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SWOV Fact sheet

Visual impairments and their effect on road safety

Summary

Visual perception is an important source of information when driving a car. Visual impairments of drivers will therefore have an effect on performing the driving task. However, the effects on the crash rate are limited. The reason is, among other things, that people with visual impairments often compensate for this disability, for example by avoiding crowded rush hours and driving in the dark, by adjusting their driving speed and by applying other visual strategies. Many visual impairments, like cataract and reduced acuity of vision, are more frequent among the elderly. However, other visual impairments, e.g. colour-blindness, are not age-related. Most of the negative results of visual impairments can be remedied by devices or treatments; this cannot be done for all impairments, for example colour-blindness. Because many visual impairments generally develop very slowly over time, people are often not aware of it, or not until very late.

Background and contents

Driving a car is a task during which the driver primarily receives information visually. Visual impairment, also called impaired vision, will therefore have an effect on performing the driving task. Research has shown that the crash rate of people with a visual impairment is a factor of 1.09 higher than that of unimpaired drivers (Vaa, 2003). This increased risk is minor compared to that of other impairments, such as cardio-vascular disorders (1.23) and the use of medication or drugs (1.58). In 2009, 5.3% of the Dutch population (12 years and older) suffered from serious visual disorders (Statistics Netherlands CBS, 2010)¹. The visual system will slowly deteriorate as one gets older. As this deterioration develops gradually, people are often not aware of it. However, a visual impairment does not necessarily imply that a driver can no longer safely participate in traffic.

This fact sheet will, among other things, discuss visual impairments in relation to road safety. Vision is defined as the ability to observe visual stimuli. This fact sheet deals with reduced visual acuity, limited field of vision or Useful Field of View (UFOV), limited contrast sensitivity, glare sensitivity, and night- and colour-blindness. Higher, cognitive processes based on visual signals are discussed in other SWOV Fact sheets, such as [Hazard perception in traffic](#), [Attention problems behind the wheel](#) and [Recognizable road design](#).

Which are the legal requirements for fitness to drive with respect to visual perception?

In the Netherlands, the requirements for drivers of motor vehicles in the categories A, B en B+E have been laid down in the *Rules on fitness to drive 2000* (Dutch Driving Test Organization CBR, 2009).

With respect to visual perception, rules specify the following:

- The visual acuity (vision) of both eyes together, whether or not corrected, should be at least 0.5. In case of the driver having the use of only one eye, the vision of this eye should be at least 0.6.
- Spectacles are permitted with strengths up to +10 and -15 dioptres. Contact lenses are permitted in all strengths, as are intraocular lenses.
- The horizontal field of vision with one or both eyes should be at least 140°.
- The ability to adapt to changes in light intensity should be relatively unimpaired.
- Deficiencies, such as impeding double vision or hindering ocular blurring, are not permitted.
- Progressive ocular disorders (cataract, glaucoma with limited field of vision, degenerative and vascular retina disorders and progressive disorders of the ocular nerve) as well as insufficiently corrected aphakia (eye without lens) result in a temporary ten-year fit-to-drive declaration if the driver is deemed fit to drive by an ophthalmologist's report and, if necessary, a test drive.
- Sudden loss of vision in one healthy eye results in temporary disqualification from driving. After a three-month period of adaptation the driver can be declared fit to drive again.

¹ Serious visual impairments are defined in the CBS statistics as self-reported difficulty reading small print in newspapers or recognizing faces from a four-meter distance.

Stricter requirements apply for drivers of lorries and buses with respect to visual acuity, loss of an ocular function and having ocular disorders. European legislation (Directive 2009/112/EG) is less strict than Dutch legislation.

How do visual impairments affect road safety?

A number of visual functional disorders have been shown to influence driving behaviour; the subparagraphs below will discuss this in more detail. However, for a number of reasons, visual impairments appear not to affect the crash rate very often. Firstly, extreme cases are fairly rare in traffic situations: people with serious visual impairments will less frequently participate in traffic as drivers. Secondly, people with limited visual ability will often adapt their driving behaviour, by avoiding certain situations, such as driving in the dark or during peak hours, for instance. This is an example of adaptation at the so-called strategic level, but driving behaviour can also be adapted at the tactical level (the driving speed, for instance) or at the operational level (by means of different visual strategies, for example). Thirdly, people rarely suffer from only one of these functional disorders. The one-to-one relationship between the disorder and the crash rate is therefore difficult to prove (Van Rijn, 2005).

Limited visual acuity

Visual acuity is a standard for the ability to distinguish details. Short-sightedness is particularly important for road safety. Short-sighted people do not distinguish details very well from a large distance. The EU project GLARE has studied how often limited visual acuity occurs among drivers in six EU countries (Van den Berg & Van Rijn, 2005). Prevalence of poor visual acuity is higher among elderly drivers than among young and middle aged drivers. Among drivers aged 75 years and older, 1.5% drive with a visual acuity of less than 0.5. Among younger drivers, visual acuity of less than 0.5 does not occur. People with a vision of 0.5-0.8 have limited visual acuity, but they are still allowed to drive. This group is in fact frequently found behind the wheel: less than 1% of drivers younger than 55 years of age, 1.7% of drivers between 55 and 64 years of age, 4.9% of drivers between 65 and 74 years of age and 13% of drivers of 75 and older. Whether visual acuity is a proper indicator of fitness to drive or crash involvement is uncertain, especially because the studies do not show consistent results (Fjerdingen et al., 2000; Lambale, Summala & Hyvärinen, 2002). Dynamic visual acuity is related to visual acuity. This is the ability to see the object distinctly when it moves in relation to the eye. Dynamic visual acuity correlates with the static visual acuity, but this correlation diminishes when the movement is faster. With older people in particular, dynamic visual acuity is less good than static visual acuity with faster movements (Dewar & Olson, 2007).

Since 2009, people with impaired visual acuity are also allowed to drive a passenger car in the Netherlands, provided that their eyes are corrected by means of a bioptic telescope. The conditions are that these people 1) are tested by an ophthalmologist, 2) have followed a training and passed a test, both CBR-approved, in driving with a bioptic telescope, and 3) drive only during daytime in a car with automatic gears (Brouwer, Keunen & Kooijman, 2006; CBR, 2009).

Reduced field of vision

The field of vision is someone's field of vision during one fixation. The fields of vision of each of the two eyes partly overlaps. The size of the field of vision determines, among other things, the extent to which signals in the periphery of the field of vision can be detected. According to Racette & Casson (2005), literature has indicated that drivers with a highly limited field of vision (<135°) are less fit to drive. The literature is less unequivocal with respect to milder impairments of the field of vision (between 135° and 186°). According to the researchers, this is partly due to differences in measuring methods and differences between patients. Impairments of the field of vision affect, for instance, adjusting speed while changing lanes, keeping position in one's lane and correctly following the bend in the road (Bowers et al., 2005). As no easily applicable method exists to measure this function on a large scale, drivers are presently not screened for problems concerning the field of vision in the Netherlands.

Limited Useful Field Of View

The Useful Field of View (UFOV) is the size of the field of vision within which stimuli can draw drivers' attention; the UFOV is never larger than the field of vision. In contrast to the visual field, the UFOV cannot be considered other than in combination with attentional processes (Vaa, 2003). Limited UFOV specifically corresponds with slow information processing and with difficulties of dividing attention between various issues. This leads to difficulties with certain manoeuvres, such as merging, exiting,

and rounding bends. Limited UFOV is also associated with a reduction of selective attention, that is to say, giving priority to important information and ignoring less important information. Difficulties with selective attention are associated with general reduction of fitness to drive and not specifically with certain manoeuvres (Bowers et al., 2005). Ball et al. (1993) also found a correlation with crash involvement: in the five years prior to the study the group of people with limited UFOV had been involved in one or more crashes six times more often than the group of people without UFOV difficulties. An inventory carried out in a number of European countries (Van den Berg & Van Rijn, 2005) showed that young people hardly ever suffer from limited UFOV, but that these difficulties increase with age. Among the group of 75 and over, 41% suffer from limited UFOV.

Reduced contrast sensitivity

Contrast sensitivity is the ability to distinguish between an object and the background, often measured by means of a grey letter against a white background (the Pelli-Robson chart). When getting older, people's contrast sensitivity diminishes. Van den Berg & Van Rijn (2005) detected among drivers from six EU countries that 0.5% of the 20- to 30-year olds suffer from reduced contrast sensitivity. This increased to 1% for those between 45 and 54 years of age and this percentage went up to 25.4% in the group aged 75 and over. Contrast sensitivity was found to be more strongly related to crash involvement and (unintentional) violations than visual acuity (Van Rijn, 2005). McGwin Jr, Chapman & Owsley (2000) conclude that reduced contrast sensitivity affects a number of complex actions in traffic, such as taking a left bend and driving on a road with heavy traffic. Moreover, Owsley et al. (2001) detected that people with reduced contrast sensitivity as a result of cataracts are also more often involved in crashes. However, not much research has been carried out into the effect of reduced contrast sensitivity in crash involvement.

Increased glare sensitivity

When a bright source of light is projected directly onto the retina, glare occurs briefly. This is, for instance, the effect of headlights of oncoming vehicles, a low sun, or the reflection of the sun on a wet road surface. Normally, glare sensitivity increases with age. According to Van den Berg & Van Rijn (2005), glare sensitivity hardly plays a role with 20- to 30-year old drivers. From the age of 55, the number of people with high glare sensitivity increases to almost 30% for the group aged 75 and over. Wearing sunglasses or using tinted windscreens can help prevent glare. Research by Van Rijn (2005) shows that people with increased glare sensitivity run a higher risk of being involved in a crash. However, this correlation has not been fully researched and no unambiguous method exists for measuring glare sensitivity.

Night-blindness

Night-blindness is diminished vision when it is dark. People suffering from night-blindness need a long time to be able to see properly again, in particular when there is a transition from light to dark. In traffic this may occur when driving into a tunnel, for example. Research has shown that drivers involved in crashes occurring in the dark more often suffer from a certain degree of night-blindness than drivers not involved in crashes in the dark (Groot, 1999).

Colour-blindness

Colour-blindness is a genetic disorder present from birth. Colour blindness does not increase with age. Treatment nor compensation (glasses) are possible. Those not suffering from colour blindness can distinguish six million hues based on three pigments (red, green, and blue), whereas for the colour-blind this number is significantly lower. In the colour-blind the red or the green cone pigments in the retina do not function or they function badly. As a result, nearly all colours are seen differently, including the colours red and green, but can also affect other colours. Of all Dutch citizens 4.2% are colour-blind (8% of the men and 0.4% of the women). There are different forms of colour blindness, which occur in varying degrees. One form and degree is more serious than the other. In traffic, the colour-blind encounter problems with for example traffic signs, traffic lights and distinguishing between red and grey lanes. The colour-blind can be assisted in the 'reading' of traffic lights by consistently placing red at the top and green at the bottom, and by using orange-red LEDs instead of red LEDs. Traffic signs are more easily read when the colours are separated by white bands and by giving the signs a white border (Verkeerskunde, 2014). Although the colour-blind encounter problems in traffic, most studies agree that there is no link with the risk of crashes (for an overview see: Charman, 1997; Owsley & McGwin, 1999). This is possibly the result of the colour-blind being capable of compensating for their disorder and because some adjustments have already been made for the colour-blind, e.g. traffic signs with white borders and traffic lights with orange-red LEDs.

A non-functioning eye

A person may miss one eye, but it may also be the case that one eye does not function well enough to contribute to the perception. Two eyes are needed for stereovision – the two-dimensional images of both eyes are in fact combined into a three-dimensional image in the brain. Stereovision is particularly relevant for estimating distances between 1.5 and 5 meters away from the viewer. Stereovision does not provide useful information with respect to larger distances. People who have been living with one functioning eye over a longer period can see depth perfectly well. They will actually learn to make use of other sources of information, such as the size of familiar objects and the movements of objects in the field of vision. However, immediately upon the occurrence of the impairment, the visual system needs time to adapt to the changed input.

Which disorders can cause visual impairments?

The disorders that can cause impairments of visual functions are listed in the table below.

Disorder	What is it?	What is the result?
Diabetic retinopathy	Ocular disorders as a result of diabetes	<ul style="list-style-type: none">– blurred image– loss of parts of the field of vision– blindness (most frequent cause)
Glaucoma	Too much pressure in the eye	<ul style="list-style-type: none">– loss of visual acuity– loss of (parts of) the peripheral field of vision– reduced adaptation to darkness– perception of rainbow-like rings around lights– headache
Cataract	Blurring of the surface of the lens	<ul style="list-style-type: none">– increased sensitivity to diffusion of light– reduced visual acuity– reduced colour vision
Macular degeneration	Damage to the central part of the retina, age-related disorder	<ul style="list-style-type: none">– blurred vision– disorder or loss of the central field of vision– disordered contrast to brilliance
Retinitis pigmentosa	Genetic degenerative disorder of specific parts of the retina	<ul style="list-style-type: none">– night-blindness– tunnel vision (loss of the peripheral field of vision)
Neuroretinitis	Limited functioning of the optical nerve	<ul style="list-style-type: none">– eye ache– loss of colour vision– loss of contrast sensitivity– sudden loss of (parts of) the field of vision– blurred vision

Overview of disorders causing visual impairments (Fjerdingen et al., 2000; Hunter et al., 2009).

Does a visual acuity test contribute to road safety?

Visual impairments increase with age. The consequences of most visual disorders can be limited by means of devices and treatments. It is important that people are aware of their visual impairments. This is a point of attention. A few years ago, the introduction of an obligatory 'eye test' for car drivers from the age of 45 was considered in the Netherlands. This measure, testing visual acuity only, was expected to have no more than a limited effect on road safety (Vlakveld et al., 2005). Since visual acuity alone does not constitute an accurate indication of fitness to drive, such a test will declare people unfit who can still safely participate in traffic, and, the other way around, not declare unfit people with visual impairments that would make it advisable for them not to participate in traffic any longer.

Conclusion

Visual perception is an important source of information when driving a car. It therefore seems logical that visual impairments have a negative effect on road safety. Undeniably, certain visual functions, such as contrast sensitivity, field of vision and Useful Field of View (UFOV) do have a correlation with driving skills. Effects on crash involvement have been found with contrast sensitivity, glare sensitivity and UFOV. However, the effects on the crash rate are limited and this is often because people with a visual impairment compensate for it. Since a visual impairment generally develops very gradually, people are often not aware of it, or if they are, not until very late.

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