Visual Acuity Standards for Driving

Keziah Latham[1,2], Sheila Rae[1,2]

1. Department of Vision & Hearing Sciences, Anglia Ruskin University, Cambridge, UK.

2. Vision & Eye Research Institute, Anglia Ruskin University, Cambridge, UK.

Address for correspondence:

Dr Keziah Latham, Department of Vision and Hearing Sciences, Anglia Ruskin University, East Road, Cambridge CB1 1PT. Keziah.latham@anglia.ac.uk

Competencies addressed:

4.1.5 Dispenses a range of lens forms to include complex lenses, multifocals and high corrections, and advise on their application to specific patients needs.

7.1.5. Assesses patients with impaired visual function and understands the use of specialist charts for distance and near vision, and the effects of lighting, contrast and glare.

Summary:

The purpose of this paper is to review the visual acuity standards for driving in the UK, and to provide guidance for optometrists to consider when assessing drivers' vision and advising patients on their visual fitness to drive.

Abstract:

This paper reviews the current visual acuity standards for UK drivers. These standards have changed in recent years such that car drivers (Group 1) now have two standards to meet: reading a number plate at 20m, and achieving an acuity of 6/12. In the light of these changes, research investigating the effect of uncorrected refractive error and simulated cataract on the ability to meet the visual standards is reviewed, as is the effect of reduced contrast sensitivity on driving. On the basis of these findings, recommendations are made for optometrists regarding how to assess acuity in drivers, and how to use this information when advising patients on their visual fitness to drive.

Driving is one of the most common visual tasks that optometrists provide advice on: there are nearly 38 million people with a full UK driving licence and 7.3 million with a provisional licence (Department of Transport, 2015). The visual standards for driving concentrate on the requirements for visual fields (Rauscher et al., 2007) and visual acuity (VA). Other criteria, regarding diplopia and night vision for example, are also specified, which are beyond the scope of this article, but can be consulted online in Chapter 6 of the 'At a Glance Guide to Medical Fitness to Drive' (Drivers' Medical Group, 2013). The purpose of this paper is to give an overview of the revised visual acuity standards for driving, and to review some recent research into how visual acuity should be measured and interpreted when providing advice to patients on their visual fitness to drive.

What is the current UK driver's vision standard?

The visual standards for driving were changed in 2012, as outlined in more detail below. Although these changes were reported in the optical press at the time (Taylor, 2012), practitioners may not be aware of the need to revise how they advise drivers on their visual fitness to drive.

Group 1 drivers

UK drivers of cars and light vans require a Group 1 licence. The visual acuity standard for a Group 1 licence is firstly the ability to read (with refractive correction if necessary) a number plate on a car registered since September 2001 (point 1 in Table 1), which consists of two letters and two numbers, followed by a group of three letters. Since 2012, there has also been an additional visual acuity standard to meet whilst wearing any necessary refractive correction (point 2 in Table 1) (Drivers' Medical Group, 2013). This additional requirement came about in order to bring the UK into compliance with European Union (EU) regulations (European Community, 1991), and is also consistent with the standard in many other parts of the world (Bron et al., 2010). Drivers should be able to meet both standards, rather than one or the other.

Table 1. Visual acuity standards for a UK Group 1 driving licence (Drivers' Medical Group, 2013): a driver must meet both standards. Note that diagrams are not to scale.

1. “The ability to read in good daylight (with the aid of glasses or contact lenses, if worn) a registration mark fixed to a motor vehicle and containing characters 79 mm high and 50 mm wide from 20 m.”	
2. “The visual acuity (with the aid of glasses or contact lenses, if worn) must be at least 6/12 (Snellen, decimal 0.5) with both eyes open, or in the only eye if monocular.”	

Issues raised by the additional vision standard

Before the introduction of the visual acuity standard in 2012, visual acuity was used by practitioners only to predict who was likely to pass and to fail the number plate test. Studies which compared the ability to read a number plate and Snellen acuity in patients with ophthalmic disease (Currie et al., 2000, Rathore et al., 2012) found considerable overlap in the acuities of those passing and failing the number plate test. Functionally, the classic paper by Drasdo and Haggarty (1980) found that an acuity of $6/9^{-2}$ excluded the same proportion of people from driving as the ability to read an old style number plate, and many practitioners used this value as a rule of thumb. However, these studies (Currie et al., 2000, Drasdo and Haggerty, 1980, Rathore et al., 2012) all used older style (pre-2001) number plates, which do not have the same format as current plates, and are thus not necessarily comparable to current requirements.

Given that there are now two standards for the acuity required for driving which have to be independently met, the relevant question becomes to what extent the two standards pass and fail the same people. By making 6/12 the additional standard, the Driver and Vehicle

Licensing Agency (DVLA) imply that this acuity is equivalent to the number plate test, but at least some discrepancy between the people passing each of the two standards would be expected. Certainly the format of the symbols on a post 2001 number plate are different to those on a test chart: letters on a number plate are more closely spaced, with a different aspect ratio (taller and thinner), and a wider range of symbols are used. The stroke width of a number plate character subtends a minimum angle of resolution which is equivalent to a Snellen acuity of 6/14.4 (Katsou, 2014). The format of different test charts may also make a difference, including differences between Snellen and logMAR progression charts, and between different letters or symbols used on test charts. Some EU countries such as Germany have adopted the 'ISO standard optotype' (British Standards Institute, 2009) of the Landolt ring to standardise acuity measurement for driving. The practitioner also needs to consider that the tests take place in different environments, with acuity measured under controlled indoor lighting conditions and the number plate assessed outside in varying weather conditions. It is not uncommon to find 'simulated' number plates on test charts, but these may not be in the current layout and will not be comparable to the driving visual standard when they are used indoors. Optometrists, as professionals providing advice on fitness to drive based on acuity measurements, need to know how ability on an acuity chart relates to ability to read a number plate, and recent studies on this question are outlined below.

Effect of uncorrected refractive error

Whilst the best corrected acuity of those with ophthalmic disease is extremely relevant when advising a patient on their visual fitness to drive, the need for refractive correction to improve acuity when driving is also a question that optometrists have to address on a regular basis. Studies that have examined ophthalmic patients did so with habitual rather than best refractive correction (Currie et al., 2000, Rathore et al., 2012), and many drivers who fail the number plate test do so because of uncorrected refractive error (Charman, 1997). With the new regulations as outlined above, it is clear that if a patient does not achieve 6/12 without correction then they must be advised to wear refractive correction when driving. However, as they must also be able to read a number plate, at what level of uncorrected vision should we insist that a patient wears a refractive correction for driving?

And what does the vision measured in the test room tell us about the likelihood of a patient being able to pass the number plate test?

The questions raised above were addressed in a study examining visions assessed in a clinical test room environment and the ability to read a number plate outdoors of people with uncorrected vision in the region of the 6/12 visual standard (Latham et al., 2014).

People with vision that was ‘borderline’ for driving were defined as those with vision in a range in which some individuals did not pass or fail both tests. For example, with a Snellen chart some people with vision of 6/9 failed the number plate test, but all those with vision of 6/7.5 or better were able to read a number plate. This value is important, as it indicates the level of vision that needs to be achieved in the test room before a practitioner can be confident that a driver would be able to read a number plate outdoors. At the other end of the scale, an individual with 6/36 still managed to read a number plate, but nobody with worse vision was able to. Subjects within this range of uncertainty, or ‘overlap zone’ (6/9-6/36) were considered as having borderline vision for driving (Table 2).

Since the introduction of the additional ‘6/12’ standard, there has been no guidance on how this should be measured. The EU directive (European Community, 1991) states a value of 0.5 decimal as this is the most common notation used in mainland Europe. However, the DVLA have adopted ‘6/12 Snellen’ (Drivers’ Medical Group, 2013), but does this mean an equivalent to 6/12 or that a Snellen chart should be used? In this study visions were measured with a Snellen chart, a logMAR progression chart using Sloan letters similar to the ETDRS chart (Ferris et al., 1982) and a logMAR progression chart using Landolt rings. Vision measured with Landolt rings was poorer than with either of the other charts, and 35% of those with borderline vision for driving were unable to achieve 6/12 with this chart (Latham et al., 2014). The first outcome from this study was therefore to suggest that Landolt rings should not be used when assessing visual fitness to drive.

For Snellen and logMAR letter charts, a 6/12 line often appears very similar on each chart despite the differences in chart layout, typically consisting of 5 letters with similar spacing. Even so, repeatability of Snellen measurements is much poorer (±0.33 logMAR equivalent) than that for ETDRS charts (±0.18 logMAR) (Rosser et al., 2001). Scoring a Snellen chart can also be tricky when relating vision to a standard. Should a driver be considered to have achieved 6/12 only if they read all the letters on the line, or could some errors be allowed such that the line is considered seen if at least half the letters are correct’ as suggested by Falkenstein et al. (2008)? In this study, it was shown that Snellen charts best reflected the ability to read a number plate when scored by full line, rather than allowing any mistakes on the line (Latham et al., 2014).

One way to deal with the vagaries of Snellen chart scoring is to use logMAR letter charts, which are becoming more widely available to optometrists through the use of computerised test charts and the ETDRS chart, which is often found in hospital eye clinics. LogMAR charts have the advantage of allowing letter by letter scoring, with a score of 0.02 logMAR assigned to every letter correctly read, regardless of where it is on the chart. Practitioners using a logMAR chart can have a clearer idea of whether their patient achieves the visual standard of 6/12, or +0.30 logMAR equivalent. For example, a patient who reads two letters incorrectly on the 6/12 or +0.30 logMAR line, but gets two letters correct on the next line down, would still be given a score of +0.30 logMAR.

<Figures 1 and 2 about here>

The results of the study of the effects of uncorrected refractive blur on the driving vision standards are summarised in Figure 1 for the logMAR chart and Figure 2 for the Snellen chart, with further details given in Table 2. The point of certainty on the test charts at which the number plate would definitely be passed lies at ≤ 6/7.5 for the Snellen chart and ≤ +0.10 logMAR. Between these values and the post 2012 standard of 6/12 (+0.30 logMAR) there will be a small proportion of patients who in spite of seeing at least 6/12 will not also pass the number plate test (false negatives in Table 2). Caution needs to be exercised when advising patients in this range as practitioners will not know if the full driving vision standard can be met without also assessing the number plate test in outdoor conditions.

There is a further group for whom there is uncertainty about the ability to meet both standards. Beyond 6/12 and up to 6/36 Snellen or +0.84 logMAR, patients may still be able to pass the number plate test yet do not meet the additional post 2012 VA standard (false positives in Table 2). This group may have believed or have been correctly advised in the past that they met the driving vision standard but are unable to meet the additional new VA requirement.

When comparing two tests, their equivalence can also be considered by the use of the concepts of sensitivity and specificity (Elliott, 1997). In this instance, sensitivity represents the ability of the 6/12 cut-off to predict failure in the number plate test, and is calculated as the number who fail both tests divided by the number who fail the number plate test. Specificity represents the ability of the 6/12 cut-off to predict a pass in the number plate test, and is calculated as the number who pass both tests divided by the number who pass the number plate test. Table 2 shows the high, but not perfect, sensitivity of both acuity charts in predicting failure on the number plate test under conditions of blur, but a lower specificity indicating less ability to identify who will pass the number plate test from their vision in the test room.

Table 2. Overview of the comparison of the two visual standards for driving under conditions of uncorrected refractive error. The overlap zone represents the range of visions within which there was uncertainty whether an individual would pass or fail the number plate test. False positives are those who can read a number plate but not achieve 6/12, and false negatives are those who can achieve 6/12 but not read a number plate. Sensitivity represents the ability of the 6/12 cut-off to predict failure in the number plate test, and specificity represents the ability of the 6/12 cut-off to predict a pass in the number plate test.

Chart	'Overlap zone'		Number in overlap zone	False positive rate	False negative rate	Sensitivity	Specificity
	Min	Max					
Snellen (full line correct)	6/9	6/36	59	15%	2%	97%	63%
ETDRS style (logMAR)	+0.12	+0.84	50	14%	6%	91%	61%

Effect of reduced contrast sensitivity

Many patients whose vision is borderline for driving have best corrected visual acuity that is reduced by some form of pathology, which is likely to reduce contrast sensitivity (CS) as well as VA. One of the most common examples of this is cataract, where CS is often as or more affected than VA (Hess and Woo, 1978). The 'At a Glance' guide (Drivers' Medical Group, 2013) recognises that cataract may affect vision in a different way to simply reduced acuity when they state that a driver ‘must be able to meet the above eyesight requirements. In the presence of cataract, glare may affect the ability to meet the number plate requirements, even with apparently appropriate acuities.’

To assess the impact of reduced CS on the ability to pass each of the visual standards for driving, a further study examined test chart vision and the ability to read a number plate for normally sighted subjects wearing simulation spectacles to reduce their vision to around 6/12 whilst also reducing contrast sensitivity (Rae et al., in press). As before, the vision levels at which the number plate test was consistently passed and failed were established, with the overlap zone lying between these values. With both the ETDRS and Snellen test charts, a lower proportion of the sample was placed in the same classification for both tests (both plate and test chart passed or failed) with reduced CS (Table 3) as compared to results with refractive blur (Table 2). There was a particular increase in the proportion of the sample who could meet the test chart standard but were unable to read the number plate outdoors (false negatives). The increased difficulty of the number plate test for this sample was also reflected by the reduced sensitivity of the acuity cut-off to predict failure on the number plate test (Table 3). With reduced contrast sensitivity as compared to refractive blur, there was also an increase in false positives (those passing the number plate test, but failing on the test chart) for the Snellen chart from 15 to 24%, which was not seen for the logMAR chart (14% and 13%). This may be due to the flexibility of the letter by letter scoring used with the logMAR chart allowing more observers with borderline vision to achieve 6/12 by considering all the letters read correctly. Overall, the results of this study suggest that for patients with reduced CS, it is particularly important to err on the side of caution when advising on visual fitness to drive solely on the basis of indoor test chart assessments.

Table 3. Overview of the comparison of the two visual standards for driving under conditions of simulated VA and CS loss. Definitions of headings are given in the text and in Table 2.

Chart	‘Overlap zone’		Number in overlap zone	False positive rate	False negative rate	Sensitivity	Specificity
	Min	Max					
Snellen (full line correct)	6/12	6/24	59	24%	15%	61%	62%

ETDRS style (logMAR)	+0.08	+0.54	50	13%	13%	56%	81%

Data presented in previous studies that have compared visual acuity and ability to read a number plate in patients with ophthalmic pathology can also be examined to determine how well achieving 6/12 Snellen predicts the ability to read a number plate. For patients at an ophthalmic clinic (Currie et al., 2000), sensitivity of 72% and specificity of 69% can be derived. For patients with wet macular degeneration receiving anti veg-F treatment (Rathore et al., 2012), sensitivity was 44% and specificity 100%. These studies all suggest that ophthalmic pathology, which tends to reduce CS in addition to VA, has a greater impact on the ability to read a number plate outdoors than on visual acuity as measured in the test room.

Why does CS matter for drivers?

In addition to reduced CS impacting on the ability to pass the visual standards for driving, it has also been shown to have a greater detrimental effect on driving performance than refractive blur. Driving performance has been compared for vision reduced to borderline 6/12 levels by refractive blur, and by use of frosted lenses to give equivalent acuity but to additionally reduce CS. It has been shown that reducing CS has a more detrimental effect on driving performance than reducing VA alone for the time taken to drive a closed circuit course, sign recognition, and for hitting road hazards in both day (Higgins and Wood, 2005) and night (Wood et al., 2010) driving conditions, and also reduces the ability to detect hazards in a video based hazard perception scenario (Marrington et al., 2008). Indeed, vision of 6/12 in conjunction with CS reduction reduces driving performance to levels achieved with refractive blur alone of 6/60 (Higgins and Wood, 2005).

Such studies using simulated visual impairment introduce an immediate visual deficit, unlike the gradual progression of pathology such as cataract. However, it has also been shown that drivers with cataract are 2.5 times more likely to have had an at-fault crash in the previous 5 years than those without cataract (Owsley et al., 1999). Cataract surgery has been shown to reduce subsequent crash rates (Owsley et al., 2002), improve driving ability on a closed circuit (Wood and Carberry, 2006) and improve self-reported driving ability (Mönestam and Wachtmeister, 1997, Elliott et al., 2000).

A patient's contrast sensitivity is not currently considered in visual standards for driving, but is known to be associated with poorer driving performance (Owsley et al., 1999, Higgins and Wood, 2005, Marrington et al., 2008, Wood et al., 2010), and also increases the likelihood of failing to achieve both UK visual acuity standards for driving (Rae et al., in press). Since cataract surgery improves driving performance (Mönestam and Wachtmeister, 1997, Elliott et al., 2000, Owsley et al., 2002, Wood and Carberry, 2006), optometrists should consider referral for cataract surgery as soon as a patient expresses difficulty with reading a number plate at 20m, regardless of whether VA has fallen to 6/12.

Dealing with the reduced vision of drivers with cataract can be problematic. Clinical Commissioning Groups often set local criteria for surgical thresholds for NHS cataract surgery. If the local criterion is an acuity of 6/12, patients whose VA is still better than 6/12 but who are unable to read a number plate at 20m might have to be referred for surgery through application for exceptional cases funding. If such an application is necessary, being able to specify a patient's CS in the justification for referral or commenting on how the cataract reduces vision when driving by more than indicated by the VA measurement may be useful.

Group 2 drivers

Drivers of large goods vehicles and passenger carrying vehicles (including most taxi and private hire drivers, bus and coach drivers and HGV drivers) need to meet the stricter Group 2 licensing requirements. VA (with correction where necessary) should be at least 0.8 decimal (6/7.5 Snellen, +0.10 logMAR) in the better eye and at least 0.1 decimal (6/60 Snellen, +1.00 logMAR) in the other eye (Drivers' Medical Group, 2013). Monocular drivers are therefore excluded from applying for a Group 2 licence. Additionally, the corrective spectacle lens power should be no greater than +8D (Drivers' Medical Group, 2013). Given these requirements, to effectively assess the VA of Group 2 drivers, practitioners either need to use a Snellen test chart that includes a 6/7.5 line or a logMAR chart.

Overview and advice to optometrists

Good vision is obviously an important factor in the ability to drive, but there is little evidence that the visual standards which are in place discriminate safe from unsafe drivers (Charman, 1997). However, a line has to be placed in the sand somewhere, and until robust evidence is available as to what visual standards would be more appropriate for driving, standards are unlikely to change significantly.

Group 1 drivers' vision is assessed at the practical driving test, where the ability to read a number plate is assessed by the driving examiner (Gov.Uk, 2015a). Since the introduction of the 6/12 standard, drivers are then expected to self-report to the DVLA if they have been told by their optometrist that they cannot see at least 6/12. However, there is no compulsion for visual assessment until licence renewal is required after the age of 70 (Gov.Uk, 2015b), or when medical opinion on visual fitness to drive is sought by the DVLA because a driver self-reports that they suffer from an ocular disease (Gov.Uk, 2014). Optometrists are therefore the only professionals assessing drivers' visual fitness to drive on a routine basis.

It is recommended that optometrists should be careful in their advice to patients on their fitness to drive (summarised in Table 4). Group 1 drivers with vision or visual acuity of 6/7.5 or better (<+0.10 logMAR) are extremely likely to pass the number plate test. If this has been achieved without correction, refractive correction is not necessary to meet legal standards. Correction might nonetheless improve reaction time, increase visual comfort, or reduce the blur circle of oncoming headlights for night driving, for example.

Some drivers with vision of 6/9 to 6/12 (+0.10 to +0.30 logMAR) may not be able to read a number plate, and so refractive correction should be suggested if this improves best corrected VA. Optometrists should be especially cautious advising patients with reduced CS due to conditions such as cataract. Even if such patients achieve an acceptable level of VA in the test room, their likelihood of not being able to read a number plate outdoors is increased. It is important to advise a patient that it is their responsibility to ensure they can read a number plate outdoors at 20m. If reading a number plate is problematic, referral for cataract surgery may be justified, even if VA is better than 6/12.

Drivers whose vision is worse than 6/12 (>+0.30 logMAR) do not meet current visual standards for driving even if they can read a number plate, which a few people can do with vision as low as 6/36. Such patients need to be advised of the visual standard and appropriate action suggested by the optometrist, depending on the cause of visual loss. If best corrected visual acuity can be improved to better than 6/12 then a refractive correction should be provided and the patient advised that it should be worn at all times when driving. If the reduction in vision is (predominantly) due to cataract, referral for cataract surgery should be discussed. If the patient declines cataract surgery or has vision that cannot be improved by refractive correction or surgery, they should be advised to inform the DVLA and to stop driving (Gov.Uk, 2014).

Table 4. Summary of advice to optometrists measuring vision / visual acuity of Group 1 drivers.

Acuity measurement:		
• Use test charts with letters rather than symbols, multiple letters on the 6/12 line, and charts that include a 6/7.5 line.		
• If using a Snellen chart, consider achieving 6/12 to be able to read all the letters on the line		
• Use a logMAR chart where possible to allow more flexibility through letter by letter scoring.		
Advice on vision / visual acuity:		
Snellen	logMAR letter	
6/7.5 or better	<+0.10	Extremely likely to pass number plate test: OK to drive
6/9 to 6/12	+0.10 to +0.30	As appropriate: a) prescribe refractive correction for driving where this improves VA b) encourage drivers to self-assess their ability to read a number plate at 20m c) be particularly wary with patients whose VA is reduced by conditions like cataract such that their CS is reduced
<6/12	>+0.30logMAR	As appropriate: a) prescribe refractive correction where this improves VA to 6/12 or better and advise this must be worn b) refer for cataract surgery c) advise patient to inform the DVLA and cease driving.

If a patient does not meet the visual standards for driving, it is the patient’s responsibility to inform the DVLA. A form is available that practitioners can give to patients to explain their obligations (Driver and Vehicle Licensing Agency, 2013). There are likely to be occasions when a practitioner advises a patient that they do not meet the visual requirements for driving, but is not convinced that the patient will take heed of this advice. The most appropriate action to take will depend on the circumstances, and it is suggested that practitioners consult the College of Optometrists’ guidance (College of Optometrists, 2015a,b). The practitioner should not, as a usual course of action, inform the DVLA themselves of their concerns about a patient's vision as this would be breaching the patient's right to confidentiality. However, practitioners do need to consider the public interest if 'failing to disclose the information would expose other members of the public to risk of death or serious harm' (College of Optometrists, 2015a,b). If a practitioner feels that a driver's vision is dangerous and that they are not likely to stop driving of their own accord, it may be appropriate to inform the DVLA, even without the patient's consent (College of Optometrists, 2015a,b). It is recommended that the practitioner should seek advice from the College or the Association of Optometrists (Association of Optometrists, 2015) before taking this route.

Figure legends

Figure 1. Summary of the effects of uncorrected refractive blur on the ability to pass the two visual acuity standards for driving using an ETDRS style logMAR progression acuity chart.

Figure 2. Summary of the effects of uncorrected refractive blur on the ability to pass the two visual acuity standards for driving using a Snellen chart, scored by considering the achievement of 6/12 to constitute the ability to correctly read all the letters on the 6/12 line.

References

Association of Optometrists. *Vision standards: Motor vehicle drivers* [Online]. Available: http://www.aop.org.uk/practitioner-advice/vision-standards/motor-vehicle-drivers [Accessed 24/06/2015].

British Standards Institute. 2009. BS EN ISO 8596:2009. Ophthalmic optics - Visual acuity testing - Standard optotype and its presentation.

Bron, A. M., Viswanathan, A. C., Thelen, U., et al. 2010. International vision requirements for driver licensing and disability pensions: using a milestone approach in characterization of progressive eye disease. *Clinical Ophthalmology,* 4**,** 1361-1369.

Charman, W. N. 1997. Vision and driving - a literature review and commentary. *Ophthalmic and Physiological Optics,* 17**,** 371-391.

College of Optometrists. 2015a. *Professional guidance: Confidentiality (C61-C90)* [Online]. Available: http://guidance.college-optometrists.org/guidance-contents/communication-partnership-and-teamwork-domain/confidentiality/ [Accessed 21/4/2015].

College of Optometrists. 2015b. *Professional guidance: Examining patients who drive (A210-A223)* [Online]. Available: http://guidance.college-optometrists.org/guidance-contents/knowledge-skills-and-performance-domain/examining-patients-who-drive/ [Accessed 21/4/2015].

Currie, Z., Bhan, A. & Pepper, I. 2000. Reliability of Snellen charts for testing visual acuity for driving: prospective study and postal questionnaire. *British Medical Journal,* 321**,** 990-992.

Department of Transport. 2015. Driving licence data. Available: http://data.gov.uk/dataset/driving-licence-data [Accessed 25/08/2015].

Drasdo, N. & Haggerty, C. 1980. A comparison of the British number-plate and Snellen vision tests for car drivers. *Ophthalmic and Physiological Optics,* 1**,** 39-54.

Driver and Vehicle Licensing Agency. 2013. *A guide to standards of vision for driving cars and motorcycles (Group 1)* [Online]. Available: http://www.aop.org.uk/uploads/motor_vehicle_drivers_aug_2013.pdf [Accessed 24/06/2015].

Drivers' Medical Group. 2013. At a glance guide to the current medical standards of fitness to drive. Driver and Vehicle Licensing Agency, Swansea. Available: https://www.gov.uk/current-medical-guidelines-dvla-guidance-for-professionals [Accessed 25/08/2015].

European Community. 1991. Second council directive on driving licences. *Official Journal of the European Communities,* 24/8/1991**,** 1-24. Available: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:31991L0439 [Accessed 25/08/2015]**.**

Elliott, D. B. 1997. *Clinical procedures in primary eye care,* Oxford, Butterworth-Heinemann.

Elliott, D. B., Patla, A. E., Furniss, M., et al. 2000. Improvements in Clinical and Functional Vision and Quality of Life after Second Eye Cataract Surgery. *Optometry & Vision Science,* 77**,** 13-24.

Falkenstein, I. A., Cochran, D. E., Azen, S. P., et al. 2008. Comparison of visual acuity in macular degeneration patients measured with Snellen and Early Treatment Diabetic Retinopathy Study charts. *Ophthalmology,* 115**,** 319-323.

Ferris, F. L., Kassoff, A., Bresnick, G. H., et al. 1982. New visual acuity charts for clinical research. *American Journal of Ophthalmology,* 94**,** 92-96.

Gov.Uk. 2014. *Health conditions and driving* [Online]. Available: https://www.gov.uk/health-conditions-and-driving [Accessed 24/06/2015].

Gov.Uk. 2015a. *Driving eyesight rules* [Online]. Available: https://www.gov.uk/driving-eyesight-rules [Accessed 25/06/2015].

Gov.Uk. 2015b. *Renew your driving licence if you're 70 or over* [Online]. Available: https://www.gov.uk/renew-driving-licence-at-70 [Accessed 24/06/2015].

Hess, R. F. & Woo, G. C. 1978. Vision through cataracts. *Investigative Ophthalmology & Visual Science,* 17**,** 428-435.

Higgins, K. E. & Wood, J. M. 2005. Predicting components of closed road driving performance from vision tests. *Optometry and Vision Science,* 82**,** 647-656.

Katsou, M. F. 2014. *Visual acuity of drivers.* MPhil, Anglia Ruskin University. Available: http://angliaruskin.openrepository.com/arro/handle/10540/346225 [Accessed 25/08/2015].

Latham, K., Katsou, M. F. & Rae, S. 2014. Advising patients on visual fitness to drive: implications of revised DVLA regulations. British Journal of Ophthalmology. doi:10.1136/bjophthalmol-2014-306173

Marrington, S. A., Horswill, M. S. & Wood, J. M. 2008. The Effect of Simulated Cataracts on Drivers' Hazard Perception Ability. *Optometry & Vision Science,* 85**,** 1121-1127.

Mönestam, E. & Wachtmeister, L. 1997. Impact of cataract surgery on car driving: a population based study in Sweden. *British Journal of Ophthalmology,* 81**,** 16-22.

Owsley, C., Mcgwin, J., G., Sloane, M., et al. 2002. Impact of cataract surgery on motor vehicle crash involvement by older adults. *Journal of the American Medical Association,* 288**,** 841-849.

Owsley, C., Stalvey, B., Wells, J., et al. 1999. Older Drivers and Cataract: Driving Habits and Crash Risk. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences,* 54**,** M203-M211.

Rae, S., Latham, K., Katsou, M.F. Meeting the UK driving vision standards with reduced contrast sensitivity. *Eye*, in press.
Rathore, D., Oyede, T., Narendran, N., et al. 2012. Snellen versus logMAR visual acuity charts for evaluating driving standards in patients with neovascular macular degeneration. *British Journal of Visual Impairment,* 30**,** 160-167.
Rauscher, F. G., Chisholm, C. M., Crabb, D. P., et al. 2007. Central Scotomata and Driving. London: Department for Transport.
Rosser, D.A., Laidlaw, D.A.H., Murdoch, I.E. 2001. The development of a "reduced logMAR" visual acuity chart for use in routine clinical practice. *British Journal of Ophthalmology*, 85, 432-6.
Taylor, L. 2012. DVLA rule changes. *Optometry Today,* May 16. Available: http://www.optometry.co.uk/news-and-features/features/?article=3473 [Acceessed 25/08/2015].
Wood, J., Chaparro, A., Carberry, T., et al. 2010. Effect of Simulated Visual Impairment on Nighttime Driving Performance. *Optometry & Vision Science,* 87**,** 379-386.
Wood, J. M. & Carberry, T. P. 2006. Bilateral cataract surgery and driving performance. *British Journal of Ophthalmology,* 90**,** 1277-1280.

Figures

Figure 1

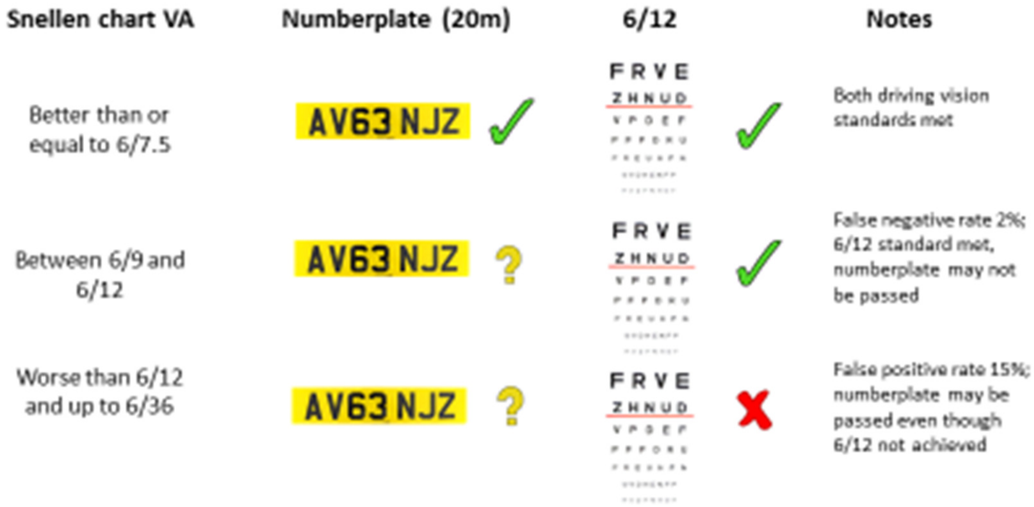
Snellen chart VA
Numberplate (20m)
6/12
Notes
Better than or equal to 6/7.5
AV63 NJZ
F R V E
Z H N U D
Both driving vision standards met
Between 6/9 and 6/12
AV63 NJZ
F R V E
Z H N U D
False negative rate 2%; 6/12 standard met, numberplate may not be passed
Worse than 6/12 and up to 6/36
AV63 NJZ
F R V E
Z H N U D
False positive rate 15%; numberplate may be passed even though 6/12 not achieved

Figure 2