Br Ir Orthopt J 2007; **4:** 27–30

The importance of cognitive function in driving following stroke

NICOLA R. MORRIS MSc BMedSci (Hons)

Birmingham and Midland Eye Centre, City Hospital, Birmingham

Abstract

Aim: **To review the published standards for driving and consider the importance of an assessment of cognitive function in determining suitability to resume driving after a stroke.**
Method: **A literature-based essay, using articles relating to driving after stroke and cognitive function and driving.**
Results: **The DVLA has guidelines on driving following a stroke and the visual standards required to drive. There are no standards for the level of cognitive function required to resume driving. Cognition is difficult to evaluate in relation to driving and there is no one test that can clearly predict whether a patient is safe to drive. Currently, where a decision cannot be made on the basis of medical reports the gold standard for fitness to drive is an on-road assessment.**
Conclusion: **Cognitive function makes a significant contribution to the ability to drive and evaluation of visual function alone is not sufficient when determining whether a patient is fit to drive.**

Key words: Cognition, Driving, Stroke

Introduction

Patients who have suffered a stroke may present to an orthoptic department with symptoms of diplopia, reduced vision, visual field loss, visual neglect and oscillopsia. Some patients are helped with prisms, glasses, visual aids or occlusion. Others can only be helped by an explanation of their symptoms, how they may affect rehabilitation and advice on coping strategies. It is not uncommon for the orthoptist to be asked advice about resuming driving. Most orthoptists will be aware of the visual standards required for driving set by the Driver and Vehicle Licensing Authority (DVLA), but driving is not just a visual task. Cognitive function is an important aspect of the ability to drive that may be affected by a stroke. As orthoptists we have limited knowledge on the cognitive demands required for driving and their assessment. This literature-based essay will consider the DVLA standards required for driving and the use of on-road driving assessments to determine suitability to resume driving. The cognitive demands of driving, cognitive testing and its importance in driving are discussed.

Correspondence and offprint requests to: Nicola Morris, Orthoptic Department, Birmingham and Midland Eye Centre, City Hospital, Dudley Road, Birmingham B18 7QU. Tel: 0121 5076829. e-mail: nicola.morris@swbh.nhs.uk

Stroke and driving

A person may resume driving after suffering a stroke unaware of the standards that are required to drive, or of the need to notify the DVLA of any problem that may affect the ability to drive. The DVLA relies on the driver to inform them of any changes in health and well-being. There is an expectation that the clinician explains to the patient that their condition may affect their ability to drive.[1]

Physical problems associated with stroke may limit the person's ability to turn the steering wheel, apply sufficient pressure to the brakes or change gear. A person may have cognitive problems, which may result in poor spatial awareness, frustration and confusion leading to dangerous behaviour and difficulty thinking, processing information, and making decisions quickly and appropriately in traffic.[2]

DVLA standards for driving

The DVLA has guidelines on the standards required to drive which cover neurological disorders, visual disorders and stroke. A person who has suffered a stroke is not permitted to drive during the first month after the stroke, but is allowed after this time provided sufficient clinical recovery has taken place. A patient is not required to notify the DVLA in this instance unless a defect persists.[3] Defects include diplopia, visual field loss, cognitive impairment and impaired limb function. In the event of multiple transient ischaemic attacks (TIAs) over a short period of time, a 3 month absence from driving is recommended. The patient must remain free of attacks during this period and the DVLA should be notified. The DVLA does not permit subjects with visual inattention to drive.

The DVLA visual standards for driving[3] are:

- the ability to read a standard number plate at a distance of 20.5 metres, which is approximately equal to a visual acuity of 6/10.
- a visual field of 120° on the horizontal meridian with no significant defect in the binocular field which encroaches within 20° of fixation above or below the horizontal meridian, when tested using white Goldmann target size III4e. Formal assessment is per-

formed using the binocular Esterman field test. There are exceptions to this, for example patients with longstanding field defects.
- driving with diplopia is permitted on confirmation to the licensing authority that it is alleviated with glasses, prisms or occlusion.

When the DVLA is notified of a problem, medical reports are requested from a patient's general practitioner, hospital consultants and therapists; these will include visual acuity, visual field and a physical examination. If a decision regarding a patient's safety to drive cannot be reached on the basis of these reports the patient is referred to a specialist centre for an on-road driving assessment.

In the United Kingdom there are eight regional driving assessment centres which determine safety to drive. Patients referred may have suffered a stroke, a traumatic brain injury or have a physical disability. In addition to driving assessments, these centres advise on modification of vehicles in cases of physical disability. Patients can contact centres directly for help and advice[4].

The on-road assessment is taken in a dual-control car with a specialist qualified driving examiner. The examiner determines whether the patient is safe to drive based on his judgement, experience and training received. Akinwuntan *et al.*[5] looked at the validity of the on-road test by evaluating 38 subjects who had suffered a stroke. Two state-registered driving assessors and the research investigator were involved in the assessment of each individual's performance in an on-road test. Variables of sex, age, type of stroke (haemorrhagic or ischaemic), side of lesion (left, right or bilateral) and driving experience showed no significant correlation with driving performance. All three assessors showed a very high correlation in their agreement of the classification (pass or fail) of driving performance. Statistical analysis showed the agreement to have a sensitivity of 80.1% and specificity of 100%.

Currently there are no published standards for the level of cognitive function required to drive. The DVLA acknowledges that cognitive impairment affects the ability to drive, the need to assess any impairment, and states that the ability to manage living on a day-to-day basis is a possible method of assessment.[3] The on-road assessment may include a cognitive assessment by an occupational therapist if a severe defect is suspected. However, such procedures are determined locally and there are no written guidelines for the assessment. The decision is based on the therapist's experience and opinion.

Cognition

Cognition is a group of related processes which include our ability to perceive, assimilate, organise and manipulate information to enable reasoning and problem-solving.[6] Some aspects of cognitive function that are required for driving are visuo-spatial perception, executive function, attention and memory.

Visuo-spatial perception is the ability to acquire, process and interpret visual information in order to understand where objects in the visual world are, with respect to oneself.[4] Visual neglect is an example of a failure in this process.

Executive function is the ability to anticipate, plan ahead, make decisions, self-monitor and change a plan of action. It is a function of the frontal lobes.[4] Defects in this area may results in poor social behaviour and judgement. Someone may have an inability to integrate behaviour and respond to changing situations appropriately and quickly.

Attention is a function of the executive system.[4]

Memory is the ability to store, recall and retrieve information.[4] Driving is a learned process that becomes automatic. Some correlation between driving behaviour and memory assessment has been found but not to the same extent as the function of the executive system and visuo-spatial perception.[4]

Tests of cognitive function

Cognitive function is particularly difficult to evaluate in relation to driving skills, because of its numerous components. Depending on the site of the lesion a stroke may lead to impaired perception, judgement, attention and the ability to make decisions. A defect in any of these functions is likely to affect the ability to drive.[4] Studies have looked at tests of cognitive function that may predict driving competence.

The correlation between visuo-spatial perception and the ability to drive safely is reported to be variable.[7–9] The incomplete letters test is a test of shape perception that requires patients to identify the correct letter from a picture of a patchy stimulus that approximates a letter.[4] This assessment was shown to be poor in predicting driving performance in 126 patients who had suffered a stroke:[7] when an on-road driving assessment evaluated driving performance, no significant correlation was found between the ability to carry out the test and driving performance.

The Benton visual form discrimination test is one of 12 neuropsychological tests used for screening and specifying the nature of central nervous system disease. The subject is presented with a number of geometric shapes of differing colours, for example circles, triangles and squares, and then required to correctly group together a common match, such as four circles of differing colour. The test was used in a group of 36 patients who had suffered from traumatic brain injury (TBI) or stroke. A good correlation between test performance and the outcome of an on-road assessment was reported ($p < 0.001$).[8]

Hunt *et al.*[9] reported on the use of traffic sign recognition in 38 normal elderly drivers. The test comprises 19 road traffic signs and 12 driving scenarios. The person taking the test is required to match the road sign to the corresponding scenario. The maximum score is 12. No pass score is quoted. The mean score for the group was 5 ± 3. A high correlation with good performance in this test and passing an on-road driving assessment was found ($p < 0.0002$).

A high correlation between executive function and performance in an on-road driving assessment has been

reported.[4] Gaski *et al.* reported a series of 35 stroke patients who had an on-road driving assessment. Two assessments of executive function, the WAIS-R block design and the Raven matrices test, were also carried out. The ability to perform these tests showed an excellent correlation ($p < 0.001$) with good or poor on-road driving.[10]

Block design is one of a number of tests that make up the Weschler Adult Intelligence Scale – Revised (WAIS-R).[11] The patient is given a series of four blocks which are all dark green on some sides, all light green on some sides, and half dark green and half light green on the remaining sides. The patient is shown a pattern and has to arrange the four blocks to reproduce the design. The examiner notes the patient's ability to understand the task, generate a solution and judge whether that solution is correct. The Raven progressive matrices test emphasises abstract, nonverbal intellectual activity.[11] The patient is presented with a picture or pattern with a missing portion and a number of substitutes. The task is to select the option that fits the space in the pattern. The task gets progressively harder with variations in colour, size and increasing complexity in the picture.

Visual inattention is a condition many orthoptists assess in stroke patients. Inattention is when the patient has reduced awareness of the body and visual environment on the contralateral side to the lesion. It is usually associated with right hemisphere lesions.[12] A number of different measures of attention such as the dot cancellation test and letter cancellation test showed a very high correlation with on-road driving ability in patients who had suffered a stroke.[8,13]

In a study of 307 patients who had suffered stroke or TBI the letter cancellation test showed an 80% predictive accuracy for classifying drivers as good or poor when compared with the result of an on-road driving assessment.[8] In a further study of 39 stroke patients the dot cancellation test showed a 95% predictive accuracy for grading driving performance at an on-road assessment as pass or fail.[13] In the dot cancellation test, the patient is presented with a piece of paper with groups of three, four or five dots arranged in rows. The task is to cross out all groups with four dots.

Cognitive test batteries

As many different components of cognition are required to drive safely it is perhaps more useful to have a group of tests that can be performed in order to assess the key areas of cognition, especially the executive system, that are required to drive. This would also encompass all those conditions which may have only one area of weakness that may be missed with one test but detected with a group of tests.

A number of test batteries have been designed to assess cognitive function.[14,15] Most are designed for specific populations, for example stroke or dementia. The batteries are designed to identify problems that need further and possibly specialist attention. They have been investigated in terms of their use in predicting driving competence.

The Mini Mental State Examination (MMSE) is a series of subtests designed by Folstein *et al.*[14] that is widely used in the clinic and rehabilitation units. The tests aim to assess orientation, attention, calculation, language and memory for objects. Orientation tasks relate to time and place. Questions include: How old are you? What date is it? Where are you? Language tests assess a variety of skills including the ability to respond to oral commands, repeating phrases, naming objects and writing. The tests are primarily used to detect the presence and progression of dementia.

A good association between driving performance at an on-road driving assessment and the scores achieved on the MMSE ($p = 0.004$) has been reported.[15] Nineteen subjects with suspected dementia of the Alzheimer's type performed the MMSE and an on-road driving assessment. Fourteen scored poorly on the MMSE, achieving a score between 19 and 24; 8 of these patients also failed the driving assessment.[15] Another study reported a group of 37 normal elderly subjects who had been referred for an on-road driving assessment following suspension of their driving licence.[16] They also performed the MMSE. Three patients failed the driving assessment and were found to have early dementia on the basis of the cognitive assessment. It is suggested that this test battery has little relevance for stroke patients because the battery was designed to detect cognitive defects that occur as a result of dementia not stroke.[4]

McKenna *et al.* reported on a cognitive battery of 12 individual tasks relevant to driving.[17] These areas included executive function and visual perception. In a study of 142 patients aged between 20 and 79 years who had suffered TBI or stroke, the test battery gave a positive predictive value of 92% for predicting those who would fail an on-road driving assessment. When considering age, the battery was far more accurate for younger patients. The test battery was 100% accurate in patients under the age of 70 years, but only 85% accurate for patients over 70, in predicting who would fail an on-road test. However, the test was not as accurate at predicting who would pass an on-road assessment: 85% of those under 70 and only 37% over 70 were predicted to pass the on-road assessment. The battery was considered to be useful in helping to inform the clinical decision as to whether a patient was safe to drive, but should be used with caution particularly in the elderly population.[17] It has not been marketed to date, in part due to the time-consuming nature of the test.

The Stroke Drivers Screening Assessment (SDSA) was designed as a screening tool to identify cognitive problems that could affect the ability to drive, and predominantly measures attention and executive abilities.[13] The tests were chosen for their relevance in investigating those areas of cognitive function needed to drive. The SDSA is performed when a patient wants to resume driving. The results are approximately 80% accurate for predicting those who would pass or fail an on-road driving assessment and are not affected significantly by age.[18] In a group of normal elderly patients, all the patients who were predicted to pass an on-road assessment by the SDSA did so.[19] The battery is very easy to administer and is used in some rehabilitation clinics around the country by occupational therapists, clinical psychologists and orthoptists.

At present, the DVLA has not recognised the SDSA or

any other battery as being clearly predictive of driving performance. Some driving assessment centres use the SDSA as a guide to aid their clinical judgement but this is not standard practice. The DVLA has commissioned a piece of work to further investigate the use of the SDSA with a view to incorporating it nationwide as part of the assessment of a patient before an on-road assessment. This would allow cognition to be fully assessed by a therapist prior to referral for an on-road assessment.

Conclusion

Cognitive function is clearly an important part of the ability to drive and evaluation of visual function alone is not sufficient to determine whether a patient is fit to drive. At present there is no cognitive test or test battery recognised by the DVLA that can be used by clinicians to clearly predict the capability to drive, and no guidelines on the level of cognition required to drive. It is prudent for an orthoptist faced with a patient's inquiry on resuming driving to direct the patient to the DVLA for advice and assessment.

References

1. British Orthoptic Society competency standards and professional practice guidelines for the extended role of the orthoptist: awareness of DVLA driving standards 2006, Section 2.11: 17.
2. The Stroke Association. Driving after stroke. London: The Stroke Association, 2000 [www.stroke.org.uk].
3. Driving and Vehicle Licensing Agency. For medical practitioners: at a glance guide to the current medical standards of the fitness to drive. Swansea Drivers Medical Unit, DVLA, 2005 [www.DVLA.gov.uk].
4. British Psychological Society. Fitness to drive and cognition. Multidisciplinary working party report 2001.
5. Akinwuntan A, De-Weerdt W, Feys H, Baten G, Arno P, Kiekens C. The validity of a road test after stroke. *Arch Phys Med Rehabil* 2005; **86:** 421–426.
6. Abreu B, Toglia J. Cognitive rehabilitation: a model for occupational therapy. *Am J Occup Ther* 1987; **41:** 439–448.
7. Galski T, Elhe H, Bruno R. Driving after cerebral damage: a model with implications for evaluation. *Am J Occup Ther* 1990; **46:** 324–330.
8. Simms B, O'Toole L. The contribution of cognitive and visual assessment to the prediction of driving performance. Transport Research Laboratory report no. PR50. Crowthorne, 1994.
9. Hunt L, Morris J, Edwards D, Wilson B. Driving performance in persons with mild senile dementia of Alzheimer type. *J Am Geriatric Soc* 1993; **41:** 747–753.
10. Galski T, Ehle, Bruno R. An assessment to predict the outcome of driving evaluations in patients with cerebral damage. *Am J Occup Ther* 1990; **44:** 709–713.
11. Gleitman H. Intelligence: its nature and measurement. In: *Psychology*, 4th edn. New York: W. W. Norton, 1995: 592–593.
12. Zoltan B. *Vision, perception and cognition*, 3rd edn. New Jersey: Slack, 1996: 45.
13. Nouri F, Tinson D, Lincoln N. Cognitive ability and driving after stroke. *Int Disabil Studies* 1987; **9:** 110–115.
14. Folstein M, Folstein S, McHugh P. Mini Mental State: a practical method for grading the cognitive state of patients. *Psychiatric Res* 1975; **12:** 189–198.
15. Fox G, Bowden S, Bashford G, Smith D. Alzheimer's disease and driving: prediction and assessment of driving performance. *J Am Geriatric Soc* 1997; **45:** 949–953.
16. Johansson K, Bronge L, Lundberg C, Persson A. Can a physician recognise an older driver with increased risk of crash potential? *J Am Geriatric Soc* 1996; **44:** 1198–1204.
17. McKenna P, Luke J, Dobson A, Frude N. The use of a cognitive battery to predict who will fail an on-road driving test. *Br J Clin Pyschol* 2004; **43:** 1–13.
18. Radford K, Lincoln N. Concurrent validity of the stroke drivers screening assessment. *Arch Phys Med Rehabil* 2004; **85:** 324–328.
19. Nouri F, Lincoln N. Validation of a cognitive assessment: predicting driving performance after stroke. *Clin Rehabil* 1992; **2:** 99–104.