VISION MEASURABILITY AND ITS IMPACT ON SAFE DRIVING – A LITERATURE REVIEW

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EXTENDED ABSTRACT

1. INTRODUCTION
Knowledge of measurability of vision and its impact on safe driving have proven to be important to secure a safe traffic system. Several different approaches to measure vision in order to improve road safety have been identified around the world. A trend seen in the literature is that traditional vision tests increasingly are supplemented by cognitive tests. Both visual impairments and cognitive impairments may develop gradually and it can take a long period of time for them to become discernable. As a consequence, affected persons seldom perceive that their driving skill has deteriorated. This is a central question to address and an important reason to advocate regular testing of drivers. The main purpose of the present study was to investigate visual capabilities that are important for safe driving. The study answered questions about the visual capabilities that are essential for safe driving; which tests are available and how they are used; and existing evidence for these tests.

2. MATERIAL AND METHODS
The literature review was based on searches in databases TRID, Web of Science and PubMed for the years between 2000 and 2014. In total the literature search rendered 267 database posts of which 139 were excluded due to lack of relevance and 128 references were included.

3. RESULTS

3.1 Visual acuity
Visual acuity is a measure of the eye's resolution power and is dependent on several components such as the optical system, the receptors on the retina and the brain. Several diseases, such as cataracts, may affect visual acuity and impair driving performance due to late detection of pedestrians and other risk factors. Numerous studies have demonstrated that the traditional tests of visual acuity, on their own, are not appropriate to identify unsafe drivers. According to several sources, testing of visual acuity used for screening should be accompanied by further tests such as contrast sensitivity, visual field, and tests of cognitive abilities.

3.2 Visual field
The visual field is the entire field of vision that can be observed in a specific moment. The maximum static visual field is approximately 180 degrees horizontally and 134 degrees vertically. Visual field loss may be the result of a disease of the eye affecting the optic nerve or the brain, which may be caused by a stroke. A driver with visual field loss cannot see the whole view, which may lead to decreased driving performance and also higher risks of accidents. However, the effects of decreased field of vision on
driving performance is far from conclusive and several argue that compensatory behavior varies, resulting in the conclusion that individual assessments should be favored.

3.3 Contrast vision
Contrast vision is the ability to distinguish differences in color and brightness, for example to distinguish an object from its background. Generally speaking, the contrast vision and thus the contrast sensitivity decrease with age and contrast vision can be negatively affected by a number of diseases, such as cataracts and Parkinson. The link between cataracts and impaired driving performance have been made in a number of studies and explained by a decrease in contrast sensitivity. Decreased contrast sensitivity has been shown associated with unsafe driving, such as difficulties with recognition of road signs and dangers, with maneuvering, and with driving at night. A contrast sensitivity test is often made with a Pelli-Robson eye chart, but other letter targets are also available and used. Generally, the contrast sensitivity is a test that is well supported by research regarding determination of driving performance and prediction of safe driving. Contrast sensitivity is suggested to be included for driver assessments since it is more common to drive with poorer contrast vision compared to impairments in visual acuity and visual field loss, which today are often included in assessments of driving ability.

3.4 Color vision
Problems with color vision are referred to as color blindness and can occur with different colors. There are three different kinds of retinal cones, some are sensitive to blue light, some are sensitive to green, and a large proportion are sensitive to red light. Persons who suffer from color blindness and are less sensitive to green light have so called protan color blindness, and those who have difficulties to distinguish between green and red shades have so called deutan color blindness. Even persons with normal vision may have some difficulties with color vision. Several variations of color blindness has been suggested to lead to higher accident risk and difficulties when reading signs. Therefore, it is proposed in various studies that color vision should be tested to assess driving ability, however the type of test has not been specified.

3.5 Diplopia
Diplopia or double vision means that a person sees two objects instead of one. This may be caused by an inability to look towards a point, resulting in that the image do not end up in the corresponding retinal (fusional) area. In this case double vision is only present when the person looks with both eyes. Double vision may also be due to cataracts that cause the person to get a prismatic image. In that case the double vision is present even if one eye is closed. Diplopia is not regarded as a complication that should affect if the person is allowed to carry a driver's license, or not.

3.6 Adaptation
Adaptation can be seen as the eyes ability to adapt to different lightning conditions. Light sensitivity or glare problems are signs of adaptation difficulties. When adapting to weak light conditions, the pupil enlarges and both visual acuity and contrast sensitivity significantly decreases. This affects vision and may affect driving safety. One medical condition affecting adaptation is night myopia, night blindness, which makes it difficult to see in half darkness and another example is cataracts which entails an increased glare sensitivity. Night time driving leads too many situations of glare and the average recovery time after glare has been shown worst for older drivers. Tests of adaption, relevant for safe driving, include visual acuity, contrast sensitivity, motion sensitivity, and tests measuring the ability to recover from glare.

3.7 Useful field of view
Cognitive aspects relating to vision such as visual attention are essential for safe driving. The most common test covering cognitive aspects of vision is Useful field of view. The test contains three elements, namely: (1) processing speed, (2) divided attention, and (3) selective attention. The reviewed literature provided strong support for the tests ability to predict driving performance and a variety of medical conditions has been connected to changes in UFOV test scores. Examples of medical conditions
where UFOV is adversely affected and for which UFOV can be used to predict safe driving are Parkinson’s disease, Alzheimer’s disease, cognitive impairments in an early stage, and Multiple sclerosis. Besides medical conditions, visual attention as measured by UFOV is also affected by natural aging. Despite the evidence supporting UFOV and its ability to predict accidents and safe driving it should also be mentioned that there is also critic presented against the test.

4. DISCUSSION

The results from this literature study are in line with others suggesting that tests currently used to assess driving ability and decide on the right to retain a driver’s license, are insufficient. Many studies carried out traditional tests of visual acuity, however according to the results of this review, no one has found a strong correlation with road safety. The fact that visual acuity is essential for safe driving is rarely doubted, but tests for visual acuity are considered inadequate. It is often suggested to be accompanied by a test for contrast sensitivity. We share this view and find it reasonable given that visual acuity is measured under very optimal conditions rarely seen in traffic. Based on the findings of this review, there are a number of vision tests that have external validity in the scientific literature, and therefore are reasonable candidates to include in an assessment to ensure safe mobility and decide the eligibility of a driver’s fitness to hold a license. The results suggest a combination of different tests according to individual conditions for a fair assessment of the driving ability.

The measurement of visual acuity (e.g. different letter boards) that are available and in use today are not sufficient to ensure safe driving, but needs to be combined with other tests. Based on the literature, contrast sensitivity and UFOV (Useful Field of View) are suggested as being the best measures of visual capabilities that are essential for safe driving and a suitable candidate to complement the already required visual acuity test. This is in line with previous research suggesting contrast sensitivity’s importance for the assessment of driving ability. The second test highlighted is the UFOV, shows that there is potential to complement classic vision test with tests containing cognitive aspects.

Several impairments are associated with normal aging, whereas others follow medical conditions. Driving and mobility is important for many individuals’ independence. It is important to have a holistic approach to ensure a continued good mobility for these individuals and still increase traffic safety. The testing of vision may be experienced as a constraint and as a threat to mobility, however, it could also act as a catalyst for continued driving. Persons who previously doubted their performance in traffic may, with the help of testing, gain self-confidence to continue driving. Having said this, it is important that testing is carried out in such a manner as to ensure continued safe mobility.

5. CONCLUSIONS

Firstly, available and broadly used tests of visual acuity are not sufficient to ensure safe driving on its own and needs to be combined with other tests. Based on the literature and it is reasonable to further investigate how these could complement visual acuity in order to acquire better predictability of safe driving. From this literature study, contrast sensitivity, UFOV, and glare sensitivity emerges as strong candidates to complement visual acuity. The literature suggests that the UFOV was also the test that best predicted driving performance. Thirdly, different tests should be combined with regards to individual case conditions in order to get a fair judgement of the whole driving ability.