

Neuropsychology – testing the brain

SALLIE BAXENDALE

Institute of Neurology, University College London, National Hospital for Neurology and Neurosurgery, Queen Square, London, and Epilepsy Society, Chalfont St Peter, Bucks

Defining and testing cognitive function

Cognitive function is the process by which an individual takes in information about the world, makes sense of it and acts upon it. Neuropsychological tests traditionally assess function in different cognitive domains, all of which can dissociate in the pathological brain. These domains include intelligence, language, memory, perception and executive or frontal lobe functions. A large number of skills comprise each domain. For example, memory tests can assess the learning, recall or recognition of different types of material presented during the testing session, in addition to long-term autobiographical recall and prospective memory skills. The distinction between declarative memory (encompassing episodic memory – the recollection of experiences and episodes, and semantic memory – knowledge of the world) and procedural memory (remembering how to do something, e.g. riding a bicycle) can also be made. Again, all of these abilities have been shown to dissociate in patients with focal lesions.

The majority of neuropsychological tests tap multiple skills from more than one domain. For example, success on a complex figure recall task, ostensibly a visual memory test, also requires intact perception and adequate comprehension, concentration and praxis. It follows therefore that failure on this test may be the result of a breakdown in any one or a number of these processes. The aim of the neuropsychological assessment is not only to identify and quantify deficits in cognitive function, but more importantly to try to identify which processes are breaking down and responsible for the dysfunction. This is normally achieved by the careful interpretation of an individual's performance and scores on a wide range of tests.

When is neuropsychology useful in epilepsy?

Like many other investigations at the neurologist's disposal, neuropsychological test results rarely stand alone but are interpreted in relation to both the clinical question being asked (be it a diagnostic issue, the lateralisation or localisation of dysfunction, or the planning of an intervention) and the results from other investigations. The overall value of a neuropsychological assessment therefore very much depends on the validity of the questions being asked and the availability of other relevant data.

In patients with epilepsy, neuropsychological assessments are most frequently used to aid diagnosis, evaluate the cognitive side effects of antiepileptic medications and monitor the cognitive decline associated with some epileptic disorders. In conjunction with MRI and other presurgical investigations, neuropsychological scores are also used to assess the suitability of patients for epilepsy surgery and can be used to predict post-operative outcome, both in terms of cognitive change and seizure control.

In an ideal world, all newly diagnosed patients with epilepsy would undergo a brief neuropsychological screen prior to the onset of treatment to create a valuable baseline against which future assessments can be measured. While local resources do not allow such a specialist assessment for most patients, it is possible to have some record of memory function at diagnosis if a self-report questionnaire is administered. Serial neuropsychological assessments can be used to evaluate the cognitive side effects of new or existing antiepileptic drug (AED) regimens and to monitor the cognitive deterioration that may be associated with long-term poorly controlled epilepsy and episodes of status. They can also contribute to the diagnostic process. However, repeated assessments over a short period of time can lead to the development of practice effects which can mask a deterioration in function. In most cases it is therefore recommended that there is at least a six-month interval between assessments to maximise the validity and utility of the results. Single assessments can be useful in the localisation of cognitive dysfunction associated with focal pathologies and also enable the setting of realistic education and employment goals. Single assessments may also reveal deficits that are amenable to rehabilitation.

Neuropsychological tools

General intellectual functioning

The majority of the tests used in the standard neuropsychological assessment remain pencil and paper desktop tasks, though the use of computerised tasks is becoming more widespread. Almost all assessments will include the current gold-standard measure of general intellectual functioning in adults, the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV UK, 2010). The most recent incarnation of the Wechsler Intelligence Scale has dispensed with the traditional distinction between verbal (VIQ) and performance IQ (PIQ) and now provides four index scores, including the verbal comprehension index (VCI), the perceptual reasoning index (PRI), the perceptual organisation index (POI) and the working memory index (WMI). The full-scale IQ (FSIQ) has been retained and an additional general ability index (GAI) has also been added. The distributions of all the indices are constructed to have a mean of 100 and a standard deviation of 15 IQ points. An index score of 100 therefore defines the performance of an average, healthy, adult at that age. Approximately two-thirds of the adult population obtain scores between 115 and 85, one standard deviation above and below the mean, respectively. Any IQ between 80 and 119 is usually classified as falling within the average range.

Memory

Memory tests are most frequently divided into three groups: verbal, visual and behavioural memory tasks. The most frequently used verbal memory tests include story recall and list-learning tasks. In these tests the patient is typically read a short local-news type story and asked to recall as much detail as they can immediately after they have heard it and again following a delay of between 30 minutes and an hour. List-learning tasks typically test an individual's ability to learn a list of 15–20 words over a number of trials and frequently include recall and/or recognition conditions following distraction or a delay. Analogous tasks involving non-verbal material include complex figure-recall tasks and design-learning tasks. In the former an individual is required to copy a complex geometric figure and then reproduce as much as they can immediately afterwards and again following a delay of up to an hour. There is a growing consensus that these complex figure-recall tasks may have limited validity in the assessment of epilepsy. Behavioural memory tests are generally thought to be more ecologically valid in that they test 'everyday memory' skills,

such as putting a name to a face and prospective memory functions (remembering that you have to do something at some point in the future). Tests are also available to examine retrieval from long-term memory store, including autobiographical recall and memory for public events.

Most neuropsychological assessments will include a basic screen of expressive and receptive language skills, as well as perceptual abilities. They will also include some tests designed to be sensitive to frontal lobe disturbance. All of these areas can be examined in greater detail with specialist test batteries such as the Multilingual Aphasia Examination, (MAE) the Visual Object Spatial Perception battery (VOSP) and the Behavioural Assessment of the Dysexecutive Syndrome (BADS), in addition to a plethora of individual tests.

The neuropsychological assessment can be combined with other investigations, such as video telemetry or ambulatory EEG recordings, to investigate the cognitive correlates of unusual EEG discharges or sub-clinical events.

Core Data Elements project: epilepsy and neuropsychology

The Core Data Elements in epilepsy project is a current US initiative designed to standardise the reporting of epilepsy studies in the peer-reviewed literature. Neuropsychology has been included among the assessments and examinations and a list of recommended tests has been proposed for adult and paediatric populations. These tests were selected on the basis of expert panel consensus rather than systematic review of the evidence base and were selected partly on the basis of good US norms. It remains to be seen whether these recommendations will be embraced by the wider international epilepsy community. Further information about the project can be found at www.commondataelements.ninds.nih.gov/Epilepsy.aspx.

Pre- and post-operative neuropsychological evaluation in epilepsy

Neuropsychological assessment has an important role in evaluating candidates for temporal lobe surgery since the temporal lobes have long been implicated in memory functioning. Bilateral hippocampal excision is associated with profound anterograde amnesia. Unilateral resections are traditionally associated with material-specific memory dysfunction. The traditional view is that the dominant temporal lobe (usually the left) is important for verbal memory processing and the non-dominant temporal lobe (usually the right) for non-verbal or visual memory processing. However, within this model, the aetiology of the seizure disorder and the underlying pathology may play a critical role in shaping the nature and extent of pre- and post-operative neuropsychological deficits. Different neuropsychological profiles are seen in patients with developmental lesions, such as those associated with cortical dysgenesis, compared to those with high-grade gliomas that develop in adulthood.

Post-operative deficits are dependent upon both the functional adequacy of the tissue removed and the functional reserve of the remaining structures. Some plasticity and the development of compensatory strategies post-operatively may also influence the nature and extent of post-operative neuropsychological deficits. Pre-operative neuropsychological scores, in conjunction with MRI and other clinical data, can be utilised to predict post-operative neuropsychological change using logistic regression techniques. Patients at high risk of a significant memory decline can be counselled pre-operatively and can be trained in compensatory strategies prior to the surgery when appropriate.

The intracarotid amobarbital procedure

There is currently a lively debate in the literature on the future of the intracarotid amobarbital procedure (IAP) or Wada test (after Juhn Wada who first introduced it in 1949) and its role in the presurgical assessment of prospective epilepsy surgery candidates. Traditionally the IAP was used to ensure that the memory capacity of the contralateral temporal lobe is adequate to maintain useful memory functions unilaterally prior to surgery and it is an effective test for language lateralisation. Recent studies have cast doubts on the reliability and validity of the IAP in predicting post-operative amnesia. The testing protocol, choice of behavioural stimuli, dosage and administration of the amytal and a host of factors related to the individual's reaction to the injection can interfere with the results.

Functional imaging

A number of fMRI paradigms have been developed to localise language function in adults and children and fMRI paradigms have also recently been used to examine memory function in prospective temporal lobectomy patients. Asymmetric fMRI activations during memory tasks are concordant with asymmetric memory performances observed during the IAP. These techniques have begun to supersede the complex and invasive IAP procedure in language lateralisation and are beginning to be combined with our traditional memory tests to further enhance the role of neuropsychology in providing lateralising and prognostic information for presurgical patients with temporal lobe epilepsy.

Further reading

- BINDER JR, GROSS WL, ALLENDORFER JB et al. Mapping anterior temporal lobe language areas with fMRI: a multicentre normative study. *Neuroimage* 2011; 54: 1465–75.
- BAXENDALE S, THOMPSON P. Beyond localisation: the role of traditional neuropsychological tests in an age of imaging. *Epilepsia* 2010; 51: 2225–30.
- CENTENO M, THOMPSON PJ, KOEPP MJ, HELMSTAEDTER C, DUNCAN JS. Memory in frontal lobe epilepsy. *Epilepsy Res* 2010; 91: 123–32.
- BINDER JR. Functional MRI is a valid noninvasive alternative to Wada testing. *Epilepsy Behav* 2010; 24: 214–22.
- BAXENDALE S, HEANEY D, THOMPSON PJ, DUNCAN JS. Cognitive consequences of childhood-onset temporal lobe epilepsy across the adult lifespan. *Neurology* 2010; 75: 705–11.
- HELMSTAEDTER C, ELGER CE. Chronic temporal lobe epilepsy: a neurodevelopmental or progressively dementing disease? *Brain* 2009; 132: 2822–30.