled.

Rosenbloom et al. (2015) discussed the development of system that could train pedestrians of all ages to safely cross streets and detect potential hazards. The system, termed as Hazard Perception Test for Pedestrians (HPTP), is an interactive computerized program containing videos of potentially dangerous pedestrian crossing scenarios. 359 participants in total were included in the study and were assigned to two practice groups and three control groups. The first practice group undertook individual training and also discussed the videos included in HPTP while the second group only participated in the individual training. ANOVA was carried out to investigate the effects of experimental groups, age, gender, and trial cases among the participants. It was found that undertaking individual training resulted in a statistically significant enhancement of the test results between pre- and post-tests. Moreover, it was found that the practice groups (i.e. the groups that undertook training either in the form of individual training or in the form of group discussion) performed better than the control groups.

Wetton et al. (2013) researched the effect that different training interventions, and especially "what happens next?" training, have on hazard perception test scores of novice drivers. Four different interventions were tested: a) what happens next, b) expert commentary training, c) hybrid commentary training (i.e. expert & self-generated commentaries and d) full training package (i.e. what happens next & hybrid commentary). The performance of those interventions was compared with a control condition. The performance of the drivers was evaluated before the interventions, immediately after the training and after a one-week delay. It was found that the full training package significantly improved hazard perception response time both immediately after and following the one-week delay. The full training package outperformed the other three interventions (i.e. expert commentary, expert and self-generated commentary and "what happens next") which however, also improved hazard perception ability when compared to the control group. The "what happens next?" training was also outperformed by the expert commentary only. Finally, it was found that the one-week delay significantly decayed the hazard response test scores among all training conditions.

Vidotto et al. (2011) presented a simulator study which aimed at identifying the effect that motorcycle riding training has on the hazard perception of teenagers. A group of teenagers was randomly divided into four groups two of which undertook pre-training and passive training (i.e. a traditional road safety lesson about driving violations, hazard perception and hazard awareness) and the performance of the groups was tested against the perception of hazards. It was found that both the groups that undertook pre-training and the ones that undertook passive training demonstrated higher average proportion of perceived hazards than the groups that had no training. However, the results were not verified in real-world scenarios.

Chapman et al. (2002) described a training intervention which informs novice drivers about typical patterns of visual search and indicates the need for scanning multiple locations in the visual scene for potential dangers. The sample was divided into two groups randomly; one which received the training and one which acted as the control group. Both groups were tested before the training session, after it and during a follow-up session (three to six months after the training intervention). It was found that trained drivers are avoiding perceptual capture and they process faster dangerous scenes. Furthermore, the training intervention improves scanning behaviour in cases of danger as well as safe cases. Finally, the results indicate that trained drivers are more conscious given the large differences between the control and intervention groups regarding the mean fixation as well as the horizontal and vertical variances.

Table 4 illustrates an overview of the main outcomes of the coded studies.

Table 4: Main outcomes of coded studies on hazard perception

Author, Year, Country	Exposure variable	Outcome variable / Outcome type	Effects		Main outcome -description
Crundall et al., 2010, UK	Driver training intervention	Difference in number of accidents	↗	F(1,38)=8.9 MSE=1.7 p<0.005	Significant reduction of the number of accidents for the group that received hazard perception training
		Difference in overall speed pre- and post-assessment between the group that received hazard perception training and the one that did not	↘	0.2 km/h increase	There is a larger increase in the overall vehicle speed for the drivers that received hazard perception training
		Change in approach speed to all hazards between trained and untrained group	↗	F(9,342)=5.1 MSE=9.4 P<0.005	There is a significant reduction in approach speed to all hazards after hazard perception training
		Change in approach speed to Dividing and Focusing Attention Hazards between trained and untrained group	-	F(9,342)=1.8 MSE=23.5 P=0.076	There is a marginally significant reduction in approach speed to Dividing and Focusing Attention hazards after hazard perception training
		Change in approach speed to Dividing and Focusing Attention hazards (30-20m before the hazard) between trained and untrained group	↗	F(9,342)=4.6 MSE=25.8 P<0.05	There is a significant reduction in approach speed 30-20m before a Dividing and Focusing Attention hazard after hazard perception training

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		Change in approach speed to Behavioural Prediction Hazards between trained and untrained group	↗	F(9,342)=4.4 MSE=24.4 P<0.001	There is a significant reduction in approach speed to Behavioural Prediction Hazards after hazard perception training
		Change in approach speed to Environmental Prediction hazards between trained and untrained group	↗	F(1,38)=5.1 MSE=5.3 P<0.05	There is a significant reduction in approach speed to Environmental Prediction hazards after hazard perception training
		Change in brake pedal pressure between trained and untrained group	↗	F(9,342)=2.7 MSE=37.3 P<0.005	There is a significant increase in braking behaviour after hazard perception training
		Change in brake pedal pressure before dividing and focusing attention hazards between trained and untrained group	↗	F(9,342)-2.6 MSE=88.7 P<0.01	There is a significant increase in braking behaviour before a dividing and focusing attention hazard, after hazard perception training
		Change in brake pedal pressure 20-10m before a dividing and focusing attention hazard between trained and untrained group	↗	F(1,38)=5.1 MSE=573 P<0.05	There is a significant increase in braking behaviour 20m before a dividing and focusing attention hazard, after hazard perception training
DiStasi et al., 2011, Spain	Training session	Difference in number of accidents caused by first-time riders and experts in Test 2 (post-training)	-	Zero difference F(1,30)=0.05	First-time riders (after receiving training) caused the same number of accidents as expert drivers, although they had caused more in the pre-test.
		Difference in riding speed between first-time riders and experts during Test 2 (post-training)	↗	<0 F(1,30)=17.09 SE=598.35 P<0.001	Experts (the group that did not receive hazard perception training) rode faster than first-time riders who received training
		Changes in speed of first-time riders around the locations in the riding course at which at least one first-time rider had an accident	↘	9.48 increase F(1,25)=6.12 SE=205.38 P=0.02	First-time riders failed to anticipate hazardous locations although they received hazard perception training
Wang et al., 2010, China	Training intervention	Difference in mean HP handling performance scores between trained and untrained group	↗	1.46 increase Mann-Whitney U=0.5 p=0.000	Trained drivers did significantly less errors resulting in crashes compared to the control group
		Difference in mean squared hazard anticipation scores between trained and untrained group	↗	11.18 increase Mann-Whitney U=0.5 p=0.000	Trained drivers anticipated hazards significantly better than the control group
		Difference in mean speed between the trained and untrained group	↗	-2.18 km/h decrease P<0.05	Trained drivers were significantly more cautious regarding speed than the control group
Fischer et al., 2006, USA	PC-based risk awareness and perception training (RAPT-1)	Percent change of fixation on areas of the roadway which could reduce the likelihood of a crash between the trained and untrained drivers	↗	22.3% increase P<0.001	Trained drivers on RAPT-1 fixated more on areas of the road that could reduce the likelihood of a crash
		Percent change of fixation on areas of hazard when interaction between near/far transfer scenarios and training is taken into account	↗	24.6% increase (near transfer) 20% increase (far transfer) F<1	Trained drivers on RAPT-1 fixated more on areas of the road that could reduce the likelihood of a crash both in near transfer as well as far transfer scenarios.
	PC-based risk awareness and perception training (RAPT-2)	Percent change of fixation on areas of the roadway which could reduce the likelihood of a crash between the trained and untrained drivers	↗	24% increase p<0.05	Trained drivers on RAPT-2 fixated more on areas of the road that could reduce the likelihood of a crash
		Percent change of fixation on areas of hazard when interaction between near/far transfer scenarios and	↗	23% increase (near transfer) 26% increase (far transfer)	Trained drivers on RAPT-2 fixated more on areas of the road that could reduce the likelihood of a crash both in near transfer as well as far transfer scenarios.

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		training is taken into account		F<1	
	Risk awareness and perception on-road training (RAPT-3)	Percent change of fixation on areas of the roadway which could reduce the likelihood of a crash between the trained and untrained drivers	↗	37% increase $p<0.001$	Trained drivers on RAPT-3 fixated more on areas of the road that could reduce the likelihood of a crash during the field trial
		Percent change of fixation on areas of the roadway which could reduce the likelihood of a crash between the trained and untrained drivers (far transfer scenarios)	↗	20% increase	Trained drivers on RAPT-3 fixated more on areas of the road that could reduce the likelihood of a crash only in far transfer scenarios.
Castro et al., 2016, Spain	Proactive Listening to a Training Commentary (PLTC)	Difference in Hazard Perception (HP) test scores between the trained and untrained group using paired-samples t-tests	↗	0.45 points improvement $t(119)=2.008$ $p=0.047$ CI=95% $\eta^2=0.033$	The HP scores significantly improved after training by PLTC compared to the untrained group
		Effect of training on pre-vs post-test scores for training gradual hazards	↗	Wilk's lambda=0.954 $F(1,118)=5.731$ $P=0.018$ CI=95% $\eta^2=0.046$	There was a significant effect of training on the pre- and the post-test HP scores for gradual-onset hazards
		Effect of training on pre-vs-post-test scores for training abrupt hazards	↗	Wilk's lambda=0.944 $F(1,119)=7.113$ $P=0.009$ CI=0.95 $\eta^2=0.056$	There was a significant effect of training on the pre- and the post-test HP scores for abrupt hazards
		Difference in HP scores for gradual hazards between pre-test and post-test for the trained group using paired-samples t-tests	↗	1.2 points improvement $t(59)=-7.639$ $p=0.001$ $\eta^2=0.5$	There was a significant improvement of HP scores with regards to gradual-onset hazards for the trained group
		Difference in HP scores for abrupt hazards between pre-test and post-test for the trained group using paired-samples t-test	↗	0.6 points improvement $t(60)=-4.255$ $p=0.001$ CI=95% $\eta^2=0.23$	There was a significant improvement of HP scores with regards to abrupt hazards for the trained group
		Difference in HP scores for the trained group of experienced drivers	↗	1-point improvement (no statistics given)	Experienced drivers improved their HP scores after training
		Difference in HP scores for the trained group of novice drivers	↗	0.8 points improvement (no statistics given)	Novice drivers improved their HP scores after training
		Difference in HP scores for the trained group of learner drivers	↗	0.5 points improvement (no statistics given)	Learner drivers improved their HP scores after training
		Effect of experience on the pre/post-test HP scores	↗	$F(1,115)=6.928$ $P=0.01$ CI=95% $\eta^2=0.093$	There was a significant effect of driving experience on the pre/post-test HP scores
		Effect of recidivism on the pre/post-test HP scores	-	$F(1,97)=0.101$ $P=0.752$ CI=95% $\eta^2=0.001$	There was not a significant effect of recidivism on the pre/post-test HP scores
Meir et al., 2015, Israel	Child-pedestrians Anticipate and Act Hazard Perception	Difference in likelihood to decide to cross between trainees and the control group	↗	$F(2,427)=8.23$ $p<0.001$	Trainees showed a significantly higher likelihood to cross in unrestricted or partially obscured fields of view

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	Training (CA2HPT)				
		Effect of training on the justification of the decision to cross between trainees and the control group when view was restricted by parked vehicles	↗	$F(1,500)=10.18$ $P<0.01$	Trainees used significantly more verbal descriptions regarding their field of view and justified properly the decision to cross
		Effect of training on the justification of the crossing decision between trainees and the control-group	↗	$F(1,500)=-8.23$ $P<0.01$	Trainees mentioned the restricted field of view as a justification for their crossing decision significantly more often than the members of the control group
Rosenbloom et al., 2015, Israel	Pedestrian hazard perception training using practice sessions and group discussions	ANOVA effect of experimental group on test scores	↗	$F(3,271)=9.62$ $p<0.001$ $\eta^2=0.1$	The group that undertook individual practice only, performed significantly better than the control group and the group that undertook both individual practice and group discussion
		ANOVA effect of experimental group on the final trial test scores	↗	$F(4,343)=16.52$ $p<0.001$ $\eta^2=0.16$	The final trial test scores were significantly higher for both practice groups (individual practice and individual practice & discussion group), when compared to the score of the control groups
Wetton et al., 2013, Australia	Full hazard perception training package	Immediate effect of the full training package on hazard perception response times using an independent samples t-test	↗	4.18 seconds reduction $t(93)=-7.02$ Cohen's $d=1.44$ $P<0.001$	The response times of the group that underwent the full hazard perception training package were significantly lower than the response times of the control group in the initial hazard perception test
		Effect of the full training package on hazard perception response times using an independent samples t-test (1 week after the first test)	↗	2.07 seconds reduction $t(66)=-2.27$ Cohen's $d=0.55$ $p=0.026$	The response times of the group that underwent the full hazard perception training package were significantly lower than the response times of the control group in the hazard perception test conducted one week after the initial one
		Decay of training effect on hazard perception test scores after one week	↘	2.42 points reduction Cohen's $d=0.73$ $p<0.001$	The hazard perception test scores were significantly lower, in the follow-up test compared to the initial test
	Expert commentary training	Difference in response times between the expert commentary condition and the control group (immediate test)	↗	3.37 seconds reduction $p<0.001$	The group that undertook training with expert commentary responded significantly faster to hazards when compared to the control group
		Decay of training effect on hazard perception test scores after one week	↘	2.21 points reduction Cohen's $d=0.78$ $p<0.001$	The hazard perception test scores were significantly lower, in the follow-up test compared to the initial test
	Hybrid commentary training	Difference in response times between the hybrid commentary condition and the control group (immediate test)	↗	3.15 seconds reduction $p<0.001$	The group that undertook training with hybrid commentary responded significantly faster to hazards when compared to the control group
		Decay of training effect on hazard perception test scores after one week	↘	2.63 points reduction Cohen's $d=0.85$ $p<0.001$	The hazard perception test scores were significantly lower, in the follow-up test compared to the initial test
	"What happens next?" training	Difference in response times between the "What happens next?" condition and the control group (immediate test)	↗	2.04 seconds reduction $p<0.001$	The group that undertook the training containing "What happens next?" exercises, responded significantly faster to hazards when compared to the control group
		Difference in response time between the "What happens next?" group and the expert commentary group (immediate test)	-	1.33 seconds increase $p=0.2$	The group that undertook the training containing "What happens next?" exercises, responded significantly slower to hazards when compared to the expert commentary group

		Difference in response time between the "What happens next?" group and the expert commentary group (1 week after the immediate test)	-	2.16 seconds increase p=0.001	The group that undertook the training containing "What happens next?" exercises, responded significantly slower to hazards when compared to the expert commentary group
		Decay of training effect on hazard perception test scores after one week	↘	2.44 points reduction Cohen's d=0.82 p<0.001	The hazard perception test scores were significantly lower, in the follow-up test compared to the initial test
Vidotto et al., 2011, Italy	Motorcycle simulator training	Relative difference between the mean proportion of avoided hazards from the first completed track to the last one	↗	0.16 hazards increase z=15.04 $p<10^{-6}$	The proportion of avoided hazards increased after training during the experiment's duration
		Relative difference between the proportion of avoided hazards between control groups that underwent pre-tests and those that did not	↗	Increase Z=4.63 p=0.00	The proportion of avoided hazards was significantly higher for the control groups that underwent pre-tests
		Relative difference between the proportion of avoided hazards between groups that underwent passive training and those that did not	↗	Increase z=2.29 p=0.022	The proportion of avoided hazards was significantly higher for the control groups that underwent passive training
Chapman et al., 2002, UK	Training intervention	Difference in mean fixation duration when a danger is present between the training and control group after training	↗	60 ms reduction F(1,86)=83.3 P<0.01	Trained drivers fixate less when a danger is present as a result of training and enhanced perception knowledge
		Difference in horizontal variance of fixation duration when a danger is present between the training and control group after training	↗	1.2 degrees of visual angle increase F(1,88)=7.2 P<0.05	Trained drivers had a significantly improved scanning behaviour in the presence of dangers
		Difference in horizontal variance of fixation duration when a danger is present between the training and control group during the follow-up session	↗	1.15 degrees of visual angle increase F(1,70)=9.5 P<0.01	Trained drivers had a significantly improved scanning behaviour in the presence of dangers

↗ = Significant positive effect on road safety, following hazard perception training (i.e. reduced accident rates and speed, and increased hazard perception ability).

↘ = Significant negative effect on road safety, following hazard perception training (i.e. increased accident rates and speed, and reduced hazard perception ability).

- = Differences in accident rates/vehicle speeds/hazard perception ability may have been found, but not statistically significant or not known (i.e. statistical analysis not carried out).

3.2 LITERATURE SEARCH

A systematic literature search was undertaken to identify papers that examined the effectiveness of education and/or training in improving road safety. The initial search was general and was then refined to focus on hazard perception education/training skills. This section describes the search terms, screening and eligibility selection processes that were used to identify relevant papers.

The following criteria were applied to a key word search in the database Scopus. See Table for full results:

- Search field: TITLE-ABS-KEY
- published: year > 2000
- Document Type: "Review" and "Article"
- Source Type "Journal"

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- Language: "English"

Table 5: EVT Scopus search terms and results

Database: Scopus **Date:** 7 Dec 2016

search no.	search terms / operators / combined queries	hits
#1	"Education" OR "Training"	891,777
#2	"road safety" OR "traffic safety" OR "driv*" OR "road" OR "transport" OR "traffic" OR "Pedestrian" OR "Rider"	1,381,363
#3	"collision*" OR "crash*" OR "accident*" OR "incident*" OR "casualt*" OR "fatalit*" OR "injur*"	1,023,558
#4	#1 and #2 and #3	5,274

Due to the large number of search results, the search was limited to papers originating in the following countries: Europe, Israel, North America, Australia, New Zealand and Japan and excluded those in the subject areas: health professions, nursing, biochemistry, genetics and molecular biology and chemical engineering. This reduced the number of papers to be screened to 3,327.

Specifically for the Hazard Perception Synopsis, an additional search was undertaken by another project partner for years 2001-2016 (_)

Table 2: Hazard Perception Scopus search terms and results

Database: Scopus **Date:** 28 Oct 2016

search no.	search terms / operators / combined queries	hits
#1	Hazard perception training AND (driver OR cyclist OR motorcyclist)	89

Screening

A screening process then took place where titles and if necessary abstracts were quickly assessed to eliminate papers that were not relevant (Table). During this process, the relevant Education and Voluntary Training subtopic(s) that the paper related to was identified.

Table 6: Title and abstract screening for relevance

Total number of studies to screen title/ abstract – 1st screening	3416
-De-duplication	53
-Exclusion: not relevant (not focusing on Education/training in relation to road safety)	3170
Remaining studies to obtain full texts	**193**

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Eligibility

The final stage was to identify the papers for which a full text could be obtained based on paper availability and which of these were eligible to be included in the SafetyCube Decision Support System (DSS) for the topic Hazard Perception (Table).

Table 7: Eligible papers

Total number of studies to screen full-text for subtopic ' Hazard Perception'	45
Full-text could be obtained	30
Exclude: not relevant	2
Exclude: not suitable for inclusion in DSS	9
Total number of eligible papers	19

Prioritisation

Once the full papers had been evaluated as eligible, they were assessed as to their suitability to be included in this synopsis based on the following prioritisation criteria:

- Prioritising Step A: Meta-analysis;
- Prioritising Step B: Studies assessing changes in number of accidents;
- Prioritising Step C: Studies assessing behaviour change with a control group;
- Prioritising Step D: Studies assessing behaviour change without a control group or with self-report;

For each prioritisation step, European studies and most recent papers were coded first.

Exclusion decisions

The full list of 19 eligible papers and the reasons why they were coded or not are shown in Table .

Table 8: Inclusion decisions

No.	Publication	Coded Y/N	Reason
1.	Castro, C., Ventsislavova, P., Peña-Suarez, E., Gugliotta, A., Garcia-Fernandez, P., Eisman, E., & Crundall, D. (2016). Proactive Listening to a Training Commentary improves hazard prediction. *Safety Science*, *82*. article. https://doi.org/10.1016/j.ssci.2015.09.018	Y	Prioritising Step C
2.	Yamani, Y., Samuel, S., Knodler, M. A., & Fisher, D. L. (2016). Evaluation of the effectiveness of a multi-skill program for training younger drivers on higher cognitive skills. *Applied Ergonomics*, *52*. article. https://doi.org/10.1016/j.apergo.2015.07.005	N	Prioritising step D
3.	Johnston, K. A., Borkenhagen, D., & Scialfa, C. T. (2015). Driving Skills Training for Older Adults: An Assessment of DriveSharp. *Canadian Journal on Aging*, *34*(4). article. https://doi.org/10.1017/S071498081500046X	N	Prioritising step D
4.	Meir, A., Oron-Gilad, T., & Parmet, Y. (2015). Can child-pedestrians' hazard perception skills be enhanced? *Accident Analysis and*	Y	Prioritising Step C

	Prevention, *83*, 101–110. article. https://doi.org/10.1016/j.aap.2015.07.006		
5.	Rosenbloom, T., Mandel, R., Rosner, Y., & Eldror, E. (2015). Hazard perception test for pedestrians. *Accident Analysis and Prevention*, *79*, 160–169. article. https://doi.org/10.1016/j.aap.2015.03.019	Y	Prioritising Step C
6.	Meir, A., Borowsky, A., & Oron-Gilad, T. (2014). Formation and Evaluation of Act and Anticipate Hazard Perception Training (AAHPT) Intervention for Young Novice Drivers. *Traffic Injury Prevention*, *15*(2). article. https://doi.org/10.1080/15389588.2013.802775	N	Similar to 4, but with less significant results
7.	Vlakveld, W. P. (2014). A comparative study of two desktop hazard perception tasks suitable for mass testing in which scores are not based on response latencies. *Transportation Research Part F: Traffic Psychology and Behaviour*, *22*. article. https://doi.org/10.1016/j.trf.2013.12.013	N	Prioritising step D
8.	Horswill, M. S., Taylor, K., Newnam, S., Wetton, M., & Hill, A. (2013). Even highly experienced drivers benefit from a brief hazard perception training intervention. *Accident Analysis and Prevention*, *52*. article. https://doi.org/10.1016/j.aap.2012.12.014	N	Prioritising Step D (self-report)
9.	Wetton, M. A., Hill, A., & Horswill, M. S. (2013). Are what happens next exercises and self-generated commentaries useful additions to hazard perception training for novice drivers? *Accident Analysis and Prevention*, *54*. article.	Y	Prioritising Step C
10.	DiStasi, L. L., Contreras, D., Cándido, A., Cañas, J. J., & Catena, A. (2011). Behavioral and eye-movement measures to track improvements in driving skills of vulnerable road users: First-time motorcycle riders. *Transportation Research Part F: Traffic Psychology and Behaviour*, *14*(1). article. https://doi.org/10.1016/j.trf.2010.09.003	Y	Prioritising Step B
11.	Vidotto, G., Bastianelli, A., Spoto, A., & Sergeys, F. (2011). Enhancing hazard avoidance in teen-novice riders. *Accident Analysis and Prevention*, *43*(1), 247–252. article. https://doi.org/10.1016/j.aap.2010.08.017	Y	Prioritising Step B
12.	Crundall, D., Andrews, B., Van Loon, E., & Chapman, P. (2010). Commentary training improves responsiveness to hazards in a driving simulator. *Accident Analysis and Prevention*, *42*(6), 2117–2124. article. https://doi.org/10.1016/j.aap.2010.07.001	Y	Prioritising Step B
13.	Horswill, M. S., Kemala, C. N., Wetton, M., Scialfa, C. T., & Pachana, N. A. (2010). Improving older drivers' hazard perception ability. *Psychology and Aging*, *25*(2). article. https://doi.org/10.1037/a0017306	N	Prioritising Step C (lower priority- non-significant effect of training – non-European)
14.	Y. B. Wang , W. Zhang & G. Salvendy. (2010). Effects of a simulation-based training intervention on novice drivers' hazard handling performance. *Traffic Injury Prevention, 11:1, 16-24*. article. http://dx.doi.org/10.1080/15389580903390631	Y	Prioritising Step C
15.	Isler, R. B. B., Starkey, N. J. J., & Williamson, A. R. R. (2009). Video-based road commentary training improves hazard perception of young drivers in a dual task. *Accident Analysis and Prevention*, *41*(3), 445–452. article. https://doi.org/10.1016/j.aap.2008.12.016	N	Prioritising Step C (lower priority – both training and control groups received training)
16.	Fisher, D. L. L., Pollatsek, A. P. P., & Pradhan, A. (2006). Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? *Injury Prevention*, *12*(SUPPL. 1). article. https://doi.org/10.1136/ip.2006.012021	Y	Prioritising Step C
17.	Chapman, P., Underwood, G., & Roberts, K. (2002). Visual search patterns in trained and untrained novice drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(2), 157–167. article. https://doi.org/10.1016/S1369-8478(02)00014-1	Y	Prioritising Step C

18.	Fisher, D. L., Laurie, N. E., Glaser, R., Connerney, K., Pollatsek, A., Duffy, S. A., & Brock, J. (2002). Use of a fixed-base driving simulator to evaluate the effects of experience and PC-based risk awareness training on drivers' decisions. *Human Factors*, *44*(2). article.	N	Prioritising step C (lower priority- similar to 16)
19.	Wang, Y. B., Zhang, W., & Salvendy, G. (2010). A comparative study of two hazard handling training methods for novice drivers. *Traffic Injury Prevention*, *11*(5). article. https://doi.org/10.1080/15389588.2010.489242	N	Prioritising step D

Using the prioritisation criteria, ten papers in total were identified as the most suitable for coding and therefore, inclusion in this synopsis.

3.3 REFERENCES

Coded studies

Castro, C., Ventsislavova, P., Peña-Suarez, E., Gugliotta, A., Garcia-Fernandez, P., Eisman, E., & Crundall, D. (2016). Proactive Listening to a Training Commentary improves hazard prediction. *Safety Science*, *82*. article. https://doi.org/10.1016/j.ssci.2015.09.018

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Wetton, M. A., Hill, A., & Horswill, M. S. (2013). Are what happens next exercises and self-generated commentaries useful additions to hazard perception training for novice drivers? *Accident Analysis and Prevention*, *54*. article.

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Chapman, P., Underwood, G., & Roberts, K. (2002). Visual search patterns in trained and untrained novice drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(2), 157–167. article. https://doi.org/10.1016/S1369-8478(02)00014-1

Additional references

Yamani, Y., Samuel, S., Knodler, M. A., & Fisher, D. L. (2016). Evaluation of the effectiveness of a multi-skill program for training younger drivers on higher cognitive skills. *Applied Ergonomics*, *52*. article. https://doi.org/10.1016/j.apergo.2015.07.005

Johnston, K. A., Borkenhagen, D., & Scialfa, C. T. (2015). Driving Skills Training for Older Adults: An Assessment of DriveSharp. *Canadian Journal on Aging*, *34*(4). article. https://doi.org/10.1017/S071498081500046X

Meir, A., Borowsky, A., & Oron-Gilad, T. (2014). Formation and Evaluation of Act and Anticipate Hazard Perception Training (AAHPT) Intervention for Young Novice Drivers. *Traffic Injury Prevention*, *15*(2). article. https://doi.org/10.1080/15389588.2013.802775

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Wang, Y. B., Zhang, W., & Salvendy, G. (2010a). A comparative study of two hazard handling training methods for novice drivers. *Traffic Injury Prevention*, *11*(5). article. https://doi.org/10.1080/15389588.2010.489242