The British
Psychological Society

Fitness to Drive and Cognition

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A document of the Multi-Disciplinary Working Party on Acquired Neuropsychological Deficits and Fitness to Drive 1999

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Foreword

A document of the Multi-Disciplinary Working Party on Acquired Neuropsychological Deficits and Fitness to Drive 1999. The main body of the report which follows was written by members of a Working Party appointed by the Professional Affairs Board, with contributions, advice and corrections from the Multi-Disciplinary Working Party.

Specific details of the Driver and Vehicle Licensing Agency's (DVLA) medical enquiry procedures and medical standards of fitness to drive were correct at completion of the document, but are revised at regular intervals. The interested reader is advised to contact the DVLA for the most recent information.

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1. Aims

This document concerns assessment of the driver with neuropsychological deficits acquired as a consequence of neurological conditions such as traumatic brain injury, stroke and dementia. Cognitive disabilitites arising from conditions existing since childhood, e.g. learning disability, will not be considered, although some of the contents of this document will have implictions for this group. It is the result of work undertaken by a Multi-Disciplinary Working Party in an attempt to gain understanding and further expertise in this difficult area.

The specific aims of the Working Party are as follows:

- To review the current state of the process of evaluation of fitness to drive in people with cognitive impairment, and to comment on the common features of the process for each of a number of relevant organisations and professions.

- To raise the issue of ensuring adequacy and thoroughness of information received by the Driver and Vehicle Licensing Agency (DVLA) during the process of decision-making regarding fitness to drive.

- To collect together and comment on published research work on the potential contribution of psychological, neuropsychological and Mobility Centre assessment procedures to the decision-making process.

- To disseminate information and knowledge regarding evaluation of fitness to drive as widely as possible within the clinical, statutory and voluntary fields to ensure a reference point for individuals and organisations working within this field.

- To offer guidance to organisations and professionals, with specific reference to Clinical Psychologists and Neuropsychologists, but also to other health professionals such as Doctors, Occupational Therapists and Nurses, and those Driving Instructors employed by some stroke and rehabilitation units, who may be faced with advising patients on issues of driving safety.

2. Overview

Individuals facing questions about their fitness to drive on medical grounds face a seemingly complicated process of investigation and advice. In practice, it is only DVLA which holds statutory responsibility for making decisions on licence-holding, but the driver comes into contact with a number of agencies from which he or she seeks information and advice. These include health and social care professionals, Mobility Centres and voluntary groups.

Co-operative liaison between care professionals, statutory bodies and Mobility Centres is important, therefore, to allow comprehensive and co-ordinated evaluation of driving abilities. As a result of concerns regarding their own individual roles in this co-ordinated process, a small group of interested professionals formed a Multi-Disciplinary Working Party to avail themselves of a wider knowledge base, and also to address potential difficulties inherent in the existing process of evaluation of driving safety. This Consensus Foreword is the culmination of this work and reflects the group's experience and perceptions of the ways in which different care professionals, statutory and voluntary personnel may co-ordinate their work in the most effective way.

Within the process of assessment, the licence-holder may be the least well-informed of all those involved, and is in need of guidance from the relevant agencies. In the case of people with acquired neuropsychological deficits, cognitive dysfunctions are particularly difficult to evaluate in relation to driving skills. Such conditions may place the individual licence-holder at increased vulnerability because of impaired insight (a frequent correlate of neuropsychological impairment).

3. Access to assessment

Statutory Procedures

The flow chart overleaf indicates the typical route for any medical enquiry regarding fitness to drive. The majority of decisions (possibly as high as 90 per cent) taken by Medical Officers of the DVLA are based on medical reports. Only borderline cases require driving assessment or an independent examination. A driving test is very rarely required.

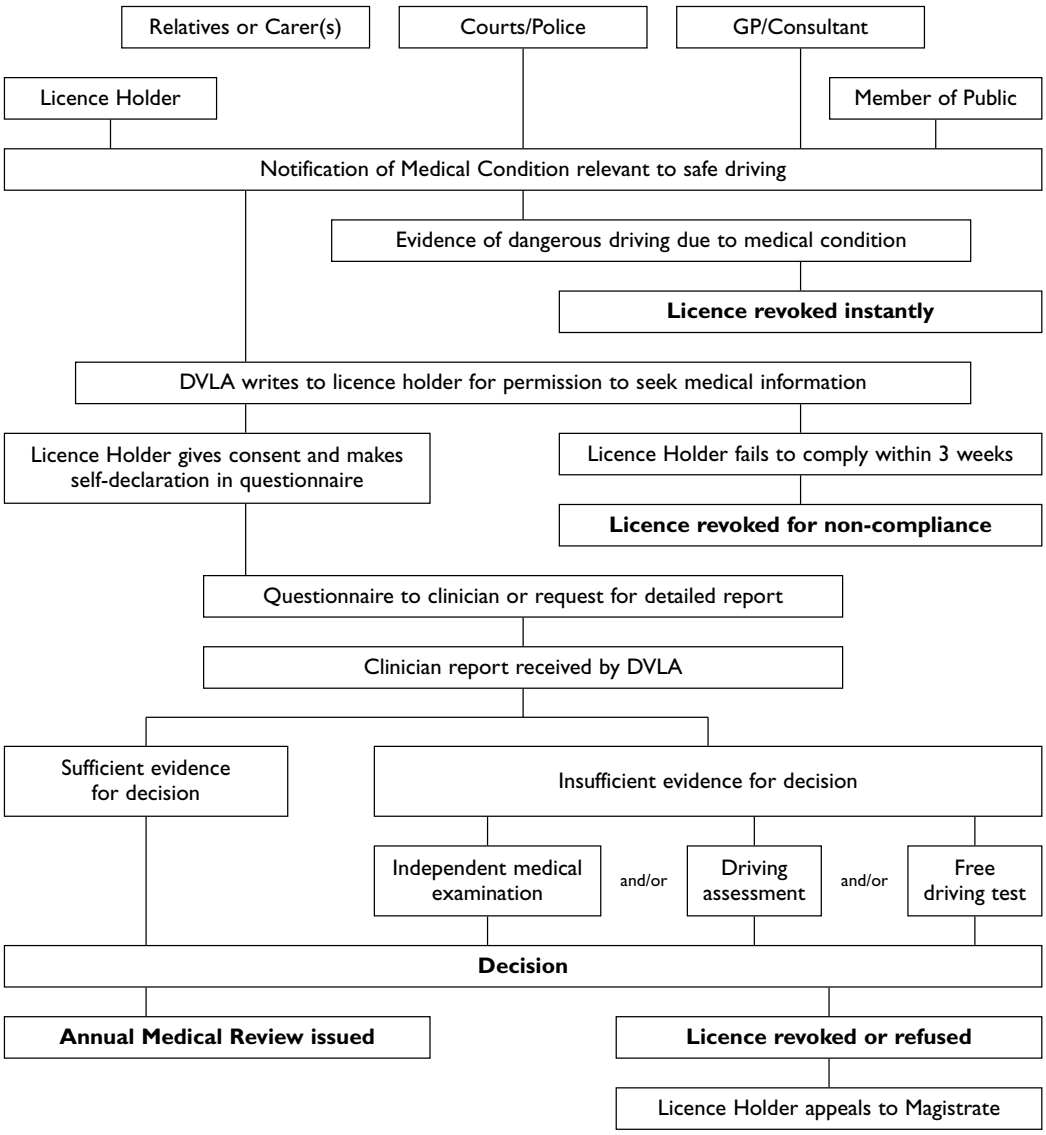
In cases of Licence Holders with medical conditions, staff at the DVLA fully appreciate that people may continue to drive after the licence is removed. When it is brought to the attention of the DVLA, Medical Officers refer the fact to the Police Liaison Department, who will be able to contact the local Police. Considerable efforts are made to ensure that this is a very sympathetic process, and usually the Police Officer will involve family members.

Clinical Procedures

Within a wide range of health settings, professionals need to be aware of the official guidance in order to remind patients of their responsibilities to inform the DVLA of their medical condition. Once this area of concern has been raised by health professionals, a client typically seeks guidance as to that professional's opinion of their likely driving safety, although the decision as to driving safety remains the responsibility of the DVLA.

During the process of clinical assessment for diagnosis or rehabilitation planning, knowledge will sometimes be gathered about a variety of cognitive functions such as visual perception, attention and memory. Such information is of use to the DVLA in their request for information from the physician caring for the patient, and – where available – is often included in information made available to the DVLA. (As already indicated, approximately 90 per cent of decisions made by the DVLA are based on such medical information.)

Medical enquiry procedure of the DVLA



There are two implications:

- The patient is normally aware that this information will be divulged to the DVLA once he/she gives permission for their doctor to be approached for information. This may have consequences for the relationship between patient and professional.
- Ethical professional responsibilities demand that information be shared with a patient, resulting in a discussion of the diagnosis and of strengths and weaknesses relevant to driving. Where such openness results in a patient making his/her own decision to stop driving without informing the DVLA (e.g. a patient with advanced dementia), this should be welcomed as an appropriate outcome, even though the DVLA have not been responsible for the decision.

A small audit undertaken by the Working Party illustrates the extent of licence holding in dementia clinic consultations, and is referred to later in the document. It is the view of the Working Party that where decisions made by the DVLA are based on medical information, the DVLA are entitled to expect a high level of quality and depth of such information. Key, detailed information regarding cognitive functioning should be available from skilled assessors. Such detailed assessments provide a more reliable basis on which decisions may be made, and it would, therefore, follow that where medical evidence is provided by a clinician, that clinician should make all reasonable attempts to obtain such detailed information from other professionals where appropriate. (Mobility Centres also make use of the results of such assessments as part of their comprehensive evaluation of clients.)

Pathways to Mobility Centres

The Forum of Mobility Centres is a self-regulating organisation of 13 Mobility Centres in Great Britain (which is currently increasing in membership size). Clients may refer themselves or may be referred for assessment by a GP, Consultant, DVLA or Motability (a charity which exists to facilitate the large-scale provision of appropriately modified vehicles at preferential rates to disabled people). One (NHS-run) centre asks every client to request a GP or Consultant to formally refer them. At the time of writing, all FORUM Centres ask potential clients to complete an application form. Unless the referral is from a medical source, all Centres ask for the client's consent to contact their GP and/or Consultant if necessary.

Mobility Centre procedure does vary a little from one centre to another, as described in detail in the document, but typically involves physical assessment (which always includes visual screening), cognitive assessment, and on-road driving, usually with an Approved Driving Instructor.

4. Conclusions

At present, no structure exists within the Department of Health to allow a specific remit to address mobility issues for people with neuropsychological impairments, which are currently addressed within the work of the Department of the Environment, Transport and the Regions (DETR). It is the view of the Multi-Disciplinary Working Party members that there is an imperative need for the Department of Health to take a more proactive perspective on the issue of mobility for patients with neurological conditions.

It would be helpful and appropriate for a Policy Division to be set up within the Department of Health which would:

- Encourage direct liaison across the Departments of Health and Transport for discussion of the clinical and statutory issues relevant to driving within a population of patients who have mobility needs;

- Drive forward statutory changes necessary to ensure the provision of high quality clinical assessment and advice to the DVLA.

There is a need to enhance the screening of Licence Holders with potential neuropsychological impairment in conditions such as traumatic brain injury, stroke and dementia. Despite limitations on the proven utility of screening in relation to driving, screening assessments nonetheless provide additional objective data to contribute to the existing processes for evaluating fitness to drive. Better co-ordination amongst health professionals and with these Government Departments offers opportunities to incorporate such screening within standard clinical procedures. Developments could expand upon good practice: e.g. Annual health screening of over 75-year-olds by General Practitioners; and others could relate to clinical governance and effectiveness issues, such as good practice in the use of standard outcome measures in the rehabilitation of patients following stroke or traumatic brain injury.

Summary

The following document describes:

- the current legal and notification procedures, and clinicians' professional responsibilities relating to health and fitness to drive, with particular reference to the assessment and management of people with cognitive impairment;
- the scale of the issue in terms of the epidemiology of major conditions causing such impairment;
- the state of knowledge about the collection of information relevant to fitness to drive using psychological, clinical neuropsychological and driving assessment methods;
- research needs, service issues and possibilities for the development of a co-ordinated response to the assessment of people with cognitive impairment.

Driving has a key role in people's lives for social and practical reasons. It is clear that medical conditions resulting in impairment to cognitive functions which control attention, perception, judgement and decision-making may affect driving competence. Traumatic brain injury, stroke and dementia are amongst the most common health problems of this kind, and although the latter are more frequently experienced in later life, old age *per se* is not incompatible with safe driving (see Retchin, 1998; Marottoli *et al.*, 1998; Brouwer & Ponds, 1994).

Drivers with health problems have a duty to notify DVLA of relevant medical conditions; and clinicians have responsibilities to advise patients of these duties and, in certain circumstances, to make disclosure in the public interest where road safety is compromised. Decision-making about fitness to drive in the presence of health problems is the responsibility of the Medical Advisers at DVLA, but they rely heavily on information from GPs and other health professionals about the extent and severity of relevant conditions. The assessment of cognitive problems is made complicated by variations in clinical judgement, and a lack of operational criteria and/or agreed assessment methods to inform responses made to DVLA.

Approximately 500,000 individuals present annually to DVLA for decisions as to their medical fitness to drive. It is not known what proportion of these have any form of neuro-logical damage, but there is a growing population of cognitively-impaired adults in the community. Changes in lifestyle over recent decades show that in future a greater percentage are likely to be, or wish to become, drivers. Indeed, they may be dependent on driving to maintain their lifestyle. Thus, there is clinical evidence of a growing need to assess reliably fitness to drive.

Different neuropsychological impairments result in different cognitive deficits. Moreover, two individuals with the same diagnosis may differ markedly in their clinical presentation and fitness to drive. Primary Care is the first point of contact for a majority of patients, yet the workload of GPs, their training and clinical relationship with the patient leave them ill-equipped to assess the cognitive factors relevant to driving. Within specialist clinical services, particularly clinical psychology, occupational therapy and psychiatry, a body of clinical knowledge and some research evidence is available to contribute to this assessment.

Driving skill and safety in the population as a whole has been the subject of considerable research. Attempts to describe the task of driving and define the psychological dimensions of the driving task within a general theory of driving have not resulted in a comprehensive body of knowledge. Novice, inexperienced drivers and both older and younger drivers experience the highest accident rates, but research is fraught with methodological difficulties owing to the infrequency of accidents as a measure of driving safety, and inaccuracies in self-report. Simulator research holds potential to yield accurate behavioural data, both for 'normal' drivers and drivers with acquired neuropsychological deficits; furthermore, simulator use may overcome issues of standardisation of the test, and the possibility of both very strong 'social desirability' and 'cueing' effects of an assessor's presence on the driver. In addition to such research on normal driving behaviour, recent work on three areas of assessment of the cognitively impaired driver is reviewed:

- Clinical research activity has investigated a wide range of neuropsychological functions and their relation to the driving competence of 'normal' and clinical populations. Results have indicated key areas of functioning which are critical in driving competence (including visual perception, attention and executive functioning), although at present no single test or battery can be recommended as clearly predictive of fitness to drive. Cognitive 'screening' tests are useful in identifying very grossly impaired functioning – e.g. in moderate to severe dementia – but have limitations to their usefulness in milder degrees of cognitive impairment.

- Driving test approaches using on-road procedures are fraught with difficulty in ensuring consistency under potentially variable conditions. Nonetheless, on-road testing is widely considered to be an appropriate 'gold standard' measure, though evidence is lacking for its predictive value.

- Specialist driving assessment and Mobility Centres have employed a wide range of procedures with variable validity. However, increasing standardisation, review and accreditation procedures are enhancing their contribution to driving assessment. Such Centres combine physical and practical driving assessments and usually incorporate some psychological tests of cognitive functioning – an approach which has its basis in the work of Clinical Psychologists and Neuropsychologists working in health settings with patients with acquired neuropsychological deficits.

In our current state of knowledge, a comprehensive system of assessments for the investigation of cognition and fitness to drive is still in the making. Further research needs to be undertaken to validate existing clinical neuropsychological assessments and psychological approaches derived for 'normal' populations against driving performance in both normal and relevant clinical samples. In developing such assessments, issues of standardisation, acceptability to users and brevity, must be considered.

It is suggested that a three-stage process could function effectively in 'funnelling' persons with cognitive impairments from initial screening, in Primary Care for example, through to a detailed assessment and finally referral to Driving Assessment/Mobility Centres, thereby maximising effective use of the latter resource.

- Initial brief screening by relevant health workers.

- A secondary more elaborate psychological/ neuropsychological assessment for cases of intermediate complexity.

- Specialist investigation by Mobility Centres.

Appropriate structures to co-ordinate expertise from and between health professionals, academics, Mobility Centres, voluntary bodies and the Departments of Health, and the Environment, Transport and the Regions could play an important role in fostering such developments.

1. Driving, health and the law

Notification procedures and professional responsibilities

Introduction

The ability and legal right to drive is taken for granted by most drivers. Legal requirements, however, impose strict conditions on driver behaviour and health. This paper addresses issues of fitness to drive in persons with cognitive impairments arising from neurological conditions acquired in adulthood as a consequence of central nervous system disorder or trauma. The following section describes formal notification procedures for drivers with health problems, professional responsibilities for clinicians and implications in the case of cognitive impairment.

The key role of driving. For a majority of adults in the UK today driving is an essential activity of daily living. It is a pre-requisite for many occupations and leisure activities, and a primary means of transport for individuals with reduced mobility. It is a crucial building block of self-esteem and social contact for many individuals and a bulwark against people's fear of crime.

> *'I need driving – it makes me feel part of the hubbub of life. It allows me to keep up a busy schedule and to travel to work comfortably.'*
>
> *'The loss of driving made me feel very isolated, unhappy and frustrated.'*
>
> *'[I need to drive]…for my independence and self-confidence…being without my car could lead to depression.'*
>
> Quotes from severely head injured people when asked about the importance of driving after injury – Newby (1996).

Driver health. Driver health is a factor in the ability to handle a car safely: conditions such as impaired visual acuity or sudden incapacity arising from loss of consciousness would clearly affect car handling. In the UK, all licences are issued by the Driver and Vehicle Licensing Agency (DVLA), which is responsible for making decisions on behalf of the Secretary of State for Transport. **In law it is the driver's duty to inform the DVLA of any existing or new disability which may affect driving ability.** However, many drivers are unaware of this, and medical practitioners have a duty of care to remind the patient of these responsibilities once a 'notifiable medical disability' is diagnosed; for example, some cardiovascular, psychiatric and neurological conditions, including epilepsy.

Neurological disorder or trauma. Neurological disease or trauma (e.g. dementia, stroke or traumatic brain injury) may result in permanent or deteriorating deficits in the inter-related neuropsychological functions which compromise the integrity of skills required to drive a car. These include the ability to carry out purposeful movement at will, to analyse the visual world, to focus attention, to process and retain information and communicate – all in a co-ordinated, speedy fashion.

There is a wide range of acquired neuropathological conditions including: traumatic brain injury; vascular disorders (e.g. stroke); degenerative disorders (e.g. dementias, such as Alzheimer's disease); progressive disorders (such as Multiple Sclerosis, Parkinson's Disease); toxic or metabolic disorders (e.g. alcohol-related disorders, neurotoxins); oxygen deprivation; infectious processes; and brain tumours.

Decisions about fitness to drive. Decision-making about medical fitness to drive is the responsibility and function of the Medical Advisers at the Drivers Medical Unit, DVLA. Guidelines to medical practitioners are regularly updated and published by the DVLA as *For Medical Practitioners: At a Glance Guide to the Current Medical Standards of Fitness to Drive*. This is a summary of legal requirements and the Secretary of State's Honorary Advisory Medical Panel's criteria of fitness in all the various disabilities. It is updated regularly as criteria are amended in the light of new knowledge. The document is available to medical practitioners; at the time of writing, the most recently dated guide is July 1999. Interested clinicians are advised to contact the DVLA for the most recent edition.

Once a patient has informed DVLA of a relevant medical condition, the Advisers request the patient's permission to contact his or her doctor (GP or specialist) for further information. The Medical Advisers are available for advice by telephone during office hours and welcome discussion on matters in relation to fitness to drive. Clinicians are not asked to make a decision about fitness to drive – one reason being concerns that this may damage the doctor-patient relationship. The clinician is expected to explain to affected patients that their condition may impair ability to drive, and that the patient has a legal duty to inform DVLA about the condition. The medical advisers then ask for information only from the practitioner, on which to base their decision. The *At a Glance Guide to the Current Medical Standards of Fitness to Drive* describes the decision process, for practitioners' use in responding to patient's questions, and emphasises that the licence holder/applicant should be referred to the Drivers' Medical Unit DVLA for decisions. Unfortunately, recent research (Gillespie *et al.*, 1998; Kelly *et al.*, 1999) suggests that many doctors' knowledge of the current licensing policy, medical restrictions to driving and actions to be taken is poor.

Three further problems arise, which are particularly acute for progressive neurological conditions, and/or where insight or compliance with advice is poorest (e.g. dementia):

1. The law requires that a patient notifies DVLA of a disability which may affect driving, as soon as a diagnosis is made. This is clearly stated on an individual's driving licence. However, diagnostic difficulties in many conditions causing cognitive impairment mean that (without specialist referral), GPs often only feel confident about diagnosis when the condition is of well-established severity. Even for more common conditions, such as dementia, accurate identification can present difficulties for general practitioners (see Section II).

2. Problems can occur with compliance with advice from a doctor that a patient should inform the DVLA of a relevant condition (see later). The patient may dispute the diagnosis or its relevance to driving, or be incapable of understanding or recalling the diagnosis and advice. For example, an audit of three Memory Clinic services (Bayer & Williams, 1998) found that, of 168 patients presenting with dementia, 21 per cent still held current licences at the time of diagnosis, though only 14 per cent were actually driving when seen. A detailed follow-up of 12 patients who were advised to inform DVLA of their condition, showed that only four of these did so without considerable further encouragement. Two drivers, about whose driving safety considerable concerns were raised, did not act to stop driving or inform the DVLA.

3. Once diagnosis and advice have been given about informing DVLA, further problems arise as a result of many patients' wishes to engage their doctor in discussion of the latter's opinion of their fitness to drive. Good clinical management requires an open discussion between practitioner and patient of any information which the former holds; as a consequence, a significant number of patients make a decision to cease driving rather than informing the DVLA. Thus, during the process of diagnosis and advising the patient on informing the DVLA, the practitioner is forming an opinion on the DVLA's question to him/her, 'whether or not the medical standards of fitness can be satisfied', and in some cases discussing this in detail with the patient.

Risk and confidentiality. In the case of a patient who disputes the diagnosis, the General Medical Council's (GMC) guidance to doctors about confidentiality (1995) describes actions a doctor may take if a patient refuses '*…to accept the diagnosis or the effect of the condition on their ability to drive, you can suggest that the patient seeks a second opinion, and make appropriate arrangements for them to do so. You should advise the patient not to drive until the second opinion has been obtained.*'

Lack of insight or recall may result in the patient's inability or failure to self-report to the DVLA when advised to do so by a medical practitioner. The same 1995 GMC

guidelines advocate disclosure to the DVLA when:
'a patient is continuing to drive contrary to medical advice, you should disclose the relevant medical information, in confidence, to the Medical Advisor of the Driver and Vehicle Licensing Agency.'

Other professions in health settings (nurses, occupational therapists, psychologists) hold similar legal and professional responsibilities where failure to disclose information may expose the patient, or others, to risk of death or serious harm, for instance, the British Psychological Society, Division of Clinical Psychology *Professional Practice Guidelines* (1995) note the example of driving when unfit as an example of disclosure in the public interest. The practitioner is reminded that they must be able to justify the disclosure on Road Safety grounds.

The DVLA *At a Glance Guide* provides an outline of the national medical standards developed by the Secretary of State's Honorary Medical Advisory Panels. The following are supplied for dementia or any organic brain syndrome and impairment of cognitive function: *'It is extremely difficult to assess driving ability in those with dementia. Those who have poor short term memory, disorientation, lack of insight and judgement are almost certainly not fit to drive. The variable rates of progression are acknowledged. Disorders of attention will also cause impairment. A decision regarding fitness to drive is usually based on medical reports. In early dementia when sufficient skills are retained, and progression is slow, a licence may be issued subject to annual review. A formal driving assessment may be necessary.'* (p.21)

'There is no single or simple marker for assessment of impaired cognitive function although the ability to manage day-to-day living satisfactorily is a possible yardstick of cognitive competence. When recovery is complete clinically, in car assessment on the road with a valid licence or on private motor circuits without a valid licence are an invaluable method of ensuring that there are no features present which are liable to cause the patient to be a source of danger, e.g. visual inattention, easy distractibility and difficulty performing multiple tasks. In addition it is important that reaction time, memory, concentration and confidence are adequate and do not show impairment likely to affect driving performance.' (p.30)

(*For Medical Practitioners: At a Glance Guide to the Current Medical Standards of Fitness to Drive,* July 1999.)

The assessment of severity in dementia and other forms of cognitive impairment requires considerable clinical evaluation and judgement of symptomatology. Operational criteria against which to undertake the task are generally lacking. There is agreement that a patient with severe dementia in need of high levels of care and attention for basic living has deteriorated beyond the lowest threshold for safe driving, and severe dementia is straightforward for practitioners to assess. However, this leaves a large number of individuals with mild to moderate conditions. It is precisely the element of clinical evaluation of the level of insight, judgement, significance of disorientation or loss of the ability to cope with day-to-day living which raises so many problems. In practice, professionals of many disciplines have a potential role in contributing to such judgements, taking into account a range of clinical and practical considerations.

The DVLA relies heavily on information provided by practitioners who best know the patient and his/her condition to contribute to a decision on whether a patient's cognitive skills fall below the lowest safe threshold for driving. Some doctors may feel unable to comment because of lack of detailed knowledge of the condition, or anxieties about the implications. As following sections will show, GPs may not be aware of cognitive impairment in their clients, especially if it is in early or atypical stages of development. Thus, GPs who do express an opinion to the DVLA may do so with varying degrees of specialist knowledge and accuracy. Where doubt exists, the DVLA Medical Advisers have recourse to request the driver to undertake on-road assessment at a Mobility Centre, or take the driving test in areas where locally-based centres do not exist.

Despite limitations, Mobility Centre evaluation is considered to be the appropriate 'gold standard' assessment at present. However, such assessments are currently available at only a few Centres in Britain (see Section III) although there are proposals to increase their availability in the future. Much current evaluation of drivers with dementia is undertaken as a clinical task, attempting to provide the DVLA with information relevant to driving competence from a close evaluation of both the patient's cognitive and daily living abilities. It is unlikely that the existing centres (even with an expansion of numbers) could effectively cope with the numbers of driving assessments required should the DVLA request this in all cases of cognitive impairment. Currently, therefore, there is reliance on the accuracy of practitioners' information to the DVLA medical advisors.

An unsuccessful attempt was made by Private Member's Bill in the House of Commons (*Hansard*, 1996) to introduce legislation requiring doctors to make direct notification of unsafe driving because of dementia to the DVLA immediately diagnosis is made. In addition to ethical misgivings, this attempt failed due to problems of:

- policing statutory medical practitioner obligations;
- accurate diagnosis and establishing the point at which driving becomes unsafe;
- damage to the doctor-patient relationship due to direct notification;
- a perception that current procedures were acceptable.

Nonetheless, it is crucial that practitioners' responses to questions posed by the Medical Advisers are based on well researched evidence of the validity of the clinical assessment undertaken. At present, more evidence exists for the usefulness and validity of cognitive and neuropsychological assessments than for doctors' opinions (see Section III).

The remainder of this Advisory Paper considers the extent of the problem of neurological impairment in demographic and clinical terms, and the complex issue of the relative merits and clinical contributions to be made by the variety of assessment procedures available.

II. The extent of the problem – neurological impairments and driving

Introduction

This section considers the impact of increasing road traffic and road system complexity on driving, and current demographic changes in the UK which will increase the numbers of drivers in the community who have neurological impairments. The implications of dementia, stroke and traumatic brain injury are considered in detail, as they are the most common acquired neurological deficits affecting fitness to drive.

1. Changes in the complexity of the driving task

Driving is an intrinsically complex task, combining well-learned routines with a requirement for the driver to respond flexibly and safely to unpredictable events. The driver must both mechanically operate the vehicle, and also respond to extensive information about other vehicles, fluctuating weather, light and varying road surfaces. Traffic volume has progressively increased accompanied by an expansion in roads and infrastructure, placing increasing demands on drivers and the psychological and physical systems involved in driving.

2. Impact of demographic changes

Projections of demographic changes in the UK (Office of Population, Census and Surveys, 1989) continue to show an increase in the older population, especially those over 75 and 85 years of age. The ability of older people to drive can be the source of debate, with often a public perception, influenced by accounts in the media of drivers with dementia, that older drivers are a particularly hazardous group. In fact, the rate of accidents in the US and the UK decreases steadily with age (Retchin, 1998). It is only after adjusting for miles driven that elderly drivers have a higher rate of accidents despite the fact that older drivers are more likely to avoid divided (dual carriageway) roads and drive mainly in congested towns amongst two-way traffic, in which the risk of collisions is likely to be higher (Janke, 1991). Older people are vulnerable to injuries and mortality as a consequence of crashes.

Over recent decades there has been a progressive increase in the numbers of older people who hold a driving licence (see Table 1). Askham *et al.* (1992) in their analysis of the 1988 General Household Survey noted that 51 per cent of the over 60s had access to a car, compared with 81 per cent of the under 60s. By the year 2010, it is estimated that the percentages of older people driving will be much higher, and more evenly distributed between the sexes in the 'younger old' cohorts.

Moreover, the greater life expectancy of older women, and their different driving histories will also have an impact. In terms of driving safety, an important result of these changes will be a corresponding increase in the proportion of people with dementia and stroke living in the community and driving on the roads.

Each year, the DVLA Medical Advisers deal with approximately 500,000 individuals with diagnosed conditions with the potential to impair driving performance. Unfortunately, figures are not available to establish the relative proportions of persons with neurological deficits in this sample. In attempting to define any relationship between neuropsychological impairment and assessment of fitness to drive, the diversity of types of impairment and prognoses must be recognised.

Table 1: Approximate percentages of UK population holding drivers' licenses in 1975/76, 1985/86 and 1989/91 by age and sex (from Bly, 1993; Maycock, 1997).

Age group	*1975/76 (%)*		*1985/86 (%)*		*1989/91 (%)*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*
30-39	84	49	86	61	89	67
40-49	82	38	85	57	89	66
50-59	74	24	80	40	85	50
60-69	59	17	72	24	78	34
70+	32	5	51	10	58	16

3. Neurological conditions and road safety

Dementia and driving – the nature and scale of the problem. Dementia is a symptom of many diseases rather than a condition in its own right. It is characterised by progressive intellectual decline, may occur at any age, but is most common in the elderly in whom it can be loosely defined as an unusual loss of mental function over and above that associated with 'normal' ageing (Bradshaw & Mattingley, 1995). Basic criteria include the development of multiple cognitive deficits, causing significant impairment in social or occupational functioning, and:

1. Memory impairment at all levels of encoding, storage and retrieval.

2. One or more of: aphasia, apraxia, agnosia, impaired thinking and judgement, constructional difficulties, and personality changes.

[For detailed criteria, see the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-R), American Psychiatric Association (1994).]

Hofman *et al.* (1991) reviewing European studies estimated a prevalence of dementia of approximately one per cent in those aged 60–69, four per cent at 70–79, 16 per cent at age 80–89 and 32 per cent at age 90 and over. However, a majority of these studies use methodologies unlikely to detect early dementias. Alternative methodologies suggest higher estimates. There is a corresponding increase in a broad range of other diseases and disabilities all with the potential to interact with driving performance, effects the problem of assessing fitness to drive.

Implications of different forms of dementia.
The implications of an increase in the numbers of people with dementia are far from straightforward. Firstly, the term 'dementia' subsumes a variety of conditions, characterised by different deficits and prognoses. Amongst the most common are:

- *Dementia of the Alzheimer type* (DAT) – progressive atrophy of the brain, of insidious onset, associated with senile plaques and neurofibrillary tangles in the brain. Characteristic cognitive problems centre on memory, language, object recognition, with difficulties carrying out practical tasks of daily living and general intellectual deterioration.

- *Vascular dementia* (VaD) – a vascular disorder, most commonly with infarcts (small strokes) occurring in the brain, causing a 'stepwise' pattern of deterioration – see also stroke, discussed later.

- *Frontal Lobe Dementias* (FLD) – in the initial stages of which changes in personality, impulsivity, motivation, organisation of behaviour and abstract thought predominate. Estimates of the relative proportions of these and rarer conditions are currently subject to much revision. (See DSM-IV for details of diagnostic criteria.)

- *Dementia with Lewy Bodies* (DLB) – a recently identified dementia, with a distinctive form of neurological deterioration, and a fluctuating pattern of symptoms, in which visual hallucinations and paranoid, or superficially psychotic symptoms may be an early manifestation.

On the basis of knowledge about the neurological structures and cognitive functions affected, different dementias will interact with the driving task in very different ways. (See references and Section on Neuropsychological Assessment.) DAT has probably been best described in terms of the observed changes to memory, language and impact on driving, but the course of the disease can still not be predicted with any accuracy. There are excellent grounds to suspect that decision-making about driving competence may be even more complex in some other conditions due to fluctuating presentation of cognitive deficit or due to the idiosyncratic location of particular damage to the individual's brain.

Despite the above differences, a majority of research has concentrated on those with presumed DAT, resulting in varying recommendations. Drachman and Swearer (1993)

suggest that the first two to three years of the illness are safe periods for driving (see also Trobe *et al.*, 1996). Tuokko *et al.* (1995) noted an increased crash rate in dementia sufferers with a four year history of symptoms compared to controls. In response to similar findings, Friedland *et al.* (1988) expressed the opinion that there is no period of safe driving in early dementia.

The difficulty of providing operational criteria for the cessation of driving, is typified by an international conference which attempted to achieve consensus regarding driving fitness in dementia (Lundberg *et al.*, 1997). The resulting document advocates a multi-agency approach to evaluation of the driver with dementia, including cognitive test results, instrumental activities of daily living (ADL) measures, informant's views of driving (usually carer), and dementia severity rating. The following was proposed:

1. Moderate or severe dementia: stop driving.

2. Mild dementia with associated functional deterioration: refer for specialist driving assessment.

3. Mild dementia with stable functional level: periodic follow-up only.

However, the consensus document was unable to provide operational definitions for the above categories.

Other progressive neurological conditions. Conditions such as Parkinson's Disease and Multiple Sclerosis also require mention. Although physical symptoms predominate in these conditions, and have themselves an impact on driving, a substantial proportion of sufferers show additional cognitive changes, including attentional disorders, deterioration in speed of processing and perceptual, memory and executive difficulties (see Lezak, 1995).

Stroke and driving – the nature and scale of the problem. Strokes, or cerebrovascular accidents (CVA's) are areas of localised brain damage, caused by obstructed blood supply or small areas of bleeding in the brain. Dependent upon the severity and site of the stroke, the patient may experience any of a range of physical and cognitive deficits, with implications for driving fitness. DVLA require that the stroke patient take at least one month off driving after the event and notify DVLA. The usual enquiry and decision making processes ensue. Strokes are a major cause of morbidity and mortality in the UK. Estimates of point prevalence of cerebrovascular (stroke) disease in people living at home in the UK suggest a rate of about 831 per 100,000 population, a total of approximately half-a-million people (Clark & Opit, 1994). Bonita (1992) reports that between 15 and 25 per cent of patients remain disabled to some extent after stroke. If the demographic changes outlined above are not accompanied by substantial changes toward lifestyles more protective against stroke, these figures are likely to increase.

The high incidence of residual mobility problems in stroke patients, enhances the importance of driving to the recovering stroke victim. Nouri and Lincoln (1992) have pioneered the development of a Stroke Driver Screening Assessment, which has made a substantial contribution to addressing the problem of screening those stroke patients unable to consider driving. Nonetheless, this screening will still produce some false positive and negative results, as it correctly predicts performance in just over 80 per cent of patients.

Severe traumatic brain injury – the nature and scale of the problem. Annually, an estimated 300 per 100,000 of the population present at UK hospitals with head injuries, though there is a two-fold variation between different districts in some regions (Tennant, 1995). Up to 70 per cent of head injuries are caused by road traffic accidents (Miller & Jones, 1985) and the long term consequences of severe traumatic brain injury often include physical, cognitive and personality changes. Since driving is considered by most adults to be an 'essential' activity of daily living, after a severe traumatic brain injury, it can often be an important symbol of returning to 'normal' post injury (Fox *et al.*, 1992; Newby & Tyerman, 1999). As such, the question of whether to return to driving post-injury is a common, complex and highly

emotive issue for head injured people themselves, their families and rehabilitation professionals.

Concerns from the clinical presentation of traumatic brain injury. A survey, following up 62 severely head-injured persons in contact with services in Southampton (Wilkinson *et al.*, 1989) found persistent difficulties which may impair safe driving. Psychometric testing highlighted memory difficulties and slowed information processing. 80.9 per cent of the Southampton sample self-reported memory difficulties; 47.6 per cent concentration; 45.2 per cent decision-making; 40.5 per cent problem-solving; and 38.1 per cent orientation difficulties; in principle, all skills/functions on which the driver may depend. Up to one third of Wilkinson *et al.*'s sample had changes consistent with damage to the emotional and behavioural control systems in the frontal area of the brain (i.e. affecting decision-making, impulse control, and personality, with aggression reported by 35.7 per cent – see also Krefting, 1989). Moreover, the Southampton survey participants under-reported their difficulties compared to close relations, reflecting a common issue of reduced insight following traumatic brain injury (Lezak, 1995) and difficulty in compensating for acquired problems (Prigatano & Schachter, 1991).

This variety of deficits, plus specific difficulties such as restricted visual fields and visuo-spatial misjudgements (Sivak *et al.*, 1981), raise intuitive concerns about the ability of head-injured drivers to cope with the vast array of information in the driving environment and to make rapid complex decisions. Of particular concern is the combination of impaired psychological systems used in driving and reduced insight and capacity to compensate for these deficits.

Identification of neuropsychological impairment. In practice, the identification of impairment is far from easy. Even identification of a condition as pervasive as dementia, is far from straightforward, especially in its early stages (see Lezak, 1995, for a discussion). The difficulty for GPs in accurately identifying dementia have been described in a range of studies (Brodaty *et al.*, 1994; O'Connor *et al.*, 1988; Illiffe *et al.*, 1991). Eefsting *et al.* (1996) found low sensitivity in the recognition of dementia by GPs. An average GP consultation lasts approximately 10 minutes (Fry, 1993), during which time it would be difficult, even for a specialist, to comment authoritatively on any cognitive impairment present, let alone on aspects which may be important for DVLA's assessment of fitness to drive. Even within the context of the national 'over 75s' primary care screening programme which aims to identify health problems in the ageing population, Chew *et al.* (1994) noted problems in the detection of mental health problems by GPs and their staff.

NHS services involved in rehabilitation and care of patients with neuropsychological impairment tend to focus on the basic activities of daily living required to enable a person to live independently, but do not routinely address the issue of driving. Resources to undertake complex (and frequently lengthy) neuropsychological assessments are very limited. It is noteworthy that Brouwer and van Zomeren (1992) and Newby (1996) suggest that a majority of individuals return to driving without considering the consequences.

Formal assessment of fitness to drive. Assessing fitness to drive in people with dementia, stroke, traumatic brain injury and other neurological conditions is particularly complex (see O'Neill, 1992; Reuben 1993; Madeley *et al.*, 1991; Pidikiti & Novack, 1991). A range of disciplines and organisations have expertise capable of contributing to the assessment of fitness to drive. However, there is no evidence that this clinical expertise can identify fit and unfit drivers with sufficient accuracy. As Fox *et al.* (1997) noted, retrospective surveys of driving and Alzheimer's Disease show that many people with DAT continue to drive and have a higher risk of crashing, but researchers are divided as to whether a diagnosis of DAT should preclude continuation of driving. Fox *et al.* found that, while 63.2 per cent of subjects with a diagnosis of probable DAT failed an on-road examination, 36.8 per cent were judged safe to drive. Reviewing the literature, van Zomeren *et al.* (1987) concluded that 'brain damaged individuals could not, in general, be seen as risky drivers'.

'Even the 'gold standard' of a detailed assessment by a qualified driving instructor may be unable to predict performance adequately; a patient assessed as a 'good and safe driver' was involved in 'two minor accidents within 24 hours' of assessment'. Wallace (1997)

A balance needs to be maintained between protection of the public, and over-restrictive reactions toward neurologically impaired drivers, who may be particularly dependent upon the car. Loss of a driving licence may have catastrophic consequences for an individual's capacity to live independently, to maintain social contacts and psychological well-being.

Evidence of risk to the population as a whole.
Reliable statistics outlining the extent of the problem, in terms of the relationship between road traffic accidents and neurological impairment are extremely hard to obtain. Attempts to assess the accident risk in relation to neurological impairment are problematic. At present, there is no mechanism to enable the routine collection of statistics relating medical impairment and accidents, though this need has been identified.

From a clinical perspective, it is clear that the assessment of fitness to drive causes clinicians considerable concern (National PSIGE Conference, Cardiff 1996: Wallace, 1997). As later sections of this document will show, research evidence shows limitations in the current assessment strategies of neuropsychological testing, driving simulators, off- and on-road driving assessment and specialist Mobility Centres.

III. Current approaches to assessing driving competence

Introduction

A number of different approaches to the assessment of driving competence have evolved over recent decades. To a considerable extent, these have developed independently from one another, driven only partly by research. This diverse development has probably resulted, at least in part, from the separation of the Health, Transport and academic organisations involved, as well as from the different models applied.

- General/academic psychological research has focused on identifying and promulgating safe driving in the 'normal' population. Approaches used have often attempted to approximate the driving task itself, increasing their acceptability for those assessed.

- Specialist clinical and neuropsychologists have focused on fitness to drive in clinical populations, often only as one part of a broad assessment of disability in the patient. As a result, they have used clinical neuropsychological assessments which were developed to identify neuropsychological deficits affecting a range of behaviour, and investigated their relevance to driving in their patients. However, they have made only limited attempts to investigate the relevance of these approaches to driving performance among the 'normal' population.

- Mobility Centres have adopted a variety of these clinical approaches and combined them with other assessments on a pragmatic basis, and with substantial practical expertise in assessing on-road driving.

The following sections describe these different approaches in some detail.

1. Behavioural/psychological skills underlying normal driving performance and their assessment

Much of the research on driver behaviour, almost since its inception in the early decades of this century, has been dominated by attempts to understand accident involvement using concepts such as accident proneness (McKenna, 1983). The only widely-cited model of driver behaviour is Michon (1979) which broadly distinguishes between three levels at which driver behaviour might be controlled, though some other approaches offer greater potential for understanding (Elander *et al.*, 1993; McKenna, 1982). These include, for example, the use of contrasting groups which differ in their likelihood of accident involvement, and exploration of the relationship between driving ability and various task indices (e.g. practice on task, task complexity) or psychological characteristics (e.g. personality, intellectual ability).

Predicting safety. Despite a number of very robust findings (e.g. greater accident rates per mile driven in younger and older motorists, and inexperienced drivers) little progress has been made towards a widely accepted description, let alone a predictive model, of driver behaviour. Consideration of the reasons for this lack of progress will help to identify issues which are also fundamental to the development of tools for the assessment of capacity to drive among motorists with acquired neurological deficits.

Firstly, serious road traffic accidents are rare events, often brought about by a range of aspects of the situation in which the accident occurs (e.g. presence of other vehicles, weather, vehicle condition, etc.) as well as the characteristics of the driver involved. Thus, the relationship between individual driver characteristics – including psychological capacities and propensities – and accident involvement will inevitably be less than perfect.

Secondly, although some findings are based on more reliable data, much psychological research measures accident involvement by drivers' self-report of the number of accidents or near accidents in which they have been involved in a given period. Leaving aside the motivations some individuals may have to misrepresent themselves, it has been shown conclusively that people 'forget' having been involved in accidents, even quite serious ones (Maycock *et al.*, 1996), and that near accidents are subject to even higher rates of forgetting (Chapman & Underwood, submitted). Since safety is usually assessed on

the basis of the number of accidents an individual has been involved in, related to the amount and type of driving undertaken – itself highly unreliable when self-reported – accident risk is an inherently unstable and unreliable index. Thus, because safety is very difficult to measure reliably, relationships between individual characteristics and accident risk will inevitably be small, and are likely to be inconsistent. Trying to develop a model of any task on the basis of unreliable findings which account for small amounts of the variance, is itself an unreliable research undertaking.

Thirdly, a recent overview of research on driving shows clearly that it involves not only perceptual-motor skills, but a range of cognitive and personality variables (Groeger & Rothengatter, 1998). A complete account of driving would ultimately require a comprehensive understanding of the whole of human behaviour in terms of this very broad array of variables, which at present is far from complete.

Measuring driving ability. Models of driving operations and their relation to 'Neurological functions' have been reviewed by Groeger (1999). There exists no widely accepted general theory of which psychological characteristics are necessary and sufficient for an acceptable standard of driving ability. Here it is not possible to do more than identify some of the more promising approaches, and their associated difficulties.

Researchers aim to measure driving abilities mainly from self-report questionnaires, driving simulation with varying degrees of fidelity (e.g. video tapes to full-size moving car rig), and actual driving on public roads or restricted locations (e.g. closed roads, test tracks). The reliability and validity of the measures vary considerably, but it is clear that measuring performance in conditions that are similar to those in which the individual will later perform optimises the likelihood of being able to predict driving behaviour. Although this would point to the need for assessment of driving on public roads, two important limitations occur. The first is that standardisation of assessment is very difficult for reasons discussed in the following section on 'Road and Simulator Approaches'; secondly, that for ethical reasons one may be reluctant to expose people to threatening situations.

One attempt to deal with this issue is to use video simulation methods. McKenna and colleagues have used this technique to assess speed choice, close following, gap acceptance and hazard perception. The results show considerable promise as a complementary package for driver assessment (Horsewell & McKenna, 1999).

Groeger, Hammond and Field (1998) describe the development and validation of a computer-based battery of psychological tests (i.e. perceptual, motor and visuo-spatial abilities, attention, hazard perception, personality, attitudes) which might be used as a basis for driver assessment. The initial version, developed on a representative sample of 400 drivers, took about three hours to complete, but was remarkably effective at predicting how a subset of 100 'normal' drivers drove on public roads when supervised by an experienced driving examiner. A subset of tests accounted for about 45 per cent of the variance in driver assessments, which would considerably shorten the battery and, with more extensive validation, might be used as a basis for initial assessments of driving related abilities. This makes a potentially useful partner to the on-road assessment (see later), but cannot replace the skills brought to the latter by a skilled driving assessor.

It is well known that the experience of observation by another can produce social desirability effects, and mask true behaviour. Unintentional 'cueing' effects (e.g. enhanced motivation and maintenance of concentration) may also occur for drivers undertaking a drive with an assessor. For both these reasons, the presence of an assessor may result in 'false positive' performance among drivers with acquired neuropsychological deficits which may possibly be overcome by unobserved computer-based testing. Assessing drivers in less socially constrained circumstances, e.g. using computer-based testing, therefore, might be a useful supplement, perhaps even precursor, to on-road assessment, although it is not yet known whether such testing does in fact significantly diminish the social desirability effect.

2. Neuropsychological assessment of fitness to drive

Within the clinical population, some individuals will no longer be safe to drive because of motor and/or cognitive deficits. As cognitive impairment is a critical factor in determining driving competence, it is essential to assess any relevant deficit. For clinicians it is a comparatively easy task to separate those clearly at risk when tests reveal multiple deficits which are severe. It becomes far more difficult to identify the level at which moderate or subtle neuropsychological deficits compromise driving. To aid this process, neuropsychological research is becoming more clearly informed by current understanding of brain function and by the specific patterns of neuropsychological breakdown found in different clinical groups. At present, no cognitive test or test battery can be recommended as clearly predictive of fitness to drive.

Over the last 20 years, a considerable international literature has developed on the neuropsychological correlates of fitness to drive (for most recent review, see Christie, 1996; McKenna, 1998). Much of this work is ill-informed by theory. Global measures of intelligence, language functioning, memory and perception have been applied to diverse clinical groups of people, ranging from small groups with circumscribed pathology to large groups with heterogeneous pathology to their nervous systems which might compromise their safety on the road. The methodology used is diverse and rarely comparable across studies (see appendices for samples). Researchers have mainly relied on widely used, familiar tests rather than seeking to develop tests with a particular relevance to the skills involved in driving. Where such tests have been developed, test batteries have not always been suitable for the clinical context, due to their excessive length, use of expensive or specialised equipment of limited availability, and reliance on fine motor skills which may discriminate against neurological patients. The relevance of some battery items to driving can also be difficult to convey to the patient, and physically frail patients could be unduly fatigued and stressed by an exhaustive battery: both these factors may result in reluctance to participate in what may be seen as an irrelevant procedure. Overall results from research have often been contradictory and confusing. **Despite some consistency in findings within specific cognitive domains, the main general conclusion that can be drawn is that the greater the neuropsychological deficit, the more likely it is that the person is unfit to drive.**

Contemporary research has begun to recognise how much a lack of specificity has hindered progress. For example, if tests of visuospatial ability are given to a heterogeneous group of people then any group effect may be concealed by the greater numbers of individuals who do not have the deficit and perform normally on the test. This has led researchers to focus more selectively on identifying specific cognitive functions which may be implicated in driving, and then testing out the relevance of these functions by targeting clinical groups known to have damage predominantly in the cognitive systems under question. For example, Nouri and Lincoln (1993) found that the Stroke Drivers Screening Assessment correctly identified 81 per cent of safe drivers post-stroke (evaluated by on-road driving instructor assessment), compared to GP's correct identification of only 56 per cent of safe drivers. Other examples would include targeting patients with parietal lobe damage for visuospatial function, and patients with frontal lobe damage to explore the effect on driving of executive function difficulties. Not only type of deficit but degree of deficit is also important. This is becoming particularly salient in the older adult population where there is an urgent need to establish the threshold of cognitive impairments in neurodegenerative conditions which render the individual unsafe to drive (Rees *et al.*, 1995; Lundberg *et al.*, 1997).

This approach has presently led to examination of those basic neuropsychological skills which are clearly implicated in driving, particularly visuoperceptual processing, the organisational skills which underlie monitoring appropriate behaviour, and attention in the traffic situation. Ongoing UK-based research is currently underway at four main Driving Centres: Mobility Advice and Information Service (MAVIS) at Crowthorne, Rookwood (Cardiff), Derby and Banstead (Surrey). Some recent Belgian research, reported

at MAVIS, suggested that results on certain neuropsychological tests were more successful in differentiating between older drivers with and without specific types of accident involvement (De Raedt, 1999).

A brief description of the relevant skills as they are presently understood are given below together with other areas of neuropsychological functioning which have been considered in the driving literature. Fuller descriptions and relevant tests and research findings from the driving literature are given in the appendix.

- **Perception: visual analysis of the three dimensional world.** This includes two separate neuropsychological functions, visuo-spatial ability to determine where things lie in relation to each other and oneself, and three-dimensional shape perception to identify objects in a constantly moving scene from different perspectives.

Implicit in these functions is the ability to monitor consistently incoming signals from all areas of the visual field in a symmetrical fashion. A not uncommon form of failure in this process following brain pathology is visual neglect, when the individual's attention is decreased or absent for events in the side of space contralateral to the lesion. This is more usual in people who have sustained damage to the right hemisphere with consequent neglect of the left side of extrapersonal space (beyond one's immediate reach), peripersonal space (within reach) or personal space (within one's body space). Ogden, (1985 and 1987) and Vallar *et al.* (1994), (cited in Bradshaw & Mattingley, 1995) found approximately one-third of right hemisphere-damaged stroke patients exhibited unilateral neglect. In its severe form it will be easily detected in everyday life when an individual will bump into objects on one side, misread clocks or miss food on one side of a plate. Milder forms of neglect will not be so apparent in daily activities, yet are still likely to affect driving ability, especially as the moving environment whilst driving requires increased speed of information processing.

Case example: *A client at an early stage of recovery but eager for driving practice and by way of providing evidence for her readiness, reported that she had successfully driven a horse-drawn carriage with ease, supervised by an equestrian friend. Knowing that visual neglect was still evident (together with some elements of a dysexecutive syndrome) she was probed about the reaction of her companion to this effortless success. 'Oh she is always a bit dramatic' came the response and when asked for clarification – 'she got noisy when I drove up a bank', thus illustrating her lack of insight into her neglect.* McKenna (1998). Source: Rookwood, Driving Assessment Centre, Wales.

Sivak *et al.* (1981) found restricted visual fields and impaired visuo-spatial judgement in many of the head-injured population. Research by Hunt *et al.* (1993) and Galski *et al.* (1992) have demonstrated correlations between performance on tests of visual perception and on-road driving assessments. Similarly there is evidence that different tests of neglect can achieve 80 per cent and 95 per cent accuracy respectively in predicting classification of on-road driving performance (Simms & O'Toole, 1994; Nouri, Tinson & Lincoln, 1987).

- **Executive or frontal lobe system: Ability to monitor cognitive processes and behaviour.** The ability to adapt behaviour to meet environmental demands depends on the 'executive system', which governs ability to anticipate, plan ahead, make decisions, self-monitor, and change a plan of action, sometimes instantaneously. These skills are essential in monitoring and adapting to the traffic situation, both in terms of carrying out vehicle manouevres and responding appropriately to other road users. See O'Toole (1997) for research describing prediction of driving performance from performance on selected tests of executive function.

- **Attention.** Though most likely a function of the executive system, 'attention' has traditionally been a topic in its own right with a substantial body of research and literature. Attention involves the ability

preferentially to select relevant information from the sensory array for processing and the faculty to maintain task orientation across one or several tasks. Attentional deficits are one of the most obvious short and long-term sequelae of brain damage (Wilkinson, Fisher & Bronfield, 1989; Fox, Bashford & Caust, 1991). Parasuraman and Nestor (1993) suggest poor attention may be an early clinical indicator of Dementia of the Alzheimer's type. Even a cursory functional analysis of driving highlights the need for the driver to attend to a huge array of information such as other vehicles, fluctuating light and varying road surfaces, and in-car instrumentation. However, to date, research has not provided more than moderate correlations between assessed attention and driving outcome. See Groeger (1997) for a review.

- **Action: The ability to conceptualise and carry out a movement at will (praxis).** Tests of limb apraxia involve tasks such as copying hand movements, producing gestures and miming the use of objects. Gross difficulties with praxis present as impairments and deficits in everyday activities such as dressing, use of scissors/tin opener, etc. Patients with such gross deficits do not typically present for driving assessment, but mild problems may remain undetected without specialist assessment. Using different measures of praxis, Galski *et al.* (1992) and Nouri and Lincoln (1992) respectively, found correlations with on-road driving, and were able to discriminate between those achieving pass, borderline and fail categories when on-road driving was assessed. This area is under-researched at present and further work is necessary to establish the relevance of milder forms of apraxia for driving safety.

- **Language: speech and comprehension of communication.** It is reasonable to expect that globally severe difficulties in language and communication skills may be indicative of marked general cognitive impairment which can compromise driving skills. It is less clear if focal linguistic deficits (such as receptive or expressive dysphasia or anomia) have very much bearing on driving skill.

  Case Example: *At an Assessment Centre a driver could not complete any of the pre-drive tests due to expressive and receptive dysphasia which was fairly global. Simulator tests, medical interview and formal visual assessments were all compromised. Practically, he had been observed to be competent in his general activities of daily living. Formal testing was abandoned and in-car assessment introduced early. He gave an excellent drive supported by hand signs to give directions*. Vernon (1998). Source: Banstead Mobility Centre, Surrey.

The appendix contains details of a number of studies investigating correlations between verbal tests and driving outcome, three report no correlation or discriminatory function, but Hunt *et al.* (1993) and Simms and O'Toole (1994) found associations between driving ability and specific aphasia assessments.

- **Memory and learning: for recent and past events.** The term 'memory' encompasses a broad range of functioning covering the registration, encoding, storage and retrieval of information. Whilst some memory deficits have been found to compromise safety (O'Toole, 1997; Galski *et al.*, 1990; Hunt *et al.*, 1993), isolated memory impairments for episodic events and places may not be an absolute bar to driving. Some memory test elements are also subsumed under the following section 'Generalised Cognitive Impairment'.

In addition to research and knowledge concentrating on the above specific cognitive domains, other work has taken a broader approach to cognitive impairments, by adopting existing screening assessments designed to identify clinically significant levels of generalised impairment. These approaches are summarised below:

- **Generalised Cognitive Impairment.** Although not assessing a specific function, cognitive screening tests, which are widely used in both research and clinical contexts, have also featured in the assessment of fitness to drive. They usually comprise a number of test items covering orientation, memory and language.

Their use may have some relevance as prior screening before specialist assessment is sought. Lundberg *et al.* (1997) reviewed the utility of the Mini Mental State Examination (Folstein *et al.*, 1975), but could only reach a majority opinion that 'some cut-off levels can cautiously be proposed in the context of decisions concerning future driving, albeit with some reservations'. Such associations have been found with other screening tests (see Appendix).

3. Practical assessment of driving ability

An earlier section has described the lack of research demonstrating an unambiguous relationship between on-road driving assessment and crash involvement. However, practical driving assessments remain a key aspect of the process in enabling DVLA Medical Advisers to make decisions in complex or doubtful cases. Clinical and neuropsychological assessments of an individual's cognitive function will give rise to results which need to be evaluated by in-car performance on public roads. However, it is difficult to set up and score a standardised on-road evaluation: driving conditions vary with respect to traffic volume, weather, time of day, and light conditions. Expertise and knowledge of cognitive functioning are necessary, if a driving assessor is to accurately evaluate the less apparent, subtle cognitive deficits relevant to driving. Assessors need also to remain objective in the observation of driving competence, uninfluenced by expectations based on knowledge of a driver's previous experience. The following outlines:

- **Assessment methods** utilised to investigate driving skill both by researchers and within Mobility Centres.

- The procedures used, and organisation of **Mobility Centres** in the UK.

Practical driving assessment methods under road and simulated driving conditions

Static rigs. Many Mobility Centres employ 'static rigs' (usually a section of a car with steering wheel, pedals and a variety of adaptations, connected to a screen viewing a static traffic scene). Such rigs give measures of motor strength, reaction and decision times, and co-ordination, though minimum standards for acceptable performance have not been standardised.

Interactive driving simulators. Simulators may be a more sophisticated way of obtaining standardised results for some aspects of driving, such as car handling (see also Section III). However, there is a dearth of well-designed studies comparing road and simulator approaches with clinical populations. Nouri and Tinson (1988) compared driving performance on a simulator with on-road driving in stroke patients, finding a low correlation. Thus simulators may not be predictive of actual driving. An additional problem has been that some people experience significant levels of nausea when undertaking simulator tests, inevitably impacting on driving performance.

Off-road tests. Various slalom courses, braking exercises and manoeuvres off-road have been tried for the assessment of driving in brain-injured and older drivers (e.g. Korteling, 1990; Stokx & Gaillard, 1986). However, these are of questionable validity given the differences between off-road driving assessments and on-road driving, where the driver must respond to other traffic and take initiative.

The standard Department of Transport driving test. Despite its critical status as the test of readiness to drive independently for all learners, the driving test cannot be fully validated without an experiment in which drivers committing 'dangerous' errors during the driving test, are allowed subsequently to drive on-road and their accident involvement monitored. This would obviously be unacceptable. However, some information is available, in the form of accident statistics in those who pass. Forsythe (1992) has indicated that 70 per cent of drivers re-taking the test would fail.

There remains the question as to whether re-taking the standard Department of Transport Driving Test is a valid measure for clinical populations. Christie (1996) in TRL report 208 states:

'Little work has been done on assessing the validity of the standard driving test as a measure of safe driving style among brain-injured drivers…It is questionable whether a normal driving test would be able to pick up any abnormal psychology…like lack of insight, impulsivity and aggression which may affect a driver's ability to drive safely under certain conditions.'

On-road tests. Various on-road assessments have attempted to develop standardised methods of scoring, e.g. Brouwer and Withaar's (1999) scale (the 'TRIP') to investigate driving and cognitive impairment in older drivers, which shows some correlation with accident involvement (De Raedt, 1999). Other approaches use specific routes, and/or include self-directed driving. Directional instructions unavoidably cue the driver to undertake appropriate manouevres and the experience of driving assessors is that individuals with some cognitive impairments, if left to drive without direction, tend not to notice junctions and other important aspects of the environment.

Case example: *The police returned an elderly gentleman to his home town after he became lost and confused on the motorway. He had been on his way to visit relatives at a coastal resort. He had coped with the drive regularly over recent years, but it transpired that he had been dependent upon directions and prompting from his wife at each stage of the journey. His first solo trip following her recent admission to hospital exposed his developing dementia.* Watts (1998). Source: Mental Health Services, Greater Manchester.

Ideally, undirected driving (i.e. a period of driving in which the driver is not cued by the assessor to respond to traffic and road conditions as they arise) should be included during any on-road test. Tests of driving ability need to include situations which mirror the real life complexity of driving situations and can expose cognitive deficits. However, there is as yet no agreed protocol for assessing actual driving performance, offering the potential for large variance in practice.

Self and family assessment. Anecdotal reports from attendees at Driving Assessment Centres suggests that many try driving again by themselves on quiet roads. However, McKenna, Stanier and Lewis (1991) have shown the unreliability of self-assessment of driving skill in all drivers and hence the very likely inadequacy of self-assessment in the neurologically impaired. Carers and family can be a useful source of information, but may lack this insight too, or may also have vested interests in maintaining the patient as a driver, to maintain their own lifestyles (Rees, Bayer & Phillips, 1995).

Mobility Centres

The actual experience of neuropsychologically-impaired individuals referred for assessment by DVLA is necessarily variable. Firstly, the licence holder answers questions about the disability and this may be sufficient. GP or consultant information follows and usually this combination of evidence is sufficient for a decision to be reached. If further assessment is required, this is achieved by referral to a FORUM-accredited Mobility Centre, described more fully below. The driver may be asked to re-take the driving test, but this is a rare option, usually for geographical reasons.

Mobility centres offer people the opportunity to seek professional help regarding their ability to learn to drive or to return to driving in safety following brain injury. In response to increasing demand, there has been a steady growth in the numbers of Mobility Centres over the last ten years. A group of centres under the self-regulating umbrella organisation, FORUM, have representatives who meet regularly to discuss standards of practice and models of assessment. Many of the Mobility Centres have been assessed by FORUM representatives in an accreditation process. A recent review (Fowler, 1997) indicates that all accredited centres are committed to providing a high quality service in helping meet the mobility needs of disabled and elderly people. A 96 per cent satisfaction rate is reported in clients of these centres.

Currently, Mobility Centres are using assessment procedures that their staff have developed based upon their experience of what is required to evaluate driving potential. There is inevitably some subjective bias to this and procedures vary from centre to centre. It is noteworthy, that many Centres do not have access to a variety of medical and related professions. All 13 currently accredited centres and associate members employ Approved Driving Instructors. Relatively few of the accredited centres employ a doctor, whilst a majority have occupational therapists, either of which profession may currently undertake some cognitive assessment.

Most Centres request a GP report to inform their assessment, the length of which varies from one to six hours. In accredited centres, physical assessment is routine for all clients. A standard written report is provided following assessment, giving advice and recommendations about driving potential, the need for adaptations and retraining. All centres assess the client's ability to read a number plate at 20.5 metres (the legal requirement), but others may undertake detailed assessment of vision or arrange further referral if their initial screening indicates a need.

Formal cognitive assessment is routine in eight of the accredited centres, though others may refer on for specialist assessment if thought necessary. Skilled psychological testing is very under-represented as only one accredited centre currently employs a psychologist on a consultancy basis, to oversee testing by other staff. There has been liaison between centres about which cognitive assessments are most relevant and predictive of driving ability, as yet there is no consensus about which tests should be used. The extent of cognitive assessment is likely to be a reflection of staff and time factors as well as local knowledge about the neuropsychological correlates of driving ability. All accredited centres must follow the FORUM's driving assessment protocol, which stipulates testing for inattention and cognitive deficits, visual-perception; some may also investigate receptive language, praxis, executive functioning and memory. At least three centres may select and use cognitive tests from the Stroke Driver Screening Assessment (Nouri & Lincoln, 1993).

There appear to be two major needs for psychological input in this context. Firstly, the above professionals may have limited expertise in the assessment of complex neuropsychological impairment. Some form of access to specialist cognitive assessment via psychology is warranted for some centre clients. In addition, psychological knowledge of neuropsychological impairment is a rapidly evolving field. At present there is no overt, formal mechanism to feed the developments from this area into the procedures used by driving assessment centres.

FORUM and Motability (a charity which exists to facilitate the large scale provision of appropriately modified vehicles at preferential leasing rates to disabled people) are keen to standardise assessment procedures and are moving towards this with new standards for accreditation, applied in 1998. It is likely that it will be necessary for all accredited centres to have at minimum a trained occupational therapist and driving instructor. Occupational therapists currently undertake the majority of cognitive assessments at mobility centres (in addition to such work in clinical rehabilitation settings). FORUM has set up a working group to develop and validate a standard battery of cognitive tests for use in mobility centres, on which clinical psychologists are collaborating closely with occupational therapists.

IV. Future research needs and implications for clinical practice

Introduction

Clearly, there is a relationship between cognitive impairment and driving ability. The evidence from neuropsychological tests is not sufficient to give hard and fast recommendations about which functions to assess, how these functions might be assessed, and the degree of deficit that is likely to affect driving safety. Further research needs to define the nature and level of cognitive impairment that will affect driving performance and to indicate which assessments will detect that level of impairment in the most efficient and valid manner. In order to do this, cognitive assessments need to be validated against driving performance in normal and relevant clinical samples.

Ideally reliable, valid, initial screening procedures, when developed, could be used by clinicians and a more detailed cognitive test battery to be used by specialists and/or Mobility Centres. The purpose of the former is to collect information to contribute to a decision to classify as fit or unfit to drive. (Those who are unfit would be those with global cognitive deficits so severe that it is not appropriate to refer them to a specialist assessment centre. This would save scarce resources at specialist centres and prevent unnecessary distress, putting those who are very likely to fail through a lengthy assessment process.) If sufficient information is provided in this way, this may preclude the necessity for assessment at a specialist centre.

Existing neuropsychological tests are essentially static tests, and in contrast, driving is a dynamic task, and one which in comparison is highly practised. Ideally, tests should appear as relevant as possible to the actual task of driving. Thus a promising approach involves investigation of the validity, for those with cognitive impairment, of 'naturalistic' driving assessment procedures evolved to evaluate driving in 'normal' populations.

General clinical responsibilities for Clinical Psychologists. Given the uncertain state of our knowledge so far, the needs of the client are best served by an organised policy-driven approach which would include the following:

- routinely incorporating the issue of driving at interview with clients and, where necessary, relatives and other carers;
- seeking and providing accurate information about clients' legal responsibilities;
- providing relevant literature (e.g. information leaflet on driving after stroke available from the DVLA, other driving leaflets published by voluntary organisations such as *Headway, Alzheimer's Disease Society, Stroke Association* and the *FORUM of Mobility Centres*);
- liaising, where necessary, with relevant health workers (particularly general practitioners and social workers);
- provision of advice and information to other health staff about screening for relevant neuropsychological deficits.

Neuropsychological testing

1. Screening. The use of a single screening test is inadvisable except to confirm impairment in a patient who is clearly performing at a very low level. Allowing for the limitations of the research which attempts to establish screening procedures, the clinician may wish to utilise:

- histories from third parties;
- evaluation of activities of daily living (see research in the Netherlands by Brouwer & Withaar, 1999);
- tests of general cognitive status as embodied in the MMSE, CAMCOG, etc. (see Appendix) and/or tests of more delineated functions such as the Stroke Drivers' Screening Assessment.

At the clinician's discretion and, depending on the client's particular pathology, tests of visual-spatial ability, space perception, attention and the executive system as well as praxis skills should all be considered. At this stage of our knowledge, a valid alternative to using tests from the evidence-based list at Appendix, is for clinicians to select

those tests of the above functions with which they are familiar with administration and interpretation.

2. Constructing Specialist Batteries. Experience from both the clinical and experimental setting has highlighted the need for specialist batteries to include the following general characteristics when considering test inclusion:

- they are sufficiently easy for the vast majority of the normal driving population to do well (and have specific norms from a driving population as well as the general population);
- they clearly identify a specific neuropsychological deficit;
- the cut-off between normal and pathological performance is clear;
- they can be completed by people with impaired motor or language function;
- they are short;
- consideration should be given to incorporating tests which assess procedural skills in a dynamic rather than static fashion.

Assessment at specialist centres would include cognitive testing to define more precisely the nature of the cognitive deficit and to identify the likely consequences of that deficit when assessed on the road. These assessments could include those developed for the assessment of 'normal' drivers.

To achieve such a system, research needs to address the key components of the two levels of assessment outlined above, and the most appropriate mode of delivery. That is, the relevant cognitive and behavioural tests that should be incorporated in a brief screening instrument and in more elaborate secondary assessment need to be identified, through research with clinical and 'normal' populations.

Methodological constraints affecting future research

Developing these two types of assessments will require that cognitive assessments are validated against driving ability assessed on a public road. There are various methodological constraints to such studies.

1. On-the-road driving ability is used as the 'gold standard' against which to validate cognitive assessments. More information is needed on how this assessment should be conducted (duration, perhaps a flexible use of routes, modified to address issues relevant to the client's circumstances, familiarity with the car's controls) and how it relates to accident risk. In addition the agreement between assessors needs to be examined to ensure that the 'gold standard' can be assessed reliably by different assessors, using different routes, at different times of day, with different client groups.

2. It is unlikely that the same screening assessments will be appropriate for all client groups – tests which are found to be sensitive to cognitive impairment will differ according to the nature of the lesion. For example, the Stroke Drivers Screening Assessment has proved less effective as an assessment for people with head injuries (Radford *et al.*, 1999).

3. Validation studies must be conducted in situations in which the assessors of driving ability and cognitive abilities are 'blind' to the others' test findings. If the cognitive test findings are used to guide the road assessment then this will bias the results towards agreement. However, for safety reasons, assessors should be experienced in the assessment of cognitively impaired individuals and able quickly to identify likely deficits, and a dual-controlled car used.

4. Subjects for validation studies must be recruited from appropriate populations. To validate the screening procedure it will be necessary to assess unselected groups of patients, not just those who request referral to a specialist centre. To validate the detailed assessment battery, all patients referred to several specialist centres should be included.

5. In order to examine the relation between each cognitive ability and driving performance, a very large sample of subjects will be required. Most studies to date have used sample sizes which are far too small in relation to the number of variables being considered.

Specific research questions

- Performance on many tests may correlate with driving ability, but it may not be necessary to administer all assessments in clinical practice. Specific patterns of 'failure' on tests may enable assessors to identify some patients as 'unsafe', without requiring that they attempt all tasks. For practical purposes a hierarchy of assessments would be desirable, whereby clients only perform the next series of tasks if they have 'passed' the preceding easier ones. Such an approach would also represent a desirable model of practice in clinical and driving assessment settings.

- To date, much academic and clinical research has been undertaken independently. Key elements could be incorporated from both these strands of research. Research needs to address the validity in clinical populations of the assessment approaches developed for behavioural/psychological skills underlying normal driving performance. Equally, research needs to investigate the performance in 'normal drivers' of neuropsychological test approaches, evolved for the assessment of clinical populations.

- The application of this needs to retain a perspective of the client's experience of assessment, and the individual's needs and feelings.

- Attention needs to be directed towards improvements in the availability of a number of laboratory-developed tests, and the practicalities of their use in a clinical context. For example, doubts about validity and uncertainty over what is being measured remains a disincentive to the adoption of the 'Useful Field of View' in most clinical contexts, though developments may follow. Similarly, Hazard Perception assessment was demonstrated to be predictive of driving in the development of the Stroke Drivers Screening Assessment, but was not included in the final Assessment battery as it was impractical to use the necessary equipment in the clinic setting.

Cognitive assessment, as it is currently organised, is time-consuming and expensive. Research can enable the development of a standardised strategy for assessing fitness to drive and must aim to be as cost-effective as possible, otherwise it will not be adopted in clinical practice.

Recommendations for clinical protocols

Whilst the review of the current literature suggests there is much to do in terms of further research, it is likely that this enterprise would take some time to both be undertaken and fed back into clinical practice. In the meantime, for health professionals to move forward, it is clear that as a group, consensus ideas must be developed for a consistent response to the issues posed by driving. Despite their limitations, neuropsychological assessments show sufficient validity to contribute to the medical information used by the DVLA Medical Advisers.

A strategic response

There is a need to orientate health professionals working from primary care through to the rehabilitation context to the whole issue of driving and cognitive impairment. Within this process there is a role for a range of professions to collaborate, including psychology, psychiatry, neurology, occupational therapy and nursing. The British Psychological Society, through its Special Interest Groups (e.g. PSIGE) and the Divisions of Clinical Psychology and Neuropsychology, could offer support in the development of a standard approach to the use of assessment tools in liaison with the professional bodies above mentioned. The process of developing this is likely to be most effective if such groups consult their membership via workshops, seminars, etc. It is hoped that such an approach would allow a wider base of clinicians to appreciate the difficulties involved in assessing driving and to consider structured and consistent approaches to patient assessment and hence more valid information for DVLA decision-making.

Service planning

It also seems sensible that health professionals should begin the process of orientating local services and managers towards the issues raised by driving. This may be best implemented by local services developing structured policies on driving. Such policies should include routinely raising and monitoring issues of driving with patients throughout diagnosis and rehabilitation.

Appendix: Summary of research on driving and neuropsychological tests

Introduction

The following provides a brief summary of research papers investigating relationships between neuropsychological test performance and driving.
As indicated in the associated Advisory document, the assessment of cognition relevant to decision-making about fitness to drive requires further development and evaluation. Thus, the compendium should be seen as a guide only to direct the reader to the relevant research literature and not as a guide to recommended test materials for use in clinical assessment. Decisions about the inclusion of specific tests within the compendium were made on the basis of the availability of research papers relating to their use in this context. Brief details of research have been reported, providing the methodologies involved reached a number of elementary criteria.

- Basic description of research participants, including nature and origin of impairment (if any).
- Some form of assessment of actual driving capability against which to assess neuropsychological test performance.
  - ⇨ on- or off-road driving
  - ⇨ simulator tests
  - ⇨ accident involvement
  - ⇨ family and self-report

Following the pattern of the main Advisory document, research reports are grouped together in sections, under headings based on the main cognitive functions evaluated by the neuropsychological test in question.

- Visual Perception and Neglect;
- Attention;
- Executive System;
- Praxis;
- Language;
- Memory;
- Cognitive Screening Tests.

Obviously, many tap a range of other cognitive functions to some extent. For futher discussion of this point see Lezak (1995) pp.122 and 333. A few points relating to subject numbers and methodology, together with the correlations and/or predictive validity of neuropsychological tests in relation to driving performance are described in a tabular format.

Finally, each section is preceded by some additional background information about the area of cognitive functioning under consideration, problems of assessment and relationship to driving assessment and research.

Visual perception and neglect

There is much evidence to indicate that two distinct systems can be differentiated which can be selectively impaired following cerebral pathology. These are shape perception and perception of the spatial relationships between objects and oneself in the visual field. Some studies have used tests which reflect this dichotomy, others have used general tests of visual perceptual function requiring the integrity of multiple systems. For instance, the Benton Revised Visual Retention test requires intact constructional ability as well as visuo-spatial processing and visual memory.

It is difficult to produce tests which allow the subject to demonstrate intact functioning in the system which enables three dimensional location in space whilst minimising the role of other systems. For instance, copying complex figures necessitates intact constructional skills as well as the organisational skills of the executive system. Two tests from the Visual Object and Space Perception Battery (VOSP) Warrington and James (1991) Cube Analysis and Centre Dots, do not require the use of drawing and minimise the involvement of complex self monitoring of responses as they involve counting and forced choice respectively. These are currently in use in some driving assessment centres but have yet to be subject to validation by on-road assessment. Some studies have used ecologically appropriate material, such as Traffic Sign Recognition, as a shape perception test. These materials do not have any neuropsychological evidence in terms of normative or clinical data, and any deficit could equally reflect difficulties at the symbolic level of the sign rather than shape perception. Nonetheless, its face and functional validity makes this a promising test for future development. Research evidence is weak for the distinctive contribution to be made by assessing shape perception, but stronger for the role played by assessment of visual spatial perception. Assessment of the latter requires careful consideration of the test to be used, as deficits in motor skills will inevitably impair performance on visuo-constructional tasks. Tests of neglect used in the clinical setting tend to be based on paper and pencil cancellation tasks which do not cover extrapersonal space beyond the physical reach of an individual, which is the most salient dimension in driving. Assessments to detect neglect should encompass different types of neglect, though our understanding of how visual neglect

Test	Reference	Research details
SHAPE PERCEPTION		
Incomplete Letters Test – sub-test of the VOSP, Warrington & James (1991). A recognition task. Stimuli are patchy black and white shapes approximating letters of the alphabet	Simms & O'Toole (1994)	Only those patients with right hemisphere cerebral vascular accidents performed poorly. No significant findings in large group with mixed pathology. Population consisted of five groups – right CVA, left CVA, bilateral CVA, multiple sclerosis and traumatic brain injury. (n=126). On-road assessment: 7 'poor' drivers, 46 'adequate' and 73 'good' drivers.
	O'Toole (1997)	No predictive value in traumatic brain injury group. Small group of 'poor' drivers (7) compared to adequate and good drivers (63).
	Harvey *et al.* (1995)	Did distinguish safe/unsafe drivers in small group of patients with early dementia n=13, against a driving simulator criterion. Gave both **Incomplete Letters Test** and **Unusual Views Test** but did not specify which of the two tests provided the criterion in each case.
Traffic Sign Recognition	Hunt *et al.* (1993)	38 elderly drivers (13 controls, 12 with questionable Alzheimer's Disease, 13 in mild stages of Alzheimer's Disease. Correlation of 0.590, p<.0002 with driving outcome on on-road test). Only 5 people failed on road test.

fractionates into particular syndromes is still evolving. As with many other cognitive functions, there is a strong inter-relationship between the presence of neglect and performance on other tasks, e.g. reading, visuo-spatial ability, visual memory and executive functions. Therefore, studies which examine the relation between these tasks and driving should either partial out the effects of visual neglect or exclude patients with neglect.

Test	Reference	Research details
VISUOSPATIAL PERCEPTION		
Benton Revised Retention Test (Form D), copying geometric figures	Hunt *et al.* (1993)	25 people in the very early, early or equivocal stages of Alzheimer's disease. Only 5 failed the on-road test. All failed on poor judgement and environmental awareness. Found a 0.424 correlation (p=0.008) between test and on-road assessment. Concluded further work needs to be done on specific cognitive functions rather than the more general indices of dementia which their tests were designed to measure.
Benton Visual Form Discrimination Test. Multiple-choice test of target stimuli using geometric designs. Subject selects correct match from four alternative stimulus sets	Galski *et al.* (1992)	35 patients with traumatic brain injury (22) or cerebral vascular accident (13) aged between 18 and 87 examined between 1 and 17 years post injury. Correlation between test and on-road test was 0.56 (p<.001).
Cube Analysis. VOSP sub-test, Warrington & James (1991)	Presently being explored in some driving assessment centres but yet to be validated.	
Position Discrimination. VOSP sub-test, Warrington & James (1991)	Presently being explored in some driving assessment centres but yet to be validated.	

Test	Reference	Research details
VISUAL NEGLECT		
As a factor following analysis on various tests of perception including **Letter Cancellation**, and computerised tachistoscopic test from their own laboratory	Sundet *et al.* (1995)	One of the most discriminating variables when discriminating patients for driving in a group of 72 patients with CVAs. No on-road assessment.
As a factor derived from battery including **Letter cancellation** and other perceptual tasks	Simms & O'Toole (1994)	307 patients, mixed aetiology. 80 per cent predictive accuracy when classifying drivers as good, adequate or poor on-road.
As a factor derived from battery including **Dot Cancellation** (a sub-test of the Bourdon-Wiersma test) and other perceptual tasks	Nouri, Tinson & Lincoln (1987)	39 patients with CVA, 95 per cent predictive accuracy for driver group (pass or fail) in a combination of eight cognitive scores and visual scores. Age range 33–75 years, no control group.

Attention

Attention is not a unitary function and current theories (e.g. Posner & Peterson 1990; Parasuraman & Nestor 1993) postulate at least three types: selective attention – the ability to preferentially select relevant stimuli, inhibit irrelevant ones and involves the ability to focus and shift attention; divided attention – the ability to monitor two or more tasks or stimuli; and sustained attention – the ability to maintain vigilance for prolonged periods. The ecological validity of the test approach may be particularly questionable when addressing attention. The structured and motivating contexts of the test situation often allow brain injured people with attentional difficulties to perform to acceptable levels during evaluation (Lezak, 1995, p.145) and are likely to be very different from the unstructured, long task duration and often random nature of real driving.

Recent reviews (Christie, 1996; Brouwer & Withaar, 1997; Groeger, 1997) suggest research to date has only provided moderate correlations or predictive models of the role of assessed attention with driving outcome. The attentional tests used cover a wide range of methodologies, have variable standardisation and do not consistently reflect the theoretical consensus (Crawford *et al.*, 1997; Lezak 1995). The Useful Field of Vision (UFOV) approach appears promising, with a burgeoning literature (Duchek *et al.*, 1997), but extensive independent evaluation is hampered by the fact that there is as yet little information on exactly how their composite measure or the regression equations are derived. The UFOV literature (Ball *et al.*, 1993) with elderly drivers and research with commercial drivers (reviewed by Groeger (1997) uses accident rates information as outcome indicators.

Robertson *et al.*'s (1994) *The Test of Everyday Attention*, which was explicitly derived to follow the theoretical consensus has not yet been reported in the literature in connection with driving. Engum *et al.*'s (1989) study suggests the relationship between psychometric performance and driving ability is only strong when cognitive impairment is so gross that the driver will make obvious mistakes during driving, otherwise it is so minimal that cognition and driving are not affected significantly. When psychometric performance is poor enough to suggest some degree of difficulty, actual driving performance may be more dependent on the adequacy of higher level compensation. Brouwer and Withaar (1997) feel compensatory strategies may help explain why drivers with attentional deficits have varying performance. In such circumstances Engum *et al.* (1990) suggest reports from family members may help unravel such borderline cases.

Test	Reference	Research details
ATTENTION **Auditory attention – Digit Span Test** (sub-test of the WAIS-R)	Galski, Bruno & Ehle (1990)	37 participants (mixed neurological aetiology). No significant correlation with on-road driving criterion. Test is IQ related.
Attentional Switching – Stroop Task	van Zomeren *et al.* (1988)	9 patients with traumatic brain injury (TBI). No significant correlation with on-road driving criterion.
Visual scanning (laboratory-based)	Engum *et al.* (1988, 1989, 1990)	94 participants (57 patients with CVAs, 20 TBIs, 17 other). Used as a component of a pass/fail cognitive test battery, the CBDI. The CBDI proved an accurate predictor of road-test for this patient sample, but not others, including youths, trauma and elderly patients.
Kahneman's task (laboratory-based)	Kahneman & Triesman (1984)	117 professional drivers. Some correlation with crash rates (range of r's=0.29–0.37).

Test	Reference	Research details
ATTENTION **Visual Selective Attention – Trail Making Test** (as part of a more detailed neuropsychological assessment, covering various aspects of attention and higher order functions)	Hunt *et al.* (1993)	25 patients with Dementia of the Alzheimer type. Correlation of 0.345 with on-road driving.
	van Zomeren *et al.* (1988), Gouvier (1989)	Correlation with lateral position control of car. Correlation with off-road performance.
	Odenheimer *et al.* (1994)	30 elderly participants (6 with dementia). Trail A correlated with in-traffic scores.
	Fox *et al.* (1997)	19 patients recruited from specialist dementia clinics. No correlation with on-road performance
	Brouwer & Withaar (1999)	80 older people with cognitive decline identified by GP screening. Test had some predictive value in identifying those granted renewal of driving licences, following on-road assessment.
Preattentive Visual Attention – Useful Field of View (UFOV) – (laboratory-based)	Owsley, Ball, Sloane *et al.* (1991)	53 participants. Correlation of 0.36 with crash rate.
	de Raedt (1999)	84 healthy older adults. UFOV, in combination with other neuropsychological tests, was predictive of driving (using a standardised assessment, the TRIP) and of accident involvement at crossings.

Ability to monitor cognitive processes and behaviour: The 'executive' system

As part of daily living, it is necessary to constantly adapt responses in order to function effectively in a range of situations. This includes the ability to anticipate, plan ahead, self-monitor and make decisions. Adequate executive functioning is important for this self-regulation of behaviour.

The 'executive' or 'supervisory' system is known to be heavily subserved by structures in the frontal lobes. These areas of the brain are especially vulnerable in severe traumatic brain injury. Following injury to the frontal lobes, impulse disinhibition and socially inappropriate behaviour may be present. Executive functioning also becomes compromised at early or moderate stages of dementia. Loss of impulse control may lead to outbursts of verbal and physical aggression, with little or no provocation. The resulting deficits can often produce poor judgement both intellectually and socially and can impair safety on the road. Whilst driving, it is necessary to integrate behaviour and to respond appropriately and instantaneously to changing situations. Assessment of executive functioning in relation to driving ability is, therefore, of paramount importance. Research indicates that there is some correlation between individual tests of executive functioning and in-car performance, but no consistency regarding which tests correlate with driver safety. Tests of executive functioning are often IQ related so driver norms are particularly relevant when assessing suitability of such tests. Assessment of social behaviour on the road is as important as tests which tap intellectual functioning when assessing driving fitness.

Test	Reference	Research details
EXECUTIVE SYSTEM **1. Weigl Colour Form Sorting**	O'Toole (1997)	75 participants with traumatic brain injury (p=.000). Small numbers of drivers who failed but difference found between those able and those only possibly able to drive.
2. Tapping		As above (p=.0009).
3. Behavioural Assessment of Dysexecutive Syndrome (BADS) – 6 elements	Wilson *et al.* (1996)	As above (p=.012). Unsuitable if language, literacy or motor problems. Difficult test, may need driver norms.
Oral Digit Symbol (also assesses other factors, including perception and memory)	Gouvier *et al.* (1989)	Small mixed sample of able-bodied, TBI and spinal-injured patients. Correlation with on-road driving was 0.758 (p<0.02).
WAIS-R Digit Symbol (also assesses other factors)	Hunt (1993)	12 elderly drivers, and 25 patients with mild DAT. Significant (p<0.007) correlation with on-road driving.
1. WAIS-R Block Design (also assesses other factors)	Galski *et al.* (1992)	35 participants with TBI or CVA. Correlation (0.6; p<0.001) with on-road driving.
2. Ravens Matrices (also assesses other factors)		Correlation (-0.6; p=0.001) with on-road driving.

Praxis

Praxis refers to the ability to carry out complex sequences of physical movements , including well-rehearsed gestures and object use and other co-ordinated tasks. Clearly, difficulties with praxis have direct implications for the manual control of a vehicle as well as other activities of daily living. Apraxia is a disorder of learned or skilled movement, typically associated with left hemisphere damage (Bradshaw & Mattingley, 1995). Affected individuals have difficulty in carrying out complex, deliberate sequences of action. which is not attributable to other deficits, such as motor problems, poor comprehension or inattention. Accounts of typical apraxic disorders and types of tests of praxis can be found in Lezak (1995) and Bradshaw and Mattingley (1995).

Many tasks used to assess praxis skills, including some of those described below, in fact rely heavily on the integrity of the executive system for successful completion. A large number of batteries used to assess cognitive impairment relative to driving have included measures of psychomotor speed. Several of the tasks used overlap with measures of praxis (tapping, pursuit rotor). The importance of psychomotor speed as a predictor of driving ability has produced conflicting results.

In addition details are included here of the relationship between driving, and a combined assessment of activities of daily living with a drawing/copying task, although the former is rather a behavioural assessment.

Test	Reference	Research details
PRAXIS Copying hand movements, gesture and mimed use of objects (Luria, 1966)	O'Toole (1997) (see above)	No-one significantly failed these tasks.
Following tapping rule (Luria 1966)	Simms & O'Toole (1994); O'Toole (1997) (see above)	All groups scored close to maximum.
Bi-manual co-ordination task (Luria 1966)	Simms & O'Toole (1994); O'Toole (1997) (see above)	Performance correlated with advice on assessment but not with driving classification by on-road performance. 'Poor' drivers obtained almost maximum scores.
Porteus Maze: Paper-and-pencil maze tracing task	Galski *et al.* (1992) (see above)	Statistically significant correlation (0.43) with on-road performance.
Pursuit Rotor	Nouri & Lincoln (1992)	Performance on task did discriminate between 'pass', 'borderline' and 'fail' for post CVA patients on on-road assessment.
ACTIVITIES OF DAILY LIVING Instrumental Activities of Daily Living Assessment (IADL) and drawing complex figures	Brouwer & Withaar (1999)	Older drivers, who were still driving, with evidence of cognitive decline from GP screening. These assessments were more predictive of on-road driving performance using the TRIP assessment.

Language

Language comprises a range of functions including verbal and non-verbal communication, involving speech, vocalisation, and gestures, conveying perceptions, intentions, impressions and actions. Cutting (1990) has suggested that there are six aspects of language, differently lateralised to the two sides of the brain: phonology, morphology, syntax, semantics, prosodic aspects (changes in pitch, stress and intonation which add an extra dimension to meaning) and pragmatic aspects (the practical use to which language is put – taking into account context, metaphor, irony, etc.).

It is reasonable to expect that globally severe difficulties in language and communication skills may compromise general cognitive functioning, including driving ability. It is less clear if specific linguistic deficits (such as receptive or expressive dysphasia or anomia) have very much bearing on driving skill. However, it could be anticipated that in specific instances the capacity to respond to verbal communication in the form of motorway signs for example can contribute to driving safety. Results of studies relating driving and language functions are very mixed.

Test	Reference	Research details
WAIS-R Verbal Sub-Tests	Brooke *et al.* (1992)	Traumatic brain injury and dementia patients with on-road validation. No discrimination.
WAIS-R Verbal Sub-Tests and Naming	Harvey *et al.* (1995)	Traumatic brain injury and dementia patients with simulator validation. No discriminatory function.
Boston Naming Test and Aphasia Battery (Faber-Languedoen *et.al.,* 1988)	Hunt *et al.* (1993)	38 elderly people. Correlation 0.42 (p=0.003)between test and driving outcome. Aphasia Battery also showed a significant correlation with outcome (0.683, p=0.0001).
Token Test (shortened version) (Derenzi & Vignolo)	Simms & O'Toole (1994)	Discriminated between 'good', 'adequate' and 'poor' drivers in a patient group of mixed pathology.
	O'Toole (1997)	No discriminatory value in 75 patients with traumatic brain injury.
Word Fluency	Hunt *et al.* (1993)	No correlation.
	O'Toole (1997)	No discrimination.

Memory

Memory is an essential process, through which we are able to register, consolidate, store and retrieve information, allowing us to build on experience and use this in a creative and adaptive way in our daily lives. Efficient memory functioning is not simply the product of a unitary system, but involves the integration of a variety of cognitive processes. Often it is not memory per se which is implicated, but the ability to integrate the information that must be recalled, suggesting an interaction effect between memory, executive functioning and perception. Many of the processes that we learn and store become 'automatic'. as in learning to use driving controls. Others require constant review, as in the need to remain vigilant, to anticipate, prioritise and take decisions when driving. It is through experience and retention of memories that we learn how to react in complex traffic situations.

There has been some evidence that memory correlates with driving behaviour, although this is by no means conclusive and may be simply an indication of widespread cognitive impairment. A specific impairment of memory for routes and places would undermine efficiency in terms of getting to places but such focal memory deficits have not been seen as central in testing fitness to drive.

Test	Reference	Research details
MEMORY **WMS Delayed Verbal Recall**	Rothke (1989)	18 patients with mixed aetiology. Correlation of 0.6 ($p<0.1$) with on-road driving. Psychomotor planning and problem solving reduced in those who had poor delayed recall.
WMS Sub-tests (not clear which sub-tests)	Odenheimer *et al.* (1994)	30 older drivers (60+). Correlations of 0.65 ($p<0.01$) and 0.54 ($p<0.01$) with on-road driving performance.
WMS Logical Memory	Hunt *et al.* (1993)	37 mild DAT patients. Correlation ($p<0.0009$). Impaired judgement and attention was also evident ($p<0.003$).
Benton Visual Retention Test	Galski, Ehle & Bruno (1990)	37 patients with CVA or TBI. Correlation of 0.44 ($p<0.001$) only with outcome on a pre-driver evaluation. It did not correlate with behind the wheel evaluation outcome.
Paired Associates: 1. Immediate recall **2. Delayed recall**	O'Toole (1997) (see above)	75 patients with TBI. Correlation ($p<0.002$). Correlation ($p<0.000$). Small number of drivers in fail category. Difference was found between those considered 'able' and those 'possibly able to drive' following re-training.

Cognitive screening tests

Cognitive screening tests are widely used to provide a gross measure of cognition, used for both diagnosis and measurement of severity of dementia. Subjects' performance and thus outcome of screening are influenced by premorbid intellect, education and verbal skills. Screening tests cannot, therefore, be used to provide a diagnosis of dementia in the absence of other clinical information. These shortcomings are particularly salient for dementia in the early to moderate range of severity. Three tests appear in the research relating to assessment of driving: Mini Mental State Examination (MMSE) Folstein *et al.*, 1975; The Cambridge Cognitive Examination for Mental Disorders of the Elderly (CAMCOG, part of the CAMDEX) Roth, Huppert *et al.*, 1988; and the Mattis Organic Mental Status Syndrome Examination (MOMSSE) Mattis (1990).

A key review paper by a large number of researchers into driving (Lundberg, Johansson, Ball *et al.*, 1997) considered the usefulness of the MMSE, and could only reach a majority opinion 'that some cut-off levels can cautiously be proposed in the context of decisions concerning future driving, albeit with several reservations'. Problems considered were as follows: risk of false positives; poor assessment of functions thought to be relevant in driving (such as judgement, impulse control); and the problems of decision-making for those scoring at the mid-range.
This consensus was reached by review of a large number of publications which will not be quoted individually here (see Lundberg *et al.*, 1997). Three additional papers using the MMSE not reviewed by Lundberg *et al.* are discussed below, with additional comments on the other two screening tests used in research.

Assessment	Reference	Research details
Mini Mental State Examination (MMSE)	Fox *et al.* (1997)	19 probable DAT subjects assessed on-road. Significant association between MMSE and total driving score (p=0.004). 14 subjects scored between 19 and 24, of whom 8 failed on-road.
	Marottoli *et al.* (1998)	Community sampling of 125 older drivers, 40 per cent of whom self-reported a recent history of crashes. MMSE in this non-clinical sample was not significantly associated with crashes (p=0.910).
	Johansson *et al.* (1996)	Control study of 37 older drivers, whose licences had been suspended following violations. Three subjects later identified as DAT or probable early DAT. The suspended drivers had significantly lower MMSE scores (p=0.010).
Cambridge Cognitive Assessment (CAMCOG)	Mitchell *et al.* (1995)	Control study of 19 patients with probable DAT, 68 per cent of whom were driving at time of study. All classified as unsafe drivers on basis of failure on Stroke Drivers Screening Assessment (Nouri & Lincoln 1993). All DAT patients scored significantly poorer on CAMCOG than controls (p=0.001).
Mattis Organic Mental Status Syndrome Examination (MOMSSE)	Sims, Owsley *et al.* (1998)	Epidemiological identification of 99 older drivers with crash history; 75 older controls without crash history. Subjects asked to self-report medical diagnoses: no DAT reports. 'Crashers' scored significantly higher on MOMSSE than controls (p=0.024).
Stroke Driver Screening Assessment (SDSA)	Nouri & Lincoln (1992, 1993)	40 stroke patients, SDSA predicted road performance in over 80 per cent of cases. Correctly predictived driving in 81 per cent of group of 27 Stroke Patients, compared with 56 per cent correct prediction by GPs.
	Radford *et al.* (1999)	52 head injured patients. The SDSA alone was not a good predictor of on-road assessment of 'unfit' drivers. Prediction accuracy was increased to 85 per cent (specificity 95 per cent; sensitivity 57 per cent) by the inclusion of information processing and executive function assessments.

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- maintain a Code of Conduct for the guidance of Members;
- compel the observation of strict rules of professional conduct;
- maintain a Register of Chartered Psychologists.

The Society has 35,500 members and:

- has branches in England, Northern Ireland, Scotland and Wales;
- accredits nearly 700 undergraduate degrees;
- accredits nearly 100 postgraduate professional training courses;
- accredits higher degrees, in partnership with the Open University Validation Service;
- confers Fellowships for distinguished achievements;
- confers Chartered Status for professionally qualified psychologists;
- awards grants to support research and scholarship;
- publishes 10 scientific journals;
- publishes books, CD-ROMS, videos and other educational resources;
- publishes *The Psychologist* each month;
- publishes newsletters for its constituent groups;
- maintains a Web site;
- has international links with psychological societies and associations throughout the world;
- provides an information service for the news media and the public;
- has an Ethics Committee;
- provides service to the Disciplinary Board;
- maintains a Register of more than 9,000 Chartered Psychologists;
- prepares policy statements on matters of social policy;
- holds conferences, workshops, continuing professional development and training events;
- recognises distinguished contributions to psychological science and practice through individual awards and honours.

The Vision Statement of the Society plans that by 2006:

- there will be 50,000 members;
- the Society will have offices in the major constituent parts of the United Kingdom;
- the public at large will have a clear understanding of psychology as both a research and applied discipline;
- the Society will seek to influence public policy on matters relating to education, the family and the community;
- all its members will contribute so that the strengths and diversity of its membership are fully utilised.

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