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SWOV Fact sheet

Hazard perception and how to test it

Summary

Hazard perception is an essential part of the driving task. There are clear indications that insufficient skills in perceiving hazards play an important role in the occurrence of crashes, especially those involving novice drivers. Proper hazard perception not only consists of scanning and perceiving a hazard in time, but also correctly appraising the seriousness of it and knowing what to do to avert the danger. This not only demands situation awareness, but also self-assessment. There are various methods for measuring the hazard perception skills of drivers. Not all these measuring methods are equally suitable to be used as examinations in the driving test. As it is not possible to predict the hazards that may occur during a practical driving test, hazard perception is best measured during the theory test, in line with the validity and reliability criteria that have to be met by the tests. Ideally, films should be used that are made from the driver's perspective.

Background and contents

Following Australia and Great Britain, the Netherlands made hazard perception a regular component of the theoretical part of the driving test for passenger cars in 2009. This was prompted by the fact that insufficient skills to perceive hazards and the failure to respond to them in time significantly contribute to the occurrence of crashes. This applies to young, novice drivers in particular. This fact sheet will discuss in detail the theory concerning hazard perception. What is hazard perception? What is the importance of hazard perception for road safety? And how can it be measured and tested? SWOV Fact sheet *Training hazard perception* (to be published) discusses the possibilities of how to learn to perceive hazards. Detecting hazards, as well as reacting to them is important in hazard perception. Until now the emphasis of the international research into hazard perception has been on detecting dangers. This is the reason why this fact sheet also contains more information about detection of hazards than it does about reaction to hazards.

What is hazard perception?

Hazard perception consists of the following processes:

1. *detecting* and *perceiving* potentially hazardous road and traffic situations;
2. *predicting* how these potentially hazardous situations may turn into situations when crashes can no longer be averted;
3. *assessing/appraising* the risk of the predicted hazards;
4. *selecting* and *implementing* actions that increase the safety margins to such an extent that a crash can still be averted in case the potential hazards should occur in actual fact. (Vlakveld, 2011).

In summary, hazard perception could be defined as the ability to read the road and anticipate forthcoming events (Horswill & McKenna, 2004). Hazard perception does not imply the occurrence of sudden hazards and the reflex of drivers to avert a crash at the very last moment. What it does imply is the perception in time of often partly hidden or completely hidden situations that *might become* hazardous. In order to distinguish them from imminent hazards, they are defined as latent or potential hazards. Hazard perception is therefore not a question of perceiving a child crossing the road in front of the car, but perceiving parked cars in an area with many children (e.g. noticing a scooter on the pavement or a climbing frame). Even before perceiving a child, a driver should anticipate that a child might cross the road from between those parked cars. A driver who has perceived and acknowledged this will decelerate and watch the spaces between the parked cars so as to be able to react in time, should a child cross the road.

Several types of hazard perception can be distinguished:

1. *Adjusting the visual strategy to the driving environment.*
Do drivers adjust their visual strategy (looking left and right more frequently) when driving into an urban area, for example? Crundall and Underwood (1998) discovered that novice drivers did not adjust their visual strategy to the environment as often as experienced drivers;
2. *Keeping an eye on other road users that might behave hazardously considering the circumstances.*
An example is a pedestrian walking on a pavement while a bus stops at a bus stop on the other side of the road. A driver perceiving this situation should be able to realize that the pedestrian might suddenly cross the road to catch the bus. Research has indicated that novice drivers less often keep an eye on other road users who may behave hazardously as compared to experienced drivers (Vlakveld, 2011 and others);
3. *Spotting hidden dangers.*
Do drivers look into directions with no noticeable visual features, from which traffic can nevertheless suddenly appear? It is a matter of looking into the direction from which you may first spot a potential road user who comes from behind an object. The visibility of this potential road user will be blocked by hedges, parked cars, houses or large vehicles, such as trucks, et cetera. Resulting crashes are defined as hidden crashes. The previously mentioned child that is not visible, but that might be present and could cross the road from between parked cars, is also an illustration of a hidden danger. Drivers, irrespective of the level of experience, find it more difficult to perceive hidden dangers than perceiving other road users who might behave hazardously. Yet, novice drivers in particular have great difficulties perceiving hidden dangers (Vlakveld, 2011);
4. *Appraising the entire traffic situation.*
This implies that one is capable of detecting all potential hazards in a traffic situation and that, subsequently, one focuses on the most important potential hazard in particular. Crundall et al. (2012) call it dividing and focusing attention. This skill is in certain respects a matter of prioritization of potential hazards. This aspect of hazard perception also indicated that experienced drivers are more skilled than novice drivers (Crundall, 2009);
5. *Being able to scan indications of approaching hazards.*
The simplest case is the perception of warning signs. An illustration of a more complex situation is the perception that the behaviour of road users in the distance has consequences for road users nearby. For instance, when you perceive brake lights lighting up in the distance, the car directly in front of you will also brake not long after. Research into being able to scan indications showed that experienced drivers are also more skilled in this respect compared to novice drivers (Garay-Vega & Fisher, 2005);
6. *Detecting and appraising signals of loss of control.*
This concerns environmental signals (e.g. a sharp bend approaching or signs indicating a slippery road surface), but also internal signals (e.g. the feeling of getting tired or failing to concentrate on the traffic situation (Fuller, 2007).

What is the correlation between age, experience and hazard perception?

Dozens of studies, including those already referred to in the previous section, indicate that young novice drivers are less capable of hazard perception than experienced drivers (for an overview, see: Vlakveld, 2011). However, a few studies did not find any difference in hazard perception between experienced and inexperienced drivers (e.g. Sagberg & Bjørnskau, 2006). This may be due in some cases to test situations being either too complex or too simple. A major issue is whether young novice drivers are less capable of perceiving hazards because they do not spot the dangers, or because they do see the dangers, but subsequently underestimate the risks, while at the same time overestimating their own skills. It appears that not spotting the hazards is the major reason. For instance, Wallis et al. (2007) discovered that novice drivers were slower in perceiving hazards and also failed to recognize potential hazards more often, whereas they did not assess the dangers differently from the way experienced drivers did. Nevertheless, it cannot altogether be ruled out that spotting hazards is different for young novice drivers, compared to older, more experienced drivers. Kinnear et al. (2013) in fact found that experienced drivers, when confronted with increasingly more hazardous traffic situations, showed more emotions than young novice drivers. This study examined whether or not emotions were experienced by measuring changes in skin conductance response (SCR).

Other than examining differences in hazard perception between young, novice drivers and older, more experienced drivers, much research has been carried out into differences in hazard perception

between drivers who had been involved in a crash and drivers who had not. Many international studies indicated that crash-free drivers are better capable of perceiving hazards than drivers who were involved in a crash (for an overview, see: Vlakveld, 2011). Studies in the Netherlands yielded the same results (Vlakveld, 2008).

There are no differences in hazard perception between men and women. In recent years, researchers have become increasingly more interested in studying hazard perception among older drivers. Research by Horswill et al. (2008) indicated that drivers of 65 and over reacted to hazards substantially more slowly than middle-aged drivers. However, these differences in reaction time do not relate to being less well capable of predicting how traffic situations will evolve, but are due to diminishing eyesight. Diminished contrast sensitivity of the eyes and reduced skills in processing visual information are mainly responsible.

How many crashes are caused by lack of hazard perception skills?

Based on an analysis of 2 000 crashes involving young, novice drivers in the US, McKnight & McKnight (2003) concluded that not perceiving and recognizing hazards in time had played a role in circa 44% of those crashes. In the remaining crashes, the young novice drivers were mainly distracted (23%) or they drove too fast under the circumstances (21%). More recent research in the US also showed that a lack of hazard perception often plays a role in the occurrence of crashes (Curry et al., 2011).

In Australia, as early as the 1990s, a hazard perception test was included in the theory examination that was part of the driving test. The norm for this examination was low, so that practically everyone passed this part of the test. Therefore, the hazard perception test hardly contributed to road safety, although it could be studied whether the test scores had predictive value. It showed from research that drivers who had a low score on hazard perception were significantly more often involved in crashes after having passed the driving test than drivers with a high score on hazard perception (Congdon, 1999).

How can hazard perception be measured during the driving test?

Because hazard perception is a skill, it should preferably be tested during the practical examination of the driving test. Yet, examining hazard perception during the practical driving test meets with many objections. New Zealand is the only country that tried this (NZ Transport Agency, 2012). To be able to measure hazard perception during the practical driving test, the ride had to be standardized to a high degree, to ensure that candidates were confronted with more or less the same situations. On eight locations during the regular test ride, the candidate was asked to speak out loud and indicate why they carried out a particular manoeuvre. Based on these reactions, the examiner determined the candidate's hazard perception skills. This method is probably not very reliable, because the examiner has to give a personal interpretation and because the traffic at those locations during the test ride will be different for each candidate. Moreover, there is a danger that candidates train the regular route, invalidating the practical examination unintentionally. Lee et al. (2008) tried to increase the reliability of the examination of hazard perception in practice by using a traffic test area and instrumented vehicles. This method worked well, but is far too costly for the driving test.

An alternative is a standardized hazard perception ride in a driving simulator. Candidates drive in an environment with potential hazards being present. For instance, it can be measured whether candidates look into directions where nothing yet shows, but from where traffic may occur (hidden dangers). For this purpose, a so-called eye tracker is used to register eye movements (e.g. Pradhan et al., 2005). Although this is a perfect way to test hazard perception, simulators and eye trackers are for as yet too costly and too complex to be used during the driving test.

As measuring during the practical test is not reliable and valid, and measuring by means of an instrumented vehicle on a traffic testing area or a driving simulator is too costly, films are often the medium selected. These films have been shot from the perspective of the driver. With the most commonly used method, candidates watch films in which at least one latent hazard is included. This latent hazard evolves into imminent danger in which it is practically impossible to prevent a crash. The candidate should press a button the moment he perceives the first signs of the initially latent hazard. It is measured how long it takes before the candidate presses the button after the first signs of danger have become visible. Those who press the button when a hazard begins to evolve are good at hazard perception, and those only pressing the button the moment a crash can hardly be prevented anymore

are bad at hazard perception. This method has been used in the United Kingdom since 2002 to measure hazard perception during the theoretical examination of the driving test. Various studies have indicated that novice drivers score significantly lower than experienced drivers with this testing method, but other studies have not found a difference between experienced and novice drivers (for an overview, see Vlakveld, 2011).

Other than the disputable validity, this method comes with another disadvantage. As it is a matter of reaction time to hazards that become increasingly more urgent, bad candidates learn that they reacted too late and that they should have pressed the button earlier. It is not in itself a bad thing that people learn from a test, but the disadvantage is that the whole point of the films quickly become general knowledge. New candidates will be able to make use of it and score higher on the test without being necessarily better at hazard perception. Another disadvantage is that hazards that do not evolve into an imminent danger, but remain hidden, cannot be used. In collaboration with the Dutch Driving Test Organization CBR, SWOV has designed a hazard perception test that uses animated films. For this purpose, a response method is used that is not based on reaction times. As a result, this test does not suffer from the disadvantages of the hazard perception test used in the United Kingdom. The first results are promising, but the test needs to be further developed before it can be used in actual practice.

Can hazard perception also be measured by means of photographs?

The most basic method of measuring hazard perception makes use of photos. In 2009, a hazard perception test making use of photos became part of the theory examination of the driving test for passenger cars. This test was developed by SWOV in collaboration with CBR. The test consists of 25 photos, each shown for 8 seconds. Part of the dashboard is shown at the bottom of each photo indicating driving speed. Imminent danger is visible in a number of these photos. This often concerns a road user who may be involved in a crash if no action is taken. Another series of photos include a potential hazard (visible, as well as hidden) and yet another series show neither an imminent nor latent hazard. The correct response to the photos with an imminent danger is to brake. The correct response to the photos with a potential danger is to decelerate and no reaction should be given to photos not showing imminent or potential danger. The response has to be given within the time frame when the photo is shown. Initial research of this testing method indicates that experienced drivers yield significantly more correct responses than driving school learners at the end of their training. Furthermore it showed that novice drivers with one and a half years of driving experience who had reported a crash scored significantly lower in the test than novice drivers with one and a half years of driving experience who had not reported a crash (Vlakveld, 2008). In the US a similar hazard perception test was developed, also making use of photographs (Scialfa et al., 2012). However, in the US, as well as in the Netherlands, research indicated that photo tests may indeed distinguish between experienced and novice drivers, but that the distinguishing capacity of a photo test is restricted and that a film test is more efficient (Scialfa et al., 2013; Vlakveld, 2011). A major reason is that it is hard to assess the speed of the road users in the photos.

Conclusion

Hazard perception consists of more than merely perceiving and recognizing hazards. It also concerns the appraisal of the seriousness of the hazard and knowing what to do to avert the danger. There are clear indications that lack of hazard perception plays a major role in the occurrence of crashes, especially in the case of novice drivers. Although hazard perception includes various processes, research into hazard perception has mainly focussed on hazard detection. Various methods have been developed to measure hazard perception. Not all methods are equally suitable to be used as tests in the theoretical part of the driving test. At present, hazard perception of candidates taking the driving examination can best be measured using film tests. In the Netherlands research has been carried out into a suitable method for measuring hazard detection with moving images (Vlakveld, 2014).

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