## General Introduction

Neuropsychological testing is a valuable tool for quantification of cognitive abilities that can be affected either by disease characteristics or its treatment. The list of cognitive domains listed below is not exhaustive, but intended to capture relevant areas across a variety of epilepsy syndromes to facilitate direct comparisons across studies and to permit data pooling across studies or epilepsy centers.

Specific neuropsychological measures have been recommended in multiple cognitive domains, but this list is not intended as a comprehensive assessment of all potentially relevant areas. There are also measures that we identify as “optional” and should be considered when a more comprehensive assessment of neuropsychological abilities is needed. Finally, we recognize that established investigators may wish to use tests that differ from these recommended to maintain continuity within and fidelity to their own research program. The recommended neuropsychological tests are intended for use either by appropriately trained psychologists, or by neuropsychology technicians under appropriate supervision.

Wherever possible, Spanish versions of neuropsychological tests are indicated, and the availability of parallel Spanish tests was one fact influencing test recommendation. We note, however, that the strict psychometric equivalence to English language versions has not always been demonstrated. Nevertheless, using Spanish measures increases the potential participation of non-English speaking subjects and increases the generalizability of research findings. Other factors influencing final test recommendation include previous use in adult epilepsy studies and, whenever possible, tests that were available in the public domain.

### Section I: Specific Test Recommendations

### GENERAL FUNCTION

1. General IQ Estimation
	1. Purpose: To characterize level of general cognitive function and provide a frame of reference from which to interpret other performances, particularly those that are language related.
	2. Recommend Test: American National Adult Reading Test (AmNART)

### Formal IQ Testing

* 1. Purpose: To characterize level of general cognitive abilities using standardized IQ tests.
	2. Recommended Test: Wechsler Adult Intelligence Test-Fourth Edition (WAIS-IV) or Wechsler Abbreviated Scale of Intelligence (WASI).

### LEARNING/MEMORY

1. Verbal Memory
	1. Purpose: To assess verbal learning and memory
	2. Recommended Test: Rey Auditory Verbal Learning Test (AVLT)
2. Visual Memory
	1. Purpose: To assess non-verbal learning and memory
	2. Recommended Test: None

Comment: There is no recommended visual memory CDE since the relationship between right TLE/ATL and various measures of visual memory has been inconsistent, making it premature to recommend a common memory test for this construct.

* 1. Potential Tests:

Brief Visual Memory Test (BVMT))

Rey-Osterrieth Complex Figure

Wechsler Memory Scale Visual Reproduction

Nonverbal Selective Reminding Test

### LANGUAGE

1. Naming
	1. Purpose: To assess the ability to name common objects.
	2. Recommended Test: Boston Naming Test (BNT)
2. Generative Verbal Fluency (phonemic)
	1. Purpose: To assess lexical retrieval. May also be used as a measure of “executive function.”
	2. Recommended Test: Controlled Oral Word Association (COWA), aka FAS.
3. Generative Verbal Fluency (semantic)
	1. Purpose: To assess retrieval from semantic storage.
	2. Recommended Test: Animal Fluency (aka Animal Naming).

### VISUOSPATIAL (optional domain)

1. General Visuospatial Function
	1. Purpose: To assess non-verbal spatial perception and reasoning.
	2. Recommended Test: WAIS-IV or WASI Block Design
2. Perceptual Reasoning
	1. Purpose: To assesses non-verbal spatial perception and reasoning
	2. Recommended Measures: WAIS-IV Perceptual Reasoning Index.

### EXECUTIVE FUNCTION

Executive function” refers to a diverse set of cognitive processes (e.g., sustained and divided attention, working memory, initiation, inhibition, planning, shifting of mental perspectives, or “sets”).

1. Setshifting
	1. Purpose: Assess visual search, mental flexibility, and task alternation.
2. Simple Span of Attention
	1. Purpose: To assessment immediate attention
	2. Recommended Tests: Digit Span subtest from the WAIS-IV/WISC-IV
3. Hypothesis Testing Ability
	1. Purpose: To assess deductive reasoning ability, perseverative ideation, and failure to maintain cognitive set.
	2. Recommended Test: Wisconsin Card Sorting Test (64 card version)

### SPEED

1. Processing Speed
	1. Purpose: Measure graphomotor and psychomotor speed
	2. Recommended Tests: WAIS-IV Coding and Symbol Search to generate the Processing Speed Index
2. Motor Speed
	1. Purpose: Assess fine motor speed
	2. Recommended Test: Grooved Pegboard

## Section II: Rationale

Whereas Section I contains the CDE Neuropsychology Group’s recommendations for specific test use, Section II is intended to provide greater background and rationale behind specific test recommendation.

### General IQ Estimation

General IQ estimation is obtained for sample characterization and is important for several purposes. IQ provides descriptive information of the patient sample being studied, and may also assist in the clinical interpretation of other cognitive tests, particularly verbal/language-related measures.

The tests that were considered as quick IQ estimates are based upon the ability to correctly pronounce words with atypical grapheme to phoneme relationship (e.g., paradigm). The primary advantage of this approach is that a general IQ estimate can generally be obtained within 5 minutes of testing.

The tests considered included the Wechsler Test of Adult Reading (WTAR), Wide Range Achievement Test (WRAT) Reading Subtest, and variants of the National Adult Reading Test (NART). Review of the literature identified no distinct advantage of one test over others, with test selection apparently determined by individual preference.

The American National Adult Reading Test (AMNART, a NART variant) was selected because it is in the public domain, which decreases the financial and administrative contract burden on individual sites. In addition, the AMNART is included as a screening measure in the CDE Comorbidities group; having a common metric endorsed by both Neuropsychology and Comorbidities CDE groups will facilitate combination of results that are based upon the recommendations based on either group.

In order to obtain a common metric across as many studies as possible, it is recommended that the AMNART be administered to all study patients examining neuropsychological performance, even when more formal IQ assessment (described below) is administered.

Recommended Test: American National Adult Reading Test (AMNART)

### Formal IQ Testing

Most epilepsy studies containing neuropsychological testing employ formal IQ assessment to characterize the sample. When neuropsychology is not a prominent component of the study, the IQ estimates provided by the AMNART will be sufficient. The AMNART is a recommended test from the Comorbidities group.

For situations in which a formal IQ assessment based upon multiple cognitive constructs is required, a test from the Wechsler scales is recommended since they are the most commonly used measures of formal IQ in both clinical practice and in clinical research.

Included in the recommended tests are both the Wechsler Abbreviated Scale of Intelligence (WASI) and the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) and Wechsler Adult Intelligence Scale- Fourth Edition (WAIS-IV).

### Verbal Memory

The most common approaches to verbal memory assessment in epilepsy include versions of the Wechsler Memory Scale (WMS), either in its entirety or selected WMS subtests, the Rey Auditory Verbal Learning Test (AVLT), and the California Verbal Learning Test (CVLT). Although less commonly used, the Selective Reminding Test (SRT) has also appeared as the primary verbal learning measure in the epilepsy research literature.

Visual memory was not addressed by this group since the relationship between right TLE/ATL and various measures of visual memory has not been consistent, making it premature to recommend a common memory test for this construct.

* Wechsler Memory Scales (WMS)
* California Verbal Learning Test-2 (CVLT-2)
* Selective Reminding Test (SRT)

Recommended Verbal Memory Test: Rey Auditory Verbal Learning Test

### Language

Language testing is an important part of neuropsychological evaluation in most clinical populations. Although assessment of language in epilepsy patients can be extensive, language testing in epilepsy research is typically limited to naming and fluency. Unlike memory testing, there are fewer options for these important constructs.

### Naming

The most common measure of naming is the 60-item Boston Naming Test (BNT). Other naming measures include the Visual Naming subtest of the Multilingual Aphasia Examination, which is considered less sensitive than the BNT (Loring et al., 2008), and the Columbia Auditory and Visual Naming Tests, which are newer and have less extensive normative data than the BNT.

Recommended Test: Boston Naming Test (BNT)

### Fluency

Generative verbal fluency is part of most neuropsychological assessment protocols and not only is sensitive to deficits in language fluency associated with linguistic impairment, but is also a common approach that has been associated with impairments in executive function. Improvements in verbal fluency have been reported after left temporal surgery.

There are 2 common techniques to measuring generative verbal fluency. The first approach requires the patient to generate as many words as possible that begin with a specified letter of the alphabet, and is termed “phonemic” fluency.

Recommended Test (phonemic): F-A-S, aka COWA

The second approach assessing generative verbal fluency uses semantic constraints, with the most common semantic category being animals (also called animal naming).

Recommended Test (semantic): Animal Fluency (Animal Naming)

### Visuospatial (Optional Domain)

Spatial skills, to date, have not been a primary interest in most epilepsy studies. Other than improvement following contralateral/dominant hemisphere surgery, visuospatial performances tend to remain stable. In addition, there is greater variability in tests used to measure visual spatial abilities compared to language measures (e.g., Judgment of Line Orientation, Visual Object and Space Perception, Rey-Osterreith Complex Figure copy).

Recommended Tests: Block Design, WAIS-IV Perceptual Reasoning Index

### Executive Function

Executive function refers to a diverse set of cognitive processes (e.g., sustained and divided attention, working memory, initiation, inhibition, planning, shifting of mental perspectives, or ‘sets’) that depend primarily on the functional integrity of the frontal lobes, although impairments on these tests may also be seen with lesions in other brain regions.

The majority of epilepsy studies identified provided cross-sectional comparisons between frontal and temporal lobe epilepsy patients, with a few longitudinal studies of change following frontal lobe resection. A range of tasks has been shown to be sensitive to frontal/temporal group differences. No single task stands out as being more frequently discriminating than any other and there are also negative results. Many studies used experimental tasks (e.g., estimating, concept formation, maze tracing, motor alternation, response inhibition, cancellation tasks) that were not considered appropriate as CDEs because of lack of standardization and normative data and are not in widespread clinical use.

* Trail Making Test
* Stroop Task (Not Recommended)

Recommendation: NOT RECOMMENDED

### Simple Attention

Recommended Test: WAIS-IV Digit Span

Hypothesis Testing Ability (optional construct)

Recommended Test (optional): Wisconsin Card Sorting Test (64 card version)

### Speed

Psychomotor Speed

Slowing of cognitive and psychomotor speed is a commonly reported cognitive complication of epilepsy. Cognitive and psychomotor slowing has been reported in adults (Taylor et al., in press) and children with new onset epilepsy (Fastenau et al., in press, Hermann et al., 2006), it is a common complication of antiepilepsy medications (Loring et al., 2007), may worsen over time (Hermann et al., 2006), and persist after remission of epilepsy in children (Berg et al., 2008).

Recommend Tests: Coding and Symbol Search, which form the Processing Speed Index.

### Motor Speed

Motor speed may be assessed by a variety of procedures including measures of reaction time (Thompson & Trimble, 1983) or more conventional measures of motor speed used in clinical neuropsychological evaluations (Grooved Pegboard, Finger Tapping). While reaction time measures are perhaps extremely pure motor speed measures and have been used in epilepsy research (Thompson & Trimble, 1983), they are not widely used clinically and have limited normative data. More conventional clinical measures have the advantage of familiarity and strong normative databases and are brief and direct in administration time and directions.

Recommended Test: Grooved Pegboard

### Cognitive Speed

Multiple measures for assessing cognitive processing speed are available, some with clear advantages. For instance the Sternberg procedure provides a measures of response speed and cognitive decision making speed and has been used in a variety of neurological disorders including MS (Rao et al., 1989) and epilepsy (Dow et al., 2004). However, it is uncommonly used to characterize clinical aspects of disease, requires specialized programming, and is not commercially available. Reaction time has also been used in the epilepsy literature, (Thompson & Trimble, 1983), but these measures do not have a strong normative database and are not commercially available. It was the consensus of the group not the recommend any specific cognitive speed measure as a CDE.

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