The concept of dementia as a 'progressive global cognitive decline in clear consciousness' has been refined gradually over the past two decades. It is increasingly apparent that each form of dementia has a distinct cognitive profile, at least in the mild stages of the disease, and that this reflects the pattern of underlying neuropathological change (Fray et al., 1996; Hodges, 1998; Rahman and Sahakian, 1999). For example, NINCDS-ADRDA (National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association) criteria for a diagnosis of probable Alzheimer's disease requires 'deterioration in two or more areas of cognition, including memory, sufficient to interfere with work or social function' (McKhann et al., 1984).

Advances in the understanding of the neuropsychology of the dementias has led to a greater role for neuropsychological assessment in the diagnosis and treatment of the various neurodegenerative diseases. In this chapter a brief outline of the rationale for neuropsychological assessment is given, together with a description of what a detailed neuropsychological assessment can offer a clinician over and above simple rating scales such as the Mini-Mental State Examination (MMSE) (Folstein et al., 1975) and ADAS-cog (Rosen et al., 1984). In addition, some commonly used neuropsychological tests are described. The article focuses on Alzheimer's disease (AD), since this is the most prevalent and probably the best understood dementia from a neuropsychological perspective, but also refers to other related conditions in the section on differential diagnosis.

5.1 Neuropsychological assessment: general considerations

5.2 Importance of a comprehensive neuropsychological assessment

5.3 Early detection of dementia

5.4 Differential diagnosis of dementia

5.5 Monitoring progression in dementia

5.6 Further considerations in neuropsychological assessment

5.7 Conclusion

References
vides a powerful investigative tool which may be crucial for the diagnosis and management of many patient groups (see McCarthy and Warrington, 1990).

The quality of a neuropsychological test is measured by how well its psychometric properties conform to theoretical notions of reliability and validity (Kline, 1986). Good validity means that the test actually measures what it is purported to measure. Good reliability means the test's measurements are accurate and consistent across different clinicians, locations, and times. In order to be used reliably for diagnosis at a single case level, the key qualities required of a test are specificity (any deficit found on a test is unique to one patient group and not a range of conditions) and sensitivity (the test should be sensitive to the earliest stages of a neurodegenerative disease and even subtle changes in a patient's condition).

Extensive validation procedures should always be employed in order to measure how well a test meets these psychometric criteria. For example, if a test is assumed to be sensitive to frontal lobe function, deficits should be observed in patients with frontal lobe lesions (Owen et al., 1990, 1995, 1996d); further, where available, neuroimaging data should demonstrate some frontal lobe activity in healthy controls performing the same task (e.g. Owen et al., 1996b).

### 5.2 IMPORTANCE OF A COMPREHENSIVE NEUROPSYCHOLOGICAL ASSESSMENT

Why should clinicians carry out a comprehensive neuropsychological assessment when brief screening measures are available? The answer is that short mental status tests are suitable for some aspects of performance assessment (e.g. screening, gross staging of severity), but neglect others. For example, the Mini-Mental State Examination (Folstein et al., 1975) is one of the most widely used brief measures of global cognitive function. Its strengths are that it is inexpensive, rapid, highly portable, and can be interpreted and administered with little training. It is standardized and has been successfully applied in cross-national studies. However, the MMSE has poor sensitivity to very mild dementia, generates false-negative diagnoses in highly educated people and false-positive diagnoses in poorly educated people, and demonstrates ethnicity biases (Tombaugh et al., 1992; Nadler et al., 1994; Wilder et al., 1995). Its major limitation, however, is that it provides only a global index of cognitive performance. A full neuropsychological battery produces a much wider range of scores and taps more cognitive domains, making early detection possible and providing differential diagnosis within the dementias. In addition, a comprehensive assessment can provide information from which to measure change as a result of the progression of the disease or the administration of a new treatment, and, in some cases, aid in the management decisions regarding individual patients. In all cases, however, neuropsychology should be viewed as contributing to a diagnosis along with other forms of assessment (e.g. structured clinical interview, neuroimaging, etc.). The most accurate diagnosis and treatment recommendations will always be made by combining clinical, neuropsychological and neuroimaging expertise (Perry and Hodges, 1996).

### 5.3 EARLY DETECTION OF DEMENTIA

Until relatively recently, the early detection of dementia has been neglected, in part because of the absence of effective treatments and also because sufficiently sensitive neuropsychological tests were not available. The emergence of new drugs to treat the symptoms of AD (e.g. rivastigmine, donepezil) is a sign that the therapeutic nihilism seen in the dementias is coming to an end. It is widely believed that if neuroprotective agents that modify the disease process are to be effective, then it is vital that clinicians are able to detect a dementia early and accurately, before the emergence of global cognitive impairment (Lawrence and Sahakian, 1996; Hodges, 1998). Further, early detection of dementias can give patients and their families more time to come to terms with the diagnosis of dementia, to make the necessary personal and financial arrangements, and to reduce the anxiety patients may feel when they are unsure of their diagnosis (Morgan and Baade, 1997).

Neuropsychological testing has a clear role in the early detection of dementia. It is non-invasive, well tolerated by patients, relatively inexpensive and, most importantly, it may be sensitive to the prodromal phase often seen in dementia (see Fowler et al., 1997). For example, it is believed that there is an insidious onset of symptoms in AD which precedes diagnosis by 2–3 years (Jost and Grossberg, 1995), and a range of evidence suggests this may first manifest as problems in learning and episodic memory (Lawrence and Sahakian, 2000).

The episodic memory deficit in AD was first demonstrated by showing that memory tests could differentiate a group of clear-cut Alzheimer's patients from a group of healthy elderly control subjects. For example, the main difference between patients with AD and healthy controls is difficulty in acquiring and retaining new information, even over a period as short as 10 minutes (Kasznai, 1986; Albert et al., 1989; Butters et al., 1995). Recent memories are more difficult to recall than older memories, referred to as a temporal gradient for recall. However, a more stringent test of how well a paradigm can detect AD is to see if it can predict which patients will go on to develop dementia. A number of longitudinal studies have taken this approach. Fox et al. (1998) followed 63 asymptomatic individuals at risk of autosomal dominant AD over a 6-year period. The 10
subjects who developed dementia during this time could be identified at first assessment (when they were ostensibly unaffected) by significantly lower verbal memory and performance IQ on cognitive testing. These subjects were initially no different in terms of age, family history and initial MMSE scores. First assessment was typically 2–3 years before symptoms were manifest and 4–5 years before a diagnosis of probable AD was made, a result that clearly illustrates the potential sensitivity of cognitive testing. Blinded assessment of serial MRI imaging showed that diffuse cerebral and medial temporal lobe atrophy was found in subjects only after they were clinically affected, suggesting that a patient's neuropsychological profile may be a more sensitive early indicator than imaging data. These results support the notion that the earliest cognitive deficits seen in AD include episodic memory impairment.

Other longitudinal studies in elderly subjects generally concur with these results. In the Framingham study, 'pre-clinical' deficits in verbal recall (as indexed by the percentage retained in the Logical Memory Test and Paired Associate Learning Test) preceded clinical diagnosis of AD in some cases by more than 6 years (Linn et al., 1995). Similarly, in the Bronx aging study, two tests of verbal memory, the Fuld Object Memory Evaluation and the Buskbye Selective Reminding Test, predicted many subjects who would go on to develop AD (Masur et al., 1995).

In a more recent study, the Cambridge Neuropsychology Test Automated Battery (CANTAB), was used to ascertain whether early AD could be detected in a group of 'questionable' dementia subjects recruited from a memory clinic setting (Fowler et al., 1997). These are people who present with subjective memory complaints, may or may not show some degree of impairment on standard neuropsychological tests, but do not fulfil NINCDS-ADRDA criteria for dementia (Rosen et al., 1984). Fowler et al. (1997) demonstrated that the paired associate learning task (PAL) from CANTAB (Robbins et al., 1998) could split the questionable dementia group between those who had a poor prognosis and went on to develop AD (between 6 and 24 months later) and those who had a good prognosis and remained unimpaired (see Figure 5.1).

The CANTAB PAL requires subjects to learn and remember abstract visual patterns associated with various locations on a touch-sensitive computer screen. Patterns are presented in one of six or eight boxes around the edge of the screen (Figure 5.2). After a brief delay, the same patterns are presented in the middle of the screen and the subject is required to touch the box in which they saw that pattern appear. If this is not completed correctly the subject is reminded where each pattern belonged and tested again. This process continues until the task is satisfactorily completed or ten trials have been attempted. The CANTAB PAL was able to detect those people in the questionable dementia group who went on to dement about 18 months earlier than traditional neuropsychological tests (Fowler et al., 1997).

The neuropsychological picture of preclinical episodic memory deficit in AD is complemented by reasonably consistent patterns of neuropathology. Thus posterior regions of association cortex are especially impaired in AD, particularly medial temporal regions (parahippocampal and entorhinal cortex). The neurodegeneration in AD is progressive, both within an affected area and extending to other previously unaffected regions. This conclusion is consistent with evidence from in vivo neuroimaging including positron
emission tomography (PET; Grady et al., 1988; Hashby et al., 1990; see also reviews by Smith and Jobst, 1996 and Goodwin, 1996), as well as post-mortem neuropathology (Braak and Braak, 1991). The particular clusters of deficits seen in AD progress in a predominantly posterior-to-anterior axis across the cerebral cortex and can be understood by reference to classical syndromes seen in the neuropsychological literature, both in terms of underlying cognitive processes and their associated neural substrates. The main difference from studies, for example, of patients with neurosurgical excisions or strokes is the relatively continuous, progressive deterioration in AD. The occurrence of focal degenerative disorders also indicates a more restricted form of progressive neurodegeneration, limited to a particular part of the cerebral cortex, as may be the case for semantic dementia and the temporal lobe (Hodges et al., 1992), or lobar atrophy which affects regions of the anterior neocortex (Neary et al., 1994).

5.4 DIFFERENTIAL DIAGNOSIS OF DEMENTIA

Neuropsychological testing can help a clinician to make a differential diagnosis between a dementia and other non-neurodegenerative disorders, such as depression. It can also help to differentiate between different neurodegenerative disorders, including AD, frontotemporal dementia (FTD), Parkinson's disease (PD), and Huntington's disease (HD). In this regard, it is increasingly apparent that each disorder, at least in its early stages, has a unique cognitive hallmark that can be used to aid differential diagnosis.

Perry and Hodges (1996) have outlined the memory profile most commonly encountered in a number of different disorders. In short, three broad domains in memory have been studied in detail: working memory, episodic and semantic (declarative) memory and implicit (non-declarative) memory.

Working memory refers to a system assumed to be necessary for holding information 'on line', usually over short periods of time. Baddeley (1986) argues this system comprises an 'articulatory loop' for rehearsing verbal material, a 'visuospatial scratch pad' for rehearsing visual information, and a 'central executive' which is assumed to regulate these two slave systems. Recent neuropsychological and neuroimaging studies using PET implicate regions of the lateral prefrontal cortex in working memory (e.g. Owen et al., 1996b, 1996c; for review see Owen, 1997).

Episodic memory can be defined as personally experienced events that are specific to a time and context. This can be tested by recall of recently presented verbal material in story or word list form or visual material such as recall of faces or abstract figures, for example, the CANTAB delayed matching to sample test (e.g. Sahakian et al., 1988). Semantic memory, on the other hand, refers to memory for facts, concepts and knowledge. It is not specific to a time or context and is culturally shared. It may be tested by picture naming, category fluency, word-picture matching and vocabulary tests. Episodic and semantic memory both rely on various regions within the medial temporal lobe and the diencephalon (Squire, 1992).

Finally, whereas episodic and semantic memory are components of 'explicit' or 'declarative' ('conscious') memory, conditioning and priming effects, skill learning, and habits are all examples of implicit (or 'non-conscious') memory.

5.4.1 Alzheimer's disease

Different neurodegenerative diseases may be associated with distinct profiles of impairment across these memory domains. AD is characterized by a profound deficit in episodic memory, usually with both verbal and non-verbal material lost (Squire, 1992; Welch et al., 1992). It is generally accepted that encoding of new memories is impaired in dementia of Alzheimer type (DAT), but it is unclear if this is accompanied by 'faster forgetting' or loss from memory stores (Kopelman, 1985; Sahakian et al., 1988; Pillon et al., 1994; Greene et al., 1996). A well-replicated finding is that delayed recall is much more impaired than immediate recall, which may support a faster forgetting hypothesis (Pillon et al., 1994). However, Greene et al. (1996) demonstrate that intact immediate recall seen in AD may reflect the preservation of working memory found in the early stages of the disease. Related research suggests that the slave systems of working memory (the 'articulatory loop' and the 'visuospatial scratch pad') are intact in early AD (Baddeley, 1986), although the central executive may be compromised (Paulesu et al., 1993). Although AD does lead to semantic memory loss, this may not be an early change (Hodges and Patterson, 1995). It is unclear if any loss of semantic memory reflects damage to memory 'stores' or impaired retrieval (Nebes, 1989; Chertkow and Bub, 1990; Bayles et al., 1991; Chan et al., 1995). Remote memory (e.g. autobiographical memory for famous persons and events) is also impaired in AD, with evidence of a temporally graded loss (Sagar et al., 1988; Kopelman, 1989; Greene et al., 1995).

5.4.2 Semantic dementia

In semantic dementia there is a selective impairment of semantic memory, which causes severe anomia, single word comprehension, reduced exemplar production in category fluency tests, and an impaired general knowledge. Other components of speech production, perceptual and non-verbal problem-solving abilities, and
episodic memory are relatively spared (Snowden et al., 1989; Hodges et al., 1992; Breddin et al., 1994; Saffran and Schwartz, 1994).

### 5.4.3 Frontal variant frontotemporal dementia

Frontal variant frontotemporal dementia (fvFTD), is usually associated with failure on frontal lobe tests in the absence of severe amnesia, aphasia, perceptual or spatial disorders. However, there are frequently marked behavioural changes including lack of insight, disinhibition, loss of personal and social awareness, mental rigidity and inflexibility, perseverative behaviour and emotional lability (Gregory and Hodges, 1996). Recent studies by Rahman, Sahakian and colleagues (Rahman and Sahakian, 2000; Rahman et al., 1999), indicate that neuropsychological tests sensitive to the orbitofrontal/ventromedial cortex are able to detect impairment even in very mild fvFTD patients.

### 5.4.4 Huntington’s disease and Parkinson’s disease

Huntington’s disease (HD) is associated with working memory decline and impaired retrieval from both episodic and semantic memory. Hodges et al. (1990) compared the performance of patients with AD and Huntington’s disease on the Boston Naming Test, a measure of visual semantic memory. HD patients made significantly more visual errors, where they produced answers visually similar to the correct solution but from a different semantic category; for example, they would mistake a pen for asparagus. By contrast, AD patients made significantly more semantic super-ordinate errors, where they gave an answer denoting the general category of the correct answer rather than the exact exemplar; for example, a car would be described as a vehicle. In a more recent study, Rosser and Hodges (1994) compared AD, HD and PD patients matched using the dementia rating scale (DRS) on verbal fluency tasks. In letter fluency tasks subjects are asked to name as many words as possible that start with a certain letter in 60 seconds. In category fluency tasks the subject has 60 seconds in which to generate as many examples that fit a certain semantic category as possible. All groups were impaired relative to controls on both measures. Interestingly, subjects in the AD group were less impaired on the letter fluency but equally impaired on category fluency as those in the other two patient groups. On this basis, it was suggested that AD involves a selective degradation of the semantic memory store whereas in HD and PD the central impairment is in the retrieval of that information.

One of the difficulties with comparing patient groups is that very rarely are the same tests employed for assessment. Lawrence and Sahakian (1996) have recently compared the profile of impairment found in AD with that observed in patients with PD, HD and progressive supranuclear palsy using the Cambridge Neuropsychological Test Automated Battery (CANTAB; Robbins et al., 1994a, 1996, 1998). Patients in the early stages of AD were impaired on tests of learning and memory sensitive to parietal and temporal lobe damage, particularly paired associate learning, pattern recognition memory and delayed matching to sample paradigms (see Figure 5.3).

They were relatively unimpaired on tests of central executive function, such as attentional set shifting. Patients in the early stages of the frontostriatal dementias showed the opposite pattern, being impaired on central executive tasks but relatively intact on memory tasks sensitive to temporal and parietal lobe damage. Indeed, the task most sensitive to genetically confirmed, but preclinical HD is the CANTAB attentional shift task (Lawrence and Sahakian, 1996, 1998). Cognitive flexibility is a requirement for this task, since patients must perform an extradimensional shift similar to a category shift in the Wisconsin Card Sorting Test.

### 5.4.5 Depression

It is now known that significant cognitive impairments often accompany the onset of depression (see Murphy et al., 1999). For this reason, in old age psychiatry, the differential diagnosis between depression and dementia remains an important problem. For example, it has been suggested that around 10% of cases initially diagnosed as dementia are later reclassified as depression (DesRosiers, 1992). Since there are effective treatments for depression, accurate diagnosis is important. Historically, reversibility has been considered a hallmark of the cognitive impair-

![Figure 5.3](https://www.example.com/image.png)

**Figure 5.3** Performance of patients with AD, PD and elderly control subjects on the CANTAB visualspatial paired associates learning task. Compared to controls, only the AD patients are profoundly impaired, even at the most basic levels of task difficulty (adapted from Sahakian et al., 1988).
ment seen in depression and is implicit in the use of the term 'pseudodementia.' However, Abas et al. (1990) suggest that significant cognitive impairment may persist in many patients following recovery of depressed mood and that the term 'pseudodementia' appears unclear and misleading. In fact, most attempts to differentiate these two disorders using traditional tests have failed. For example, O’Carroll et al. (1994) showed that the Wechsler memory scale could not reliably differentiate between depression and DAT, with up to 25% of the depressed patients being misclassified. O’Carroll et al. (1997) showed that the delayed word recall test led to 44% of depressives being misclassified as suffering from AD.

In summary, it is clear that traditional neuropsychological tests cannot yet unambiguously differentiate between depression and dementia. However, Murphy et al. (1999) have suggested that divided attention tasks and tests of prospective memory may be useful for this purpose and, in particular, in examining the way in which patients fail may be important for the differential diagnosis of depression. For example, Beattie et al. (1996) reported that elderly depressed patients showed a 'catastrophic' response to perceived failure. Following on from this, recent work by Elliott, Sahakian and colleagues (Elliott et al., 1996, 1997b) indicted that depressed patients show an abnormal response to feedback and that this appears to be diagnosis specific. The efficacy of this measure is currently being tested to see if it can reliably differentiate AD from depression.

5.5 MONITORING PROGRESSION IN DEMENTIA

Another role for neuropsychological testing is to measure the rate of progression of disease, achieved by giving an identical assessment at a number of different time intervals. This is important because it can help the clinician assess the efficacy of any pharmacological or other therapeutic intervention. At the moment the ADAS-cog (Rosen et al., 1984) is a test commonly used to measure the efficacy of agents acting on memory. However, recent advancements in the understanding of the taxonomy of memory and the cognitive profile of dementia makes it likely that a more advanced neuropsychological test will be needed. For example, the ADAS-cog lacks an attentional subscale, an important cognitive domain for AD and one which responds to cholinergic therapies such as tacrine and nicotine (see Sahakian et al., 1990; Jones et al., 1992). It is good practice to look for change on neuropsychological measures applied in a memory clinic setting to determine whether an individual patient is benefiting from medication at a cognitive level. Obviously for this purpose, measures which are sensitive to change must be used (e.g. CANTAB Rapid Visual Information Processing task, CANTAB Simple and Choice Reaction Time task). It is also important to determine how gains in cognitive function impact on the patient’s daily living and quality of life, as well as on the quality of life of the patient’s carer.

5.6 FURTHER CONSIDERATIONS IN NEUROPSYCHOLOGICAL ASSESSMENT

The neuropsychological assessment has to be tailored to the individual needs of the patient and the reason for the referral. Nevertheless, it is important to retain 'benchmark' tests that remain the same in order that the neuropsychologist can compare between patients within the same group, across patient groups and for use for longitudinal follow-up. On a very general level, the assessment of a patient should involve an evaluation of their cognitive function in the major domains afflicted by the dementia, an estimate of premorbid functioning to compare results to, and a measure of how much this affects the patient's functioning in everyday life. The test battery chosen should ideally be sensitive to even subtle deficits in patients, have demonstrated psychometric reliability and validity, be relatively easy to administer and not excessively long, have been validated longitudinally, have equivalent forms, and have its practice effects understood (Ferris and Kluger, 1997).

Exactly which test to use depends on the precise hypothesis being tested. For example, different tests are sensitive to different severities of dementia. A test like the CANTAB paired associate learning task (Fowler et al., 1997) is excellent for the early detection of AD (see Figure 5.1), but due to its sensitivity may not be ideal for measuring disease progression. Other CANTAB tests, such as the Delayed Matching To Sample Test, the Attentional Shift Test and the Visual Search Test, may be more suitable for assessing staging and severity of dementia (see Sahakian et al., 1988, 1990; Sahgal et al., 1992a, 1992b). Further, a lengthy battery may be useful for the detailed assessment of cognitive function in the mild stages of dementia but may not be appropriate or feasible in more moderately/severely demented patients with major attentional difficulties. The CANTAB nonverbal tests may be combined with tests of verbal function, together with measures of premorbid or current intelligence level (e.g. NART, WAIS-R, respectively). For those without access to computerized assessment, an example of a pencil and paper battery may include measures of premorbid and current intellectual function (e.g. National Adult Reading Test, Wechsler Adult Intelligence Scale ~ Revised, respectively), episodic memory (e.g. Wechsler Logical Memory, Kendrick Object Learning Task, Warrington Recognition Memory for words and faces), working memory (e.g. Corsi block tapping task, forward and backwards digit span), semantic memory (e.g. Graded Naming Test, category fluency,
Boston Naming Test), attention (e.g. the Stroop test, symbol digit substitution), visuospatial construction (e.g. drawing a clock face, Ray-Osterreicht figure), and executive functions (e.g. Wisconsin Card Sorting Test). It is important to include verbal and non-verbal stimuli, to examine both recognition and recall, and to assess performance at both immediate and delayed memory. An alternative to combining individual tests is to use an already constructed battery. Some of the more commonly used ones are described briefly below.

- The Consortium To Establish A Registry For Dementia of the Alzheimer's Type (CERAD; Morris, 1997) battery includes the Boston Naming Test, verbal fluency, the MMSE and two other subtests, covering memory, language, constructional praxis, and intellectual status.

- The Wechsler Memory Scale – Revised (WMS-R; Kaplan et al., 1991) is made up of 13 subtests that take about 45 minutes to administer. The areas tested include orientation, attention, verbal memory, visual memory and delayed recall.

- The Halstead–Reitan battery (Reitan and Wolfson, 1993) consists of 10 tests that tap sensory, perceptual, motor, attention, language and problem-solving abilities.

- The Cambridge Neuropsychological Test Automated Battery (CANTAB; Robbins and Sahakian, 1994) is a set of computerized neuropsychological tests that tap visual memory, attention, and working memory and planning. Computerized batteries have a number of distinct advantages over more traditional 'paper and pencil' tests (see Figure 5.4), and this has been discussed in detail elsewhere (see Robbins et al., 1994b, 1996, 1998).

In brief, each CANTAB battery employs a touch-sensitive screen and has a preliminary test of sensorimotor function, which enables subjects with marked visual or motor deficits to be screened out. The range of tests utilized allows a component analysis of cognitive function, offering the clinician a profile of a patient's strengths and weaknesses. Moreover, the various tests have been validated on neuropsychological cases with well-defined cortical excisions (e.g. Owen et al., 1990, 1991, 1995, 1996d). In addition, neural validation has been provided by a growing set of neuroimaging data, some conducted in elderly depressed patients (e.g. Owen et al., 1996a, 1996b, 1999; Baker et al., 1996; Elliott et al., 1997a). The main elements of the battery have already been tested in probable (subsequently confirmed) cases of DAT in a memory clinic setting (Sahakian et al., 1988, 1990; Sahgal et al., 1991, 1992a, 1992b), in longitudinal follow-up of some patients (Robbins et al., 1996) and in a double-blind, placebo-controlled trial of the acetylcholinesterase inhibitor tacrine (Egger et al., 1991; Sahakian et al., 1993). The pattern of cognitive deficits shown on this battery fits quite well with the generally accepted neural progression for the disease proposed above. Thus, for example, tests that are particularly sensitive to temporal lobe (including hippocampal) damage are more sensitive to impairments in DAT patients than tests shown to be sensitive to frontal lobe dysfunction (Sahakian et al., 1990). The CANTAB tests have also been given to elderly patients with depression, who exhibit some gross similarities to AD in the nature of the deficits, but where cognitive improvement on many, though not all, cognitive measures, may occur on remission from clinical depression. Recently, norms have been published for many of the CANTAB tests on a large (n = approximately 800) sample of normal community-dwelling elderly volunteers (Robbins et al., 1994b, 1997), and a high degree of test-retest reliability has been confirmed using the same subjects. Moreover, the existence of graded difficulty levels within each test reduces the common problem of floor and ceiling effects on neuropsychological tests for AD. It should be emphasized that computerized testing with non-verbal tests offers some advantages over conventional testing in terms of multination trials and objective standardization of the administration (e.g. timing of stimuli and nature of feedback) and of the measures that include latencies. However, it is important for such testing to be conducted in the presence of a trained clinical psychologist and in conjunction with conventional tests.

Whilst the CANTAB battery shows some promise in the detection and evaluation of dementia, it has only recently been compared against more traditional methods in a memory clinic setting. As discussed above, Fowler et al. (1995, 1997) have shown recently that the CANTAB test of visuospatial paired associates learning

**Figure 5.4 The advantages of computerized testing.**
effectively differentiated cases of questionable dementia compared with tests from the Wechsler Memory Scale including delayed recall. In 21 cases, there was an advantage of 6–12 months in the differentiation afforded by these tests over their conventional counterparts. Moreover, there are both neuropsychological (Owen et al., 1995) and neuroimaging (Owen et al., 1996c) data which suggest that this test may be sensitive to damage to regions including the parahippocampal gyrus and entorhinal cortex, areas thought to be at risk in early AD.

In summary, the CANTAB tests are objective and standardized, have a high patient compliance, store and log data accurately and efficiently, are well normed and cover a wide range of cognitive functions.

5.7 CONCLUSION

In an age where no means of preventing devastating neurodegenerative diseases such as AD exists, neuropsychological assessment will continue to have a useful role in the early detection of dementia, in differentiating between the various forms of dementia, in monitoring the progression of the disease, in assessing the efficacy of any new treatments, and in managing individual patients. Recent neuropsychological research has developed our understanding of these, and related, conditions and should continue to do so in the future. The key challenges for neuropsychologists over the next decade are to translate their experimental knowledge into clinically useful tests that reliably detect and differentially diagnose depression and dementia at a single case, rather than a group level, to compare patient groups on the same tests (i.e. ‘benchmark’ tests), and to more fully understand the neural networks underlying task performance. Theoretically driven neuropsychological testing will have a key role in the early detection, differential diagnosis and development of rational treatment strategies for the dementias well into the new millennium.

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