SWOV Fact sheet

Hazard perception

Summary
Hazard perception is an essential part of the driving task, but is poorly developed in novice drivers. From 2009, testing hazard perception will therefore be incorporated in the theory examination which must be passed to acquire the driver's license for passenger cars. Hazard perception involves more than just seeing a hazard (or danger). It also involves estimating the extent of a hazard, and knowing what to do to avert it. What is important here is not only traffic insight but also self-assessment. There are different methods for testing hazard perception of drivers. And because different skills play a role in hazard perception, a hazard perception test should also use several different methods. Studies have shown that learner drivers who have had a hazard perception training are better at hazard perception tests. In countries where hazard perception is already part of the theory examination, novice drivers with the lowest possible scores for this part of the examination were found to have a higher crash rate than novice drivers with high scores.

What is hazard perception?
There are many definitions of hazard perception, but not one of them is accepted by all experts. Generally speaking, hazard perception involves the process of noticing in time, recognizing and predicting potentially hazardous situations, and making the correct choice of actions to avert the hazard. We speak of potentially hazardous situations if there is a high risk of a crash occurring if behaviour is not changed. Hazard perception is seen as an essential part of the driving task, and there are clear indications that it is poorly developed among novice drivers (OECD, 2006). From 2009, the Netherlands will therefore incorporate testing hazard perception in the theory examination which must be passed to acquire the driver's license for passenger cars. This will lead to a lot more attention being paid to this subject during driver training and, hopefully, to a decrease in the high crash rates of novice drivers.

This fact sheet first of all summarizes what is known about the role of a lack of hazard perception in the high crash rates of young novice drivers. Then the theory of hazard perception will be gone into more deeply, and methods for measuring and training hazard perception will be discussed.

Which role does lack of hazard perception play in crashes occurring?
Just after having got their driving licence, novice drivers have high crash rates. After this, the longer they drive the lower their crash rate becomes. This decrease happens quickly in the beginning and then gets more gradual (see Vlakveld, 2005, for an overview). By gaining driving experience drivers become more skilful, especially regarding their 'higher order skills' such as traffic insight and hazard perception. It is also presumed that the longer novice drivers have gained experience, the better they know how to tune traffic tasks to their capacity (Kuiken & Twisk, 2001). We call this 'calibration' or improvement of state awareness. A lack of basic skills such as vehicle control and applying traffic rules, also explains the high crash rates of novice drivers. Because the basic skills have not yet been sufficiently automated, they require a lot of attention while being carried out, leaving less attention for higher order skills.

Many studies show that hazard perception, measured by special tests, gets better with driving experience (Soliday, 1974; McKenna & Crick, 1997; Fisher et al., 2002; Whelan et al., 2004). There are however some exceptions (Sagberg & Bjørnskau, 2006, among others). This difference in findings is perhaps due to the way in which hazard perception is measured. Sagberg & Bjørnskau only measured visible hazards and not the 'hidden risks'. It is possible that, from the very beginning, novices are quite good at recognizing explicit hazards, but that it will take many years of driving experience to recognize hidden risks.

Which skills play a role in hazard perception?
Hazard perception is often only described as recognizing looming hazard. According to Groeger (2000) however, four different skills play their part in hazard perception:
1. detection of the looming hazard;
2. threat appraisal;
3. selection of actions to avert the hazard;
4. implementation of chosen actions.

The first skill concerns observing, paying attention to what is relevant, analysing the situation, diagnosing the situation, and predicting how traffic situations will develop. Here an important role is played by active searching and being able to 'read' and predict the traffic situation. Suppose that a driver is going down the road and sees, in the opposite direction, a bus halting at a bus stop. He simultaneously sees a man starting to run on the pavement on the other side of the road. The driver must then be able to realize that the man could possibly cross the road just in front of him to catch the bus without looking out. Besides these matters that are visible and have to be interpreted, hazard perception also involves 'seeing' those matters that are actually invisible, i.e. the hidden risks. An example of this is looking obliquely along a lorry because, from this direction, something can happen that you only can see very late because the lorry is blocking your view.
The second skill – threat appraisal – is described too limited by Groeger, and should include risk acceptance and estimation of one's own capabilities.
An example of the third skill is if it is, considering the situation, better to brake, just slow down, change course, or give a signal, etc.
The fourth skill concerns the actual carrying out of the vehicle control actions. According to Groeger, these four skills influence each other (Grayson et al., 2003). His model is shown in *Figure 1*. The arrows indicate the influence of the one skill on the other. This influencing is mutual. What one is capable of ultimately influences what one sees, but what one sees influences what one is capable of.

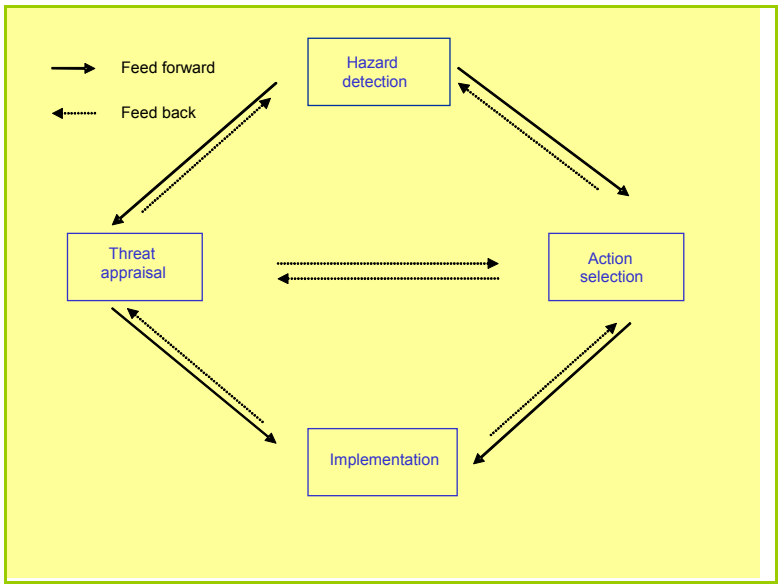

Figure 1. *Hazard perception model of Groeger (from Grayson et al., 2003).*

Some people are of the opinion that hazard perception is a too limited concept and prefer to talk about 'situation awareness'. This term is often used. What is meant here is that a driver always knows what is going on around him/her. Endsley (1995) defines situation awareness as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". The language used in this definition is rather formal, but it means practically the same as the description of hazard perception given at the beginning of this section. If hazard perception only means the first skill in Groeger's model - seeing the looming hazard - then the definition of situation awareness goes further. However, when hazard perception refers to continuously searching for potential hazards, and to all four of the skills in

Groeger's model, then there is really no difference between situation awareness and hazard perception.

How do you measure hazard perception?
Many methods have been developed to measure driver hazard perception. During the initial period of this field of research, i.e. the 1970s, hazard perception was 'measured' by observing drivers, especially where they looked, and by getting drivers to think out loud while they were actually driving. Later on more use was made of driving simulators, video fragments, and photos. Nearly always researchers only tried to measure the first skill (seeing what is possibly hazardous) and, very rarely, a single aspect of the second skill (threat appraisal) was implicitly included. There are actually four ways of measuring traffic insight and hazard perception:

– Testing *Reaction Time.* This can be done, for example, with video fragments of traffic situations, shot from the driver's eye position. Candidates must press a button if they think it's getting hazardous. The time it takes to press after the first indications of hazard, is measured.
– Testing *Searching Strategies*. This is done, for example, by measuring eye movements (does one deliberately focus one's visual attention on hazards?). This can be done by eye trackers in instrumented vehicles or in driving simulators. Seeing is, however, not the same as looking. After all, one can look at something without seeing it. A simpler way of testing is by showing photographs. On the photos, candidates must point to what they see as a hazard and sometimes they have to say why they think it is hazardous.
– Testing *Situation Awareness*. The tests used for this resemble reaction time tests, but here the situations do not have to be hazardous. Situation awareness is measured by, for example, showing video fragments from the driver's eye position. Then the picture disappears and the candidate has to describe the traffic situation he/she has just seen. Those with good situation awareness not only describe accurately what they have seen, but also start by mentioning the points that are really important for road safety.
– Testing *Behaviour Choice*. Here is tested if the driver knows what must be done to avert the hazard. For example, a video fragment (from the driver's eye position) can be shown. The picture is then stopped at certain moments and candidates have to indicate what they would do, e.g. brake.

Because various skills play a role in hazard perception, a hazard perception test should include several sorts of tests. Until now this usually is not the case. In the hazard perception test of the British theory exam (since 2002) only reaction time is tested.

Can hazard perception be trained?
Training attempts to speed up the process in which hazard perception is taught in practice. Two important criteria for judging the quality of training are *transfer* and *retention*. Transfer is good if one can apply in practice that which one has learned during the lessons. We refer to 'near transfer' if one can apply the things learned to situations that closely resemble the situations during the lessons. We refer to 'far transfer' if one can apply the things learned to situations that look clearly different from the situations during the lessons, but which are similar as far as the underlying principle is concerned. The retention is bad if the 'trick' learned is quickly forgotten; if what one has learned sinks in, the retention is good.

Various studies have shown that it is possible to train hazard perception. In the training which was developed in Great Britain by McKenna & Crick (1997), novice drivers received lessons in hazard perception for about four hours during a period of three weeks. These lessons consisted of video films in which the participants were encouraged to predict what could happen. The trainers made comments and gave instructions on the answers given. After this training, the participants scored significantly better in the hazard perception test – a reaction test – than before the training. After the training the novice drivers had an almost as good score as drivers with ten years experience.

In the United States also a hazard perception training has been developed of which the effects have been studied extensively (Fisher et al., 2006). Before the training a hazard perception test was taken. In this pre-test the participants were confronted with a series of successive still photos of traffic situations from the driver's eye position. They then had to click the mouse on the spots that they especially wanted to keep an eye on. A traffic situation is, for example, a car turning left. Contrary to the test of McKenna & Crick, the one of Fisher et al. especially concerns hidden risks. After the pre-test, in the first training phase, the participants were confronted with a view from above the traffic situations, and they were asked to imagine what could happen. By first having to think and imagine

information is processed better and it is more likely that the knowledge obtained will be remembered. By presenting pictures 'from above' and not from the driver's eye position, the 'far transfer' is stimulated. In the second phase of the training the candidates were given an explanation about the situations which they had just looked at 'from above'. Also here views from above were used, but this time with sketched sight lines and text about what could not be seen directly and what could have happened. The third training phase consists of tasks that look like the ones in the pre-test. On stationary pictures from the driver's eye position, the candidates had to click on the spots where they especially would look for information about looming hazard. The traffic situations were the same as those in the views from above in the first two training phases. None of the situations was exactly the same as those in the pre-test. The last part of the study was a post-test, which was the same as the pre-test. The participants of the training not only did this post-test significantly better, but also their looking technique on the road had improved.

Can you train yourself in hazard perception?
Training programmes have also been developed for a pc. Novice drivers can play CD-ROMs or DVDs on their own pc. In the United States in the late 1990s, the AAA Foundation for Traffic Safety introduced the 'Driver-Zed' programme and in Australia the Môn ash University Accident Research Centre (MUARC) developed the 'Drive Smart' application. Drive Smart was introduced in 2000.

In Driver-Zed the participants follow the training modules *scan, spot, act,* and *drive* for three different road types. In the *scan* module they are shown video fragments. After each fragment they get questions (Did you see the pedestrian? Did you see the car approaching you in the mirror? Did you see how fast you were driving? etc.) and an explanation is given. In the *spot* module the participant has to click in time where a hazard is looming in the video fragment. After this an explanation is also given. In the *act* module the participant is shown a video fragment of a looming hazard. Just before the hazard has completely developed, the fragment stops. The participant is asked what he/she would do in such a situation: brake, slow down, change direction, and such. After that the participant is shown the rest of the film, based on his/her answer. It is also explained why the answer was correct or not. The *drive* module takes one step further. The participant now also has to decide on the moment at which he/she would take action. Driver-Zed has been assessed at the behaviour level in a driving simulator (Fisher et al., 2002). Two weeks after having followed Driver-Zed, the novice drivers drove significantly more carefully in a driving simulator and they saw looming, potential hazards earlier than untrained novice drivers. The scenarios in the driving simulator were different from the scenarios in Driver-Zed. The researchers concluded that transfer had taken place and that a kind of general risk awareness had developed.

Drive Smart works in about the same way as Driver-Zed. The modules in Drive Smart are *Scan, Keep Ahead, Play Safe* (SKAPS). Besides the first two qualities in Groeger's model (hazard detection and threat appraisal) Drive Smart attempts to also explicitly pay attention to determining priorities and state awareness (calibration). In contrast with Driver-Zed, Drive Smart is not an optional matter. The Australian state of Victoria has a graduated driving licensing system. A hazard perception test is part of this system. Drive Smart is meant to prepare for this hazard perception test. The effect of Drive Smart has been measured with a driving simulator (Regan et al., 2000). In the case of looming hazard, the Drive Smart group did better than the control group (for example, they braked sooner), but the differences were not very large. Directly after the Drive Smart course, the effect was significant at the 10% level in half of the near transfer situations and half of the far transfers situations. In the measurement held four weeks later, this was true in three-eights of the near transfer situations and half of the far transfer situations. In not one case did the control group score better than the Drive Smart group.

Does the crash rate of novice drivers decrease with a hazard perception test in the driving test?
Since the 1990s hazard perception tests have been part of the driving exam in most of the states of Australia and since 2002 in Great Britain. The effect on crash rates in Great Britain is still being studied. In the state of Victoria, Australia, a hazard perception test has been part of the driving exam since the early 1990s. Based on the fatal crash data and the scores in the hazard perception tests, Cogdon (1999) found that licence holders with a low score in the hazard perception test had a higher risk of being involved in a fatal crash than licence holders with a high score. Although the effect was perhaps statistically significant, it was not very large. Furthermore, Congdon's study showed that the hazard perception test that was then used in Victoria had a low reliability. In England, a large number

of novice drivers were followed for three years after having passed the driving test. Part of the group were novices from before the introduction of the hazard perception test, and part were from after the introduction (Wells et al., 2008). The results show that incorporating hazard perception in the theory examination resulted in at least a 3% decrease of the crash rate in the first year after having passed the driving examination.

What are the developments in the Netherlands?
In response to a proposal of The Dutch Driving Test Organization (CBR, 2005) the Minister of Transport decided to adapt both the theory and practical driving tests. In this new driving test, matters such as traffic insight and hazard perception will be tested more than in the current one. The intention is to introduce this new driving test in 2008.

In its 2007-2010 research programme, SWOV will study how to measure and train hazard perception. SWOV is particularly interested in the role that the new Advancing Sustainable Safety principle 'state awareness' (the same as calibration) plays in hazard perception. CBR will use the results of this study to renew the driving test.

Conclusion
Hazard perception involves more than seeing hazard. It also involves estimating the extent of the hazard (threat appraisal) and knowing what to do to avert it. For threat appraisal, both traffic insight and self-assessment are important.
Different methods exist to test hazard perception of drivers. And because different skills play a role in hazard perception, a hazard perception test should also use several different methods. Studies have shown that learner drivers are better at hazard perception tests after having followed hazard perception training. In England, incorporating a hazard perception test in the theory examination reduced the crash rate in the first year after passing the driving test with at least 3%.

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