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Reliable Change Indices and Standardized Regression-Based Change Score Norms for Evaluating Neuropsychological Change in Children with Epilepsy

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Abstract

Reliable change index scores (RCIs) and standardized regression-based change score norms (SRBs) permit evaluation of meaningful changes in test scores following treatment interventions, like epilepsy surgery, while accounting for test-retest reliability, practice effects, score fluctuations due to error, and relevant clinical and demographic factors. Although these methods are frequently used to assess cognitive change after epilepsy surgery in adults, they have not been widely applied to examine cognitive change in children with epilepsy. The goal of the current study was to develop RCIs and SRBs for use in children with epilepsy. Sixty-three children with epilepsy (age range 6–16; *M*=10.19, *SD*=2.58) underwent comprehensive neuropsychological evaluations at two time points an average of 12 months apart. Practice adjusted RCIs and SRBs were calculated for all cognitive measures in the battery. Practice effects were quite variable across the neuropsychological measures, with the greatest differences observed among older children, particularly on the Children's Memory Scale and Wisconsin Card Sorting Test. There was also notable variability in test-retest reliabilities across measures in the battery, with coefficients ranging from 0.14 to 0.92. RCIs and SRBs for use in assessing meaningful cognitive change in children following epilepsy surgery are provided for measures with reliability coefficients above 0.50. This is the first study to provide RCIs and SRBs for a comprehensive neuropsychological

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Conflict of Interest

None of the authors has any conflicts of interest to disclose.

battery based on a large sample of children with epilepsy. Tables to aid in evaluating cognitive changes in children who have undergone epilepsy surgery are provided for clinical use. An excel sheet to perform all relevant calculations is also available to interested clinicians or researchers.

Keywords

epilepsy; reliable change indices; standardized regression-based change score norms; children; neuropsychology

1.1 Introduction

Neuropsychological assessment is an essential component of epilepsy surgery programs. These evaluations help determine the cognitive risks associated with epilepsy surgery and assess postsurgical neurobehavioral outcomes. Change in cognitive abilities across time or in response to interventions has historically been evaluated by: 1) examining differences in cognitive outcome between groups of patients or 2) comparing change scores in individual patients to some predetermined, yet often arbitrary, difference believed to reflect actual change based on conventional practice (e.g., 10 or 15 standard score points). These procedures for assessing change are confounded by methodological artifacts (e.g., imperfect test reliability, measurement error, practice effects, regression toward the mean) that are likely to lead to erroneous conclusions regarding cognitive outcome.

Beginning in the 1990s, two methods for assessing postsurgical cognitive change while controlling these confounding factors emerged in the adult epilepsy literature: reliable change index scores (RCIs) and standardized regression-based change score norms (SRBs) [1–3]. These methods have been developed for a wide range of cognitive measures and are now routinely applied to assess cognitive outcome in adults following epilepsy surgery [1–4]. Despite the clear benefits, RCIs and SRBs have not been developed to examine cognitive change in children after epilepsy surgery across a wide range of cognitive measures.

Our prospective, longitudinal study was designed to address this gap in the literature. Specifically, this study provides RCIs and SRBs for children with epilepsy across a comprehensive neuropsychological battery using the same methods employed by Martin and colleagues [4] for adults with epilepsy. These data allow clinical neuropsychologists to objectively assess cognitive change after pediatric epilepsy surgery. Moreover, clinicians can use these RCIs and SRBs to monitor the effect epilepsy has on the cognitive development of children who do not undergo surgery and to examine both the efficacy and potential side effects of non-surgical medical treatments.

2.1 Materials and Methods

2.1.1 Participants

This prospective study was approved by the Cleveland Clinic Institutional Review Board. Children who were being evaluated and/or treated for epilepsy within the Cleveland Clinic Epilepsy Center were approached regarding study participation during an outpatient appointment if they met the following inclusion criteria: 1) ages 6 to 16 years; 2) confirmed

history of seizures as evidenced on EEG recordings; 3) history of seizures for at least one year; 4) maintained on a stable AED regimen; 5) fluent in English; 6) no past neurosurgical intervention; 7) no history of neurodegenerative disorder; and 8) no neuropsychological testing within the previous 6 months.

A total of 76 children met inclusion criteria, agreed to participate, and completed the initial assessment. Caregivers provided written informed consent, and children over the age of 12 provided assent for the study. Repeat neuropsychological evaluations were scheduled approximately 9 months following the initial evaluation, whenever possible. This test-retest interval was selected to approximate the average interval between pre and postoperative neuropsychological assessments of children who undergo epilepsy surgery at our center. Participants received a $40 gift card after completing their first assessment and a $60 gift card at follow-up. A copy of the test results was also provided to interested caregivers. A total of 13 (17.1%) children did not complete the second neuropsychological assessment. This resulted in a final sample size of 63 children who were an average of ten years old and had completed approximately five years of education. The mean age at seizure onset was 6.5 years (SD = 3.1), and the average duration of epilepsy was 3.7 years (SD = 2.6). Eighty-four percent of the sample was Caucasian, and just over half of the participants were female (57.1%).

Given the wide age range of participants and age-specific differences in test items and developmental factors, participants were stratified into 2 age groups: 6–10 years old (younger group; n=36) and 11–16 years old (older group; n=27). Additional demographic and seizure information for the participants is presented in Table 1.

2.1.2 Measures

Participants completed a comprehensive neuropsychological evaluation that included measures of intelligence, memory, language, visuospatial skills, executive functioning, and academic achievement. The following instruments were administered on two separate occasions: Wechsler Intelligence Scale for Children – Fourth Edition[5], Children's Memory Scale[6], Expressive One-Word Picture Vocabulary Test - Revised[7], The Beery-Buktenica Developmental Test of Visual-Motor Integration – Fourth Edition[8], Test of Visual Perceptual Skills – Third Edition[9] (Visual Discrimination, Visual Memory, and Spatial Relations subtests), Wisconsin Card Sorting Test[10], Delis-Kaplan Executive Function System[11] (Trail Making Test, Verbal Fluency Test, and Tower Test), and the Woodcock-Johnson III Tests of Achievement[12] (Letter-Word Identification, Reading Fluency, Calculation, Math Fluency, Spelling, Writing Fluency, Passage Comprehension, Applied Problems, Writing Samples, Word Attack, and Punctuation & Capitalization subtests). All measures were administered according to standardized instructions provided in the respective test manuals and scored using age-adjusted norms.

2.1.3 Analyses

Reliable Change Indices—Practice adjusted RCI cutoff scores were calculated for each of the neuropsychological measures in the test battery according to the methods outlined by Jacobson & Truax[13]. First, test-retest reliability coefficients were computed for each of the

neuropsychological measures. Then RCIs were developed for the two separate age ranges (i.e., 6–10 and 11–16). The standard error of measurement was used to calculate the standard error of the difference (SE_{diff}), where $SE_{diff} = \sqrt{2}(SEM)^2$. As noted by Jacobson and Truax [13], the SE_{diff} describes "the spread of the distribution of change scores that would be expected if no actual change had occurred" (p. 14), that is, based solely on chance fluctuations in test scores across time. Next, confidence intervals were established at 80% and 90% by multiplying the SE_{diff} by ±1.28 and ±1.64, respectively. This provided two different distribution ranges of change scores, with the 90% confidence interval offering a more conservative estimate of test-retest change and the 80% confidence interval a more liberal estimate. The resulting cut-off score ranges were then adjusted for practice effects[3, 14]. Average practice effects were determined by calculating the mean change (i.e., Time 2 mean minus Time 1 mean) for each cognitive measure. Finally, these practice effects were added to the confidence interval in order to center the range of cut-off scores around the average test-retest practice. Score changes outside of these confidence intervals are considered uncommon in children with epilepsy who have not undergone surgery during the test-retest interval since they occur in less than 80% (80% CI) of these children or 90% (90% CI) of these children in the absence of surgical intervention.

Standardized Regression – Based Change Score Norms—A series of multiple regression equations were used to predict retest scores for each neuropsychological measure using the baseline test score and potential modifying factors (e.g., age, age at seizure onset, and test-retest interval). Because age was included as a predictor in the regression equations, SRBs were calculated using data from the full sample of nonsurgical children (N=63). Linear regression analyses were conducted for each neuropsychological test score using the methods outlined by McSweeney et al.[2] Specifically, variables were entered into the regression equation in a stepwise fashion. A probability level of .05 was used to determine variable entry and .10 was used to determine variable removal at each step.

3.1 Results

A summary of baseline and retest mean scores and standard deviations along with mean change scores and test-retest reliabilities for each test is presented in Table 2. Paired t-tests were used to examine differences between baseline and retest performances. Mean change scores were quite variable across the neuropsychological measures, with the greatest differences observed among older children, particularly on the standard scores associated with the Children's Memory Scale Indices (mean improvement of 8–12.62 points on five of the eight indices) and the Wisconsin Card Sorting Test (mean change scores of 8 on Total Errors and 9.82 on Perseverative Responses). There was also notable variability in test-retest reliabilities across measures in the battery, with coefficients ranging from 0.14 to 0.92. Given the very low reliability of some of these measures, RCI intervals and regression analyses are only reported for those measures with test-retest reliabilities above 0.50.

Adjusted reliable change cut scores at both 80% and 90% confidence intervals are provided in Table 3 along with the correction value used to adjust for practice effects. Separate RCIs are provided for younger and older children. The adjusted reliable change scores reported in Table 3 represent cutoff values at or beyond which an observed change score would

represent a clinically meaningful change after adjusting for test-retest reliability and practice effects. For example, a 7 year-old whose Working Memory Index improved by 12 standard score points from baseline to retest would show a clinically meaningful change falling outside of the 80% confidence interval, but not outside of the 90% confidence interval. This same 12-point improvement would be considered unremarkable in a 12 year-old patient, but rather would be thought to reflect unreliability of the measure and typical practice effects.

Results of regression analyses for all neuropsychological measures in the battery are provided in Table 4. Specifically, the multiple R value, standard error of the estimate, and constant are included for each measure along with beta weights for the preoperative test score and any relevant modifiers retained in the equation (e.g., age, onset, or test-retest interval). Preoperative test score was a significant predictor of postoperative test score for all cognitive measures. Modifiers only entered the equation for select cognitive measures, accounting for 1% to 12% of the variance in postoperative test score. For those measures in which a modifier was retained in the equation, two equations are reported – one that includes the modifier and indicates the percentage of variance accounted for by the modifier and one that does not – for clinicians who may prefer to use a simpler equation in clinical practice. Using baseline test scores and modifiers, the SRB equation predicts re-test performance. The difference between the predicted score and the actual score is then transformed into a z-score by dividing it by the standard error of the estimate. Z-scores that are $\geqq 1.28$ exceed the 80% confidence interval and those that are $\geqq 1.64$ exceed the 90% confidence interval and represent clinically meaningful changes.

Case Example

To demonstrate the utility of reliable change indices and standardized regression-based change scores in clinical practice, a brief case example follows. At the time of his preoperative neuropsychological evaluation, the patient was 13 years-old and in the 8th grade. He began experiencing staring spells at age 11, which were subsequently diagnosed as seizures. Video-EEG monitoring showed interictal sharp waves and spikes in the left posterior temporal-occipital regions. Brain MRI revealed a focal area of abnormal morphology and signal intensity in the left temporal lobe posteriorly and inferiorly that involved the fusiform gyrus, parahippocampal gyrus, and medial aspect of the inferior temporal gyrus. PET studies revealed hypometabolism in the left posterior basal temporal, temporal occipital junction, and posterior hippocampus. The patient underwent a left temporal lobectomy approximately three months after his preoperative neuropsychological assessment. The resection extended posteriorly, inferiorly, and mesially to include the lesion visualized on MRI. Pathology was suggestive of low grade glial/glioneuronal neoplasm (WHO grade I/II). The patient was seizure free at the time of his last clinical follow-up, which was two years following his resection.

The patient completed a postoperative neuropsychological assessment approximately 6 months following surgery. A summary of a small subset of his test-retest scores is provided in Table 5 for illustrative purposes. Examination of his change scores against the 90% confidence interval RCIs provided for older children in Table 3 reveals a significant decline in Verbal Memory. In contrast, a significant improvement was apparent on the Visual Motor

Integration Test. All other test scores remained unchanged per RCIs. That is, neither the two Standard Score point decline in the Verbal Comprehension Index nor the three Standard Score point improvement in Visual Delayed Memory exceeded the amount of change expected based on typical practice and error in these measures.

When using SRBs to assess cognitive change on these measures, similar results emerged. Specifically, if we use the SRB equation for Verbal Delayed Memory provided in Table 4, this patient's predicted postoperative score on this index is calculated as follows: Predicted Postoperative Score = Constant + (T1 Score* $B_{baseline}$) = 23.078 + (94*.806) = 98.84. The difference between his actual postoperative score and his predicted postoperative score can then be calculated and translated into a z-score as follows: z-score = (Actual Score − Predicted Score) / SE_{est} = (77 − 99) / 12.76 = −1.72. This z-score exceeds the 90% confidence interval (i.e., ± 1.64) for identifying statistically significant and clinically meaningful change, providing further support that this patient experienced a meaningful decline in Verbal Delayed Memory following his left temporal lobe resection. SRBs have the added advantage of transforming all of the test scores in the battery to the same metric (i.e., z-scores) allowing for a simple and direct comparison of the magnitude and direction of changes observed across the measures of the battery as depicted in Figure 1.

These calculations have been programmed into a Microsoft Excel spreadsheet to enable clinicians to effortlessly determine meaningful change in scores following pediatric epilepsy surgery. This document requires entering some basic information about the patient (age, age at onset, test-retest interval) and the standardized pre and postoperative test scores. It then compares patients' change scores to the appropriate RCI intervals and calculates SRBs for each test at both 80% and 90% confidence intervals. This excel document is available from the corresponding author upon request.

4.1 Discussion

This research provides clinicians with the tools necessary to objectively evaluate change in cognitive functioning in their pediatric epilepsy patients. It includes a common metric that researchers can use in future studies to more accurately characterize cognitive outcomes following epilepsy surgery in children. Importantly, the methods for assessing cognitive change provided here allow differentiation between changes in cognition due to epilepsy versus epilepsy surgery, which cannot be accomplished using traditional methods (e.g., change scores). Although the primary goal of this study was to develop RCIs and SRBs for use in evaluating cognitive change in children following epilepsy surgery, it is important to note that these methods can easily be applied to assess change in children with epilepsy in other circumstances such as after a medical event (e.g., seizure cluster) or treatment intervention (e.g., medication change).

We have provided three different metrics for assessing cognitive change – RCIs, SRBs with modifiers, SRBs without modifiers – so that clinicians and researchers can choose the method that best suits their needs. RCI methodology calculates the degree of individual change associated with test imprecision and practice effects and identifies the amount of test-retest change necessary to conclude that clinical change has occurred independent of

measurement error. Because RCIs provide cut-off scores to identify meaningful change, they require no additional calculation beyond test-retest difference scores. This permits quick and easy application to patients' test results. However, RCIs do not correct for regression to the mean or other potential modifiers and, in the case of our study, are based on smaller samples than the SRBs because they were calculated for two separate age groups.

While SRB methodology is more complicated to use, it corrects for multiple confounding factors that RCIs do not. Statistically, SRBs correct for practice by using an individual's baseline score as a predictor of postoperative performance. This provides more accurate adjustment of practice effects than RCIs because practice can be estimated differently at different levels of baseline performance. SRBs also allow for correction of demographic and disease-related variables that could potentially impact cognitive performance over time. Finally, SRBs convert changes in test scores to a common metric (i.e., z-scores) permitting direct comparison of cognitive change across a wide range of neuropsychological measures.

Studies that have compared RCI and SRB methodologies head-to-head suggest that predictive accuracy is similar for both measures [15, 16]. This has led many clinicians to utilize the easily employed RCI cutoffs rather than calculating SRBs for individual patients. Nevertheless, we have created a Microsoft Excel calculator that calculates SRBs to facilitate the interpretation of cognitive change in individual patients for clinicians and researchers who prefer this more rigorous methodology derived with a larger sample of children. This calculator is available from the corresponding author upon request.

One interesting and unanticipated finding in our study was the negative practice effects observed on a number of cognitive measures. Rather than showing the typical practice effects demonstrated by healthy children, children in our epilepsy sample achieved lower test scores during repeat testing on some cognitive measures. Interestingly, Hermann and colleagues [17] also observed a lack of typical practice effects in adults with temporal lobe epilepsy compared to controls. In our study, this may indicate that children with epilepsy are not developing along the expected trajectory. All of the measures in the neuropsychological battery are age-normed; therefore, if children with epilepsy are not gaining skills at a rate comparable to healthy standardization samples, their scores on these measures will decline over time. Alternatively or additionally, there may be some potential negative effects associated with having taken these tests previously (e.g., overconfidence, trying to remember rather than figure out answers, using a new strategy that is less ideal). While the reason for negative practice effects needs to be investigated, this was typical for some measures like those evaluating working memory, processing speed and delayed recognition amongst the younger age group and those assessing academic achievement regardless of age. This was accounted for in our development of RCIs and SRBs by centering intervals around typical changes in scores, regardless of whether the practice effects were positive or negative.

It is also interesting to note that some of the measures in our neuropsychological battery had very poor test-retest reliability (<.50) in this pediatric epilepsy sample. For example, Dot Locations from the Children's Memory Scale had test-retest reliability coefficients ranging from .14–.21 and Word List Delayed Recognition had a test-retest reliability coefficient of .

44. Other measures in the battery with low test-retest reliability included subscores from the Wisconsin Card Sorting Test (categories, failure to maintain set, total errors), the Delis-Kaplan Executive Function System (Trail Making – visual scanning, number sequencing, motor speed, total errors; Verbal Fluency – set loss errors, repetition errors; Tower Test – rule violation/item ratio), and Test of Visuoperceptual Skills (Visual Discrimination, Visual Memory, Visual Spatial Relationships). Restricted score range (e.g., WCST number of categories) may have contributed to this for some measures. Regardless, the very low test-retest reliability of these measures in this sample raises the question of whether these measures should be used in the repeated neuropsychological assessment of pediatric epilepsy patients. Given the poor psychometric properties in this sample, RCIs and SRBs for these measures are not reported.

Several limitations of the current study deserve discussion. First, the ideal control group for determining meaningful cognitive change in children who undergo epilepsy surgery would be a group of surgical children tested twice prior to surgery, as this group would most closely approximate the demographic and seizure characteristics of children who undergo epilepsy surgery. In the United States, including our Epilepsy Center, children generally proceed to surgery as soon as they are deemed suitable candidates. It is neither feasible, nor ethical, to delay epilepsy surgery in order to obtain neuropsychological testing on two occasions 12 months apart. While we were able to obtain a small subset of surgical patients who were tested twice prior to surgery due to surgical delays or other factors, most of the patients in our control group had a confirmed diagnosis of epilepsy for at least one year but were not surgical candidates. Second, our study did not include any children under the age of 6. Therefore, our results should not be applied to younger children. Only children aged 6 to16 were included primarily to enable the use of the same neuropsychological battery with age-appropriate normative data for all children. The neuropsychological measures for children younger than 6 and older than 16 are different and use different normative groups. Third, to control for age-specific differences in test items and developmental factors, we stratified patients into younger (ages 6–10) and older (ages 11–16) age groups before developing the RCIs. This resulted in reduced samples sizes (n=36 and 27, respectively) for the RCI calculations compared to SRB calculations (n=63) with relatively small numbers of patients with different seizure foci. Finally, despite attempts to have a rather consistent 9 month test-retest interval for all children, there was some variability in the length between baseline and repeat neuropsychological testing due to limited availability of the families to return for testing and/or other scheduling limitations. While not ideal, this is likely to reflect clinical practice as test-retest intervals often vary among our surgical patients as well. Further, the vast majority of patients (80%) in our sample completed both assessments within a 5–12 month interval.

5.1 Conclusions

The establishment of RCIs and SRBs for use in evaluating cognitive change in children with epilepsy is an important step towards improving their care. These methods allow neuropsychologists to more accurately assess cognitive change after surgery or to evaluate other treatment interventions while taking into account the effects of epilepsy on the developing brain. These methodologies also permit researchers to compare cognitive

outcomes across studies in order to further our understanding of the "true" cognitive changes associated with epilepsy surgery in children. Finally, use of these methodologies can aid clinicians in advising parents and physicians about the potential cognitive outcomes of epilepsy surgery on an individual level and may result in more targeted and relevant cognitive and school interventions for children with epilepsy regardless of whether or not they undergo surgery.

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Highlights

- RCIs and SRBs were developed to evaluate cognitive change in children with epilepsy
- These methods control for test-retest reliability, practice effects, error, and clinical factors
- These methods allow for accurate assessment of cognitive change related to treatments
- Tables for calculating RCIs and SRBs are provided for clinical use

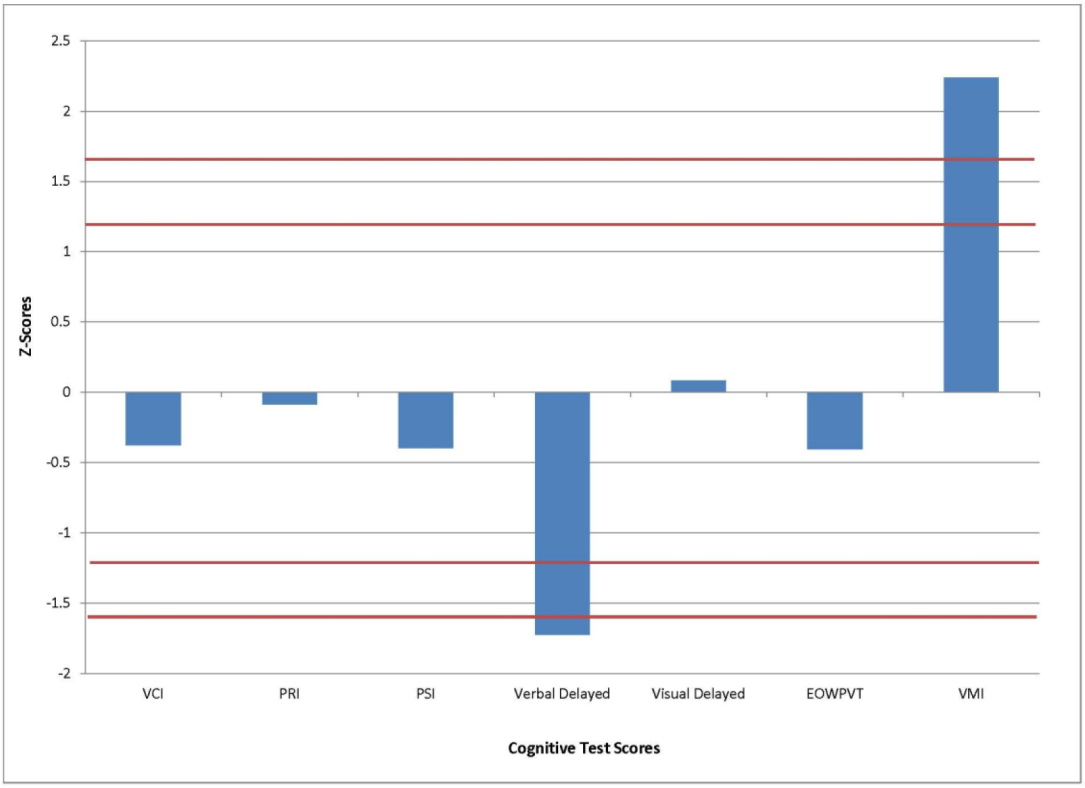

Figure 1.

Plot of the z-scores demonstrating magnitude of postoperative cognitive change on each of the cognitive measures for the child in the case example. Note that bars exceeding the red lines (z±1.28 for 80% CI or z±1.64 for 90% CI) reflect those postoperative measures for which the change scores reflect significant and meaningful cognitive change.

Table 1

Demographic and Seizure Data for Study Patients

Variable	Younger Group Ages 6–10 N=36	Older Group Ages 11–16 N=27
	M (SD)	M (SD)
Age (years)	8.36 (1.38)	12.63 (1.60)
Education (years)	2.69 (1.31)	7.00 (1.66)
Full Scale IQ (standard score)	86.61 (17.27)	83.67 (16.06)
Age at Seizure Onset (years)	5.24 (2.24)	8.26 (3.18)
Duration of Epilepsy (years)	3.12 (2.13)	4.48 (3.03)
Inter-test Interval (months)	13.03 (8.47)	10.93 (2.97)
Sex	Male = 17 (47.2%)	Male = 10 (37.0%)
	Female = 19 (52.8%)	Female = 17 (63.0%)
Race	Caucasian = 32 (88.9%)	Caucasian = 21 (77.8%)
	African American = 2 (5.6%)	African American = 3 (11.1%)
	Other = 2 (5.6%)	Other = 3 (11.1%)
Handedness	Left = 6 (16.7%)	Left = 4 (14.8%)
	Right = 29 (80.6%)	Right = 23 (85.2%)
	Ambidextrous = 1 (2.8%)	Ambidextrous = 0 (0%)
Type of Seizures	Generalized = 16 (44.4%)	Generalized = 13 (48.1%)
	Focal = 20 (55.6%; 9 left, 11 right)	Focal = 14 (51.9%; 10 left, 4 right)
Seizure Focus	Temporal = 4	Temporal = 5
	Frontal = 4	Frontal = 2
	Parietal = 2	Parietal = 0
	Occipital = 1	Occipital = 1
	Multilobar = 9	Multilobar = 6

M = mean; SD = standard deviation

Table 2

Test-Retest Means, SD, Mean Difference Scores, and Test-Retest Reliability

Index/Subtest	Younger Group			Older Group			Test- Retest Reliability
	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	
Intelligence							
Wechsler Intelligence Scale for Children – Fourth Edition							
Full Scale IQ	86.94 (17.40)	86.71 (16.84)	−0.23	83.67 (16.06)	84.56 (14.86)	0.89	0.92
Verbal Comprehension Index	92.06 (16.06)	91.00 (15.91)	−1.06	90.52 (17.80)	88.63 (13.83)	−1.89	0.88
Perceptual Reasoning Index	90.89 (14.55)	93.57 (17.08)	2.68	87.11 (14.72)	88.67 (13.73)	1.56	0.78
Working Memory Index	85.23 (17.71)	82.31 (14.37)	−2.92	85.70 (20.03)	88.41 (19.28)	2.71	0.80
Processing Speed Index	89.37 (16.02)	87.91 (16.02)	−1.46	83.78 (14.46)	84.22 (12.46)	0.44	0.76
Similarities	9.29 (3.39)	9.29 (3.13)	0.00	8.63 (2.95)	8.26 (2.44)	−0.37	0.82
Vocabulary	8.21 (3.07)	8.18 (3.40)	−0.03	8.52 (3.82)	8.41 (3.19)	−0.11	0.87
Comprehension	8.06 (2.98)	8.09 (2.80)	0.03	7.78 (3.12)	7.56 (2.68)	−0.22	0.71
Word Reasoning	9.19 (3.30)	9.00 (3.44)	−0.19	8.92 (3.35)	9.08 (3.43)	0.16	0.78
Block Design	8.18 (2.96)	9.18 (3.14)	1.00*	6.89 (2.47)	7.78 (2.90)	0.89**	0.79
Picture Concepts	8.94 (3.42)	9.44 (3.17)	0.50	9.04 (3.24)	8.22 (3.07)	−0.82	0.54
Matrix Reasoning	8.26 (2.85)	8.18 (3.57)	−0.08	7.78 (2.85)	8.44 (2.49)	0.66	0.51
Digit Span	7.68 (3.52)	7.71 (3.18)	0.03	7.96 (3.76)	8.56 (3.94)	0.60	0.73
Letter-Number Sequencing	6.76 (3.55)	6.09 (3.22)	−0.67	7.19 (4.19)	7.48 (3.98)	0.29	0.69
Coding	7.15 (3.12)	7.09 (3.03)	−0.06	6.81 (3.18)	6.81 (2.79)	0.00	0.76
Symbol Search	8.75 (3.79)	8.41 (3.29)	−0.34	6.93 (3.09)	7.59 (2.72)	0.66	0.61
Cancellation	10.25 (2.72)	10.03 (2.78)	−0.22	8.88 (2.79)	9.24 (3.14)	0.36	0.73
Memory							
Children's Memory Scale							
Visual Immediate	91.45 (13.45)	93.24 (14.92)	1.79	90.30 (12.97)	100.15 (14.08)	9.85*	0.53
Visual Delayed	89.53 (13.61)	97.00 (15.00)	7.47*	87.15 (13.84)	98.56 (15.43)	11.41*	0.54
Verbal Immediate	87.67 (23.07)	89.82 (25.96)	2.15	88.41 (22.29)	94.07 (22.59)	5.66*	0.90
Verbal Delayed	82.50 (22.40)	88.38 (22.97)	5.88**	87.78 (22.30)	95.85 (21.28)	8.07*	0.83

Index/Subtest	Younger Group			Older Group			Test- Retest Reliability
	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	
General Memory	85.31 (22.45)	89.47 (23.66)	4.16	83.92 (21.08)	96.54 (22.37)	12.62*	0.85
Attention/Concentration	91.86 (21.66)	89.00 (20.70)	−2.86	90.40 (16.80)	89.76 (18.73)	−0.64	0.89
Learning	89.55 (18.12)	91.45 (19.00)	1.90	86.52 (13.88)	94.52 (17.97)	8.00*	0.69
Delayed Recognition	91.25 (21.42)	87.00 (19.26)	−4.25	89.26 (22.91)	93.22 (18.39)	3.96	0.66
Dot Locations - Learning	9.18 (2.89)	9.18 (3.32)	0.00	7.92 (2.48)	9.58 (2.89)	1.66**	0.19
Dot Locations - Total Score	9.48 (2.92)	9.70 (3.39)	0.22	8.33 (2.63)	10.04 (2.65)	1.71**	0.21
Dot Locations - Short Delay	10.00 (3.10)	10.48 (2.82)	0.48	8.88 (2.73)	10.08 (2.66)	1.20	0.15
Dot Locations - Long Delay	9.41 (3.00)	10.78 (2.57)	1.37**	8.56 (2.79)	9.70 (3.04)	1.14	0.17
Stories - Immediate	8.88 (3.70)	8.79 (4.34)	−0.09	8.56 (3.81)	9.93 (4.09)	1.37*	0.82
Stories - Delayed	8.34 (4.24)	8.56 (4.33)	0.22	8.11 (4.42)	9.52 (4.20)	1.41**	0.83
Stories - Delayed Recognition	9.12 (3.78)	7.81 (2.79)	−1.31**	7.92 (4.44)	8.92 (3.76)	1.00	0.60
Faces - Immediate	7.73 (2.96)	8.12 (2.74)	0.39	8.48 (3.09)	10.00 (3.14)	1.52**	0.52
Faces - Delayed	7.19 (2.76)	8.25 (3.40)	1.06**	7.26 (3.35)	9.85 (3.39)	2.59*	0.56
Word Pairs - Immediate	7.52 (3.65)	8.64 (4.15)	1.12**	8.32 (3.68)	7.60 (3.65)	−0.72	0.71
Word Pairs - Learning	7.42 (4.48)	8.06 (4.51)	0.64	7.46 (4.09)	8.31 (4.01)	0.85	0.82
Word Pairs - Total Score	7.12 (4.20)	7.91 (4.73)	0.79	7.67 (4.09)	8.19 (3.98)	0.52	0.82
Word Pairs - Long Delay	5.97 (3.85)	7.66 (3.79)	1.69**	7.93 (3.75)	9.11 (3.69)	1.18**	0.60
Word Pairs - Delayed Recognition	8.06 (4.09)	8.28 (4.18)	0.22	8.27 (4.14)	8.73 (3.54)	0.46	0.68
Numbers - Total Score	8.53 (3.84)	7.87 (3.30)	−0.66	7.88 (3.18)	7.60 (3.70)	−0.28	0.79
Sequences - Total Score	8.45 (3.80)	8.23 (3.79)	−0.22	8.92 (2.97)	9.04 (3.12)	0.12	0.84
Family Pictures - Immediate	9.57 (3.09)	9.73 (3.03)	0.16	9.21 (3.18)	10.21 (2.75)	1.00	0.52
Family Pictures - Delayed	9.28 (3.25)	9.21 (3.06)	−0.07	9.50 (3.40)	9.88 (3.42)	0.38	0.57
Word List - Learning	7.75 (5.37)	6.96 (3.93)	−0.79	6.14 (2.88)	6.77 (3.28)	0.63	0.62
Word List - Delayed	6.67 (3.53)	6.74 (3.46)	0.07	6.41 (3.33)	6.82 (3.62)	0.41	0.57
Word List - Delayed Recognition	7.74 (3.81)	5.89 (3.25)	−1.85*	6.68 (3.21)	7.23 (3.69)	0.55	0.44
Language							

Index/Subtest	Younger Group			Older Group			Test- Retest Reliability
	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	
Expressive One-Word Picture Vocabulary							
	96.59 (17.49)	97.06 (16.50)	0.47	93.68 (16.08)	94.48 (19.41)	0.80	0.86
Visuospatial							
Test of Visual Perceptual Skills							
Visual Discrimination	7.33 (3.08)	6.89 (2.81)	−0.44	5.82 (3.03)	6.50 (3.22)	0.68	0.48
Visual Memory	7.07 (4.12)	7.48 (3.27)	0.41	4.77 (3.44)	6.45 (3.08)	1.68	0.16
Spatial Relations	9.52 (4.42)	9.81 (4.29)	0.29	8.14 (3.31)	7.77 (3.89)	−0.37	0.45
Visual Motor Integration	89.77 (10.01)	88.20 (11.18)	−1.57	85.11 (12.36)	84.96 (14.28)	−0.15	0.70
Executive Functioning							
Wisconsin Card Sorting Test							
Categories Completed	3.75 (1.62)	4.79 (1.53)	1.04**	3.80 (1.83)	4.60 (1.63)	0.80**	0.32
Total Errors	89.92 (13.10)	95.71 (15.23)	5.79	85.91 (12.00)	94.00 (17.21)	8.09**	0.48
Perseverative Responses	93.08 (14.35)	98.50 (13.51)	5.42	87.22 (14.81)	97.04 (18.06)	9.82*	0.50
Delis-Kaplan Executive Function System							
Tower Test							
Total Achievement	9.24 (2.20)	10.71 (2.20)	1.47*	7.45 (3.24)	9.90 (3.63)	2.45*	0.67
Move Accuracy Ratio	8.47 (3.56)	9.53 (2.27)	1.06	9.05 (2.70)	9.60 (2.39)	0.55	0.66
Rule Violations Per Item Ratio	8.06 (3.03)	10.41 (1.18)	2.35*	8.65 (2.21)	10.10 (1.07)	1.45**	0.42
Verbal Fluency							
Letter Fluency	8.67 (2.93)	8.39 (3.40)	−0.28	7.77 (2.84)	8.82 (3.38)	1.05**	0.74
Category Fluency	10.11 (3.23)	9.94 (3.62)	−0.17	8.86 (3.71)	9.23 (3.70)	0.37	0.63
Category Switching Total Correct	10.00 (3.18)	9.44 (3.05)	−0.56	8.82 (2.94)	9.14 (3.06)	0.32	0.51
Category Switching Accuracy	10.11 (3.16)	9.83 (2.31)	−0.28	8.86 (2.59)	9.56 (2.58)	0.70	0.53
Set-Loss Errors	9.78 (2.88)	11.00 (1.94)	1.22	10.45 (2.04)	11.45 (1.74)	1.00**	0.30
Repetition Errors	7.28 (2.05)	6.89 (2.25)	−0.39	7.32 (2.68)	7.64 (2.01)	0.32	0.14
Trails							
Visual Scanning	10.33 (2.64)	10.11 (3.23)	−0.22	9.77 (2.53)	10.50 (2.41)	0.73	0.48

Index/Subtest	Younger Group			Older Group			Test- Retest Reliability
	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	Time 1 Mean (SD)	Time 2 Mean (SD)	Mean Change	
Number Sequencing	7.94 (3.57)	9.56 (3.45)	1.62	8.50 (2.96)	8.59 (2.67)	0.09	0.17
Letter Sequencing	7.78 (4.01)	8.28 (4.10)	0.50	8.41 (3.38)	8.14 (4.04)	−0.27	0.68
Number-Letter Switching	7.06 (4.33)	8.00 (4.56)	0.94	6.86 (4.28)	7.64 (3.53)	0.78	0.73
Motor Speed	10.00 (2.03)	10.00 (2.57)	0.00	8.45 (3.16)	8.91 (2.93)	0.46	0.43
Total Errors	8.56 (4.32)	10.12 (2.28)	1.56**	8.95 (3.63)	10.50 (1.44)	1.55	0.46
Academic Achievement							
Woodcock Johnson							
Broad Reading	98.83 (21.65)	97.04 (19.70)	−1.79	92.76 (15.68)	95.84 (17.51)	3.08*	0.95
Broad Math	94.58 (15.53)	95.42 (15.19)	0.84	93.30 (17.60)	89.78 (14.96)	−3.52**	0.87
Broad Written Language	97.65 (21.13)	97.00 (18.61)	−0.65	99.74 (14.10)	100.26 (14.07)	0.52	0.91
Academic Fluency	94.36 (20.79)	95.16 (20.72)	0.80	91.92 (16.26)	95.12 (17.60)	3.20*	0.90
Letter-Word Identification	99.00 (18.44)	95.00 (18.19)	−4.00*	95.15 (13.52)	95.96 (11.17)	0.81	0.91
Reading Fluency	97.96 (22.48)	98.36 (23.41)	0.40	93.46 (15.98)	97.96 (19.71)	4.50*	0.90
Calculations	94.25 (16.11)	95.71 (13.17)	1.46	93.56 (17.88)	87.96 (16.07)	−5.60**	0.74
Math Fluency	85.32 (16.59)	85.92 (19.53)	0.60	89.96 (17.93)	91.00 (17.30)	1.04	0.85
Spelling	96.41 (20.96)	96.37 (19.17)	−0.04	102.36 (14.36)	102.72 (15.33)	0.36	0.92
Writing Fluency	96.38 (19.80)	94.62 (18.38)	−1.76	94.84 (15.17)	95.32 (13.37)	0.48	0.79
Passage Comprehension	94.59 (17.28)	91.59 (15.45)	−3.00**	90.42 (13.59)	90.19 (12.59)	−0.23	0.88
Applied Problems	95.31 (17.27)	95.85 (17.16)	0.54	93.80 (15.15)	91.40 (12.46)	−2.40	0.83
Writing Samples	96.88 (15.99)	98.96 (16.19)	2.08	93.84 (14.85)	93.92 (15.49)	0.08	0.69
Word Attack	98.26 (15.61) (16.00)	96.22 (13.49)	−2.04	98.12 (10.21)	95.85 (7.58)	−2.27	0.85
Punctuation and Capitalization	87.58 (19.43)	84.31 (22.32)	−3.27	85.26 (21.11)	88.87 (19.18)	3.61	0.71

* $p < 0.01$,

** $p < 0.05$

Table 3

Adjusted Reliable Change Indices (80% and 90% Confidence Intervals)

Index/Subtest	Younger Group			Older Group		
	Practice	Adjusted RC 80%	Adjusted RC 90%	Practice	Adjusted RC 80%	Adjusted RC 90%
Intelligence						
Wechsler Adult Intelligence Scale for Children – Fourth Edition						
Full Scale IQ	0	−9, 9	−12, 11	1	−8, 9	−10, 12
Verbal Comprehension	−1	−11, 9	−14, 12	−2	−13, 9	−16, 12
Perceptual Reasoning	3	−10, 15	−13, 18	2	−11, 14	−14, 17
Working Memory	−3	−17, 11	−21, 15	3	−13, 19	−18, 23
Processing Speed	−1	−16, 13	−20, 17	0	−12, 13	−16, 17
Similarities	0	−3, 3	−3, 3	0	−3, 2	−3, 3
Vocabulary	0	−2, 2	−3, 3	0	−3, 2	−3, 3
Comprehension	0	−3, 3	−4, 4	0	−3, 3	−4, 4
Word Reasoning	0	−3, 3	−4, 3	0	−3, 3	−3, 4
Block Design	1	−1, 3	−2, 4	1	−1, 3	−2, 3
Picture Concepts	1	−4, 5	−5, 6	−1	−5, 3	−6, 4
Matrix Reasoning	0	−4, 4	−5, 5	1	−3, 4	−4, 5
Digit Span	0	−3, 3	−4, 4	1	−3, 4	−4, 5
Letter-Number Sequencing	−1	−4, 3	−5, 4	0	−4, 5	−5, 6
Coding	0	−3, 3	−4, 3	0	−3, 3	−4, 4
Symbol Search	0	−5, 4	−6, 5	1	−3, 4	−4, 5
Cancellation	0	−3, 2	−3, 3	0	−2, 3	−3, 4
Memory						
Children's Memory Scale						
Visual Immediate	2	−15, 19	−20, 23	10	−6, 26	−11, 31
Visual Delayed	7	−9, 24	−14, 29	11	−6, 28	−10, 33
Verbal Immediate	2	−11, 16	−15, 19	6	−7, 19	−11, 22
Verbal Delayed	6	−11, 23	−16, 28	8	−9, 25	−14, 30
General Memory	4	−12, 20	−16, 24	13	−2, 27	−6, 32

Index/Subtest	Younger Group			Older Group		
	Practice	Adjusted RC 80%	Adjusted RC 90%	Practice	Adjusted RC 80%	Adjusted RC 90%
Attention/Concentration	−3	−16, 10	−20, 14	−1	−11, 9	−14, 12
Learning	2	−16, 20	−22, 25	8	−6, 22	−10, 26
Delayed Recognition	−4	−27, 18	−33, 25	4	−20, 28	−27, 35
Stories - Immediate	0	−3, 3	−4, 4	1	−2, 4	−2, 5
Stories - Delayed	0	−3, 3	−4, 4	1	−2, 5	−3, 6
Stories - Delayed Recognition	−1	−6, 3	−7, 4	1	−4, 6	−6, 8
Faces - Immediate	0	−3, 4	−4, 5	2	−2, 5	−3, 7
Faces - Delayed	1	−2, 4	−3, 5	3	−1, 7	−3, 8
Word Pairs – Immediate	1	−2, 5	−3, 6	−1	−4, 3	−5, 4
Word Pairs - Learning	1	−3, 4	−4, 5	1	−2, 4	−3, 5
Word Pairs- Total Score	1	−2, 4	−3, 5	1	−3, 4	−4, 5
Word Pairs - Long Delay	2	−3, 6	−4, 7	1	−3, 5	−4, 7
Word Pairs - Delayed Recognition	0	−4, 4	−5, 6	0	−4, 5	−5, 6
Numbers – Total Score	−1	−4, 3	−5, 3	0	−3, 2	−4, 3
Sequences – Total Score	0	−3, 3	−4, 3	0	−2, 2	−3, 3
Family Pictures - Immediate	0	−4, 4	−5, 5	1	−3, 5	−4, 6
Family Pictures - Delayed	0	−4, 4	−5, 5	0	−4, 4	−5, 6
Word List - Learning	−1	−7, 5	−8, 7	1	−3, 4	−4, 5
Word List - Delayed	0	−4, 4	−5, 5	0	−4, 4	−5, 6
Language						
Expressive One Word Picture Vocabulary						
	0	−11, 12	−15, 16	1	−10, 12	−13, 15
Visuospatial						
Visual Motor Integration	−2	−12, 8	−14, 11	0	−13, 12	−16, 16
Executive Functioning						
Wisconsin Card Sorting Test						
Perseverative Responses	5	−13, 24	−18, 29	10	−9, 29	−14, 34
Delis-Kaplan Executive Function System						

Index/Subtest	Younger Group			Older Group		
	Practice	Adjusted RC 80%	Adjusted RC 90%	Practice	Adjusted RC 80%	Adjusted RC 90%
Trails						
Letter Sequencing	0	−4, 5	−5, 6	0	−4, 3	−5, 4
Number-Letter Switching	1	−3, 5	−4, 6	1	−3, 5	−4, 6
Verbal Fluency						
Letter Fluency	0	−3, 2	−4, 3	1	−2, 4	−2, 4
Category Fluency	0	−4, 3	−5, 4	0	−4, 4	−5, 6
Category Switching Total Correct	−1	−5, 3	−6, 5	0	−3, 4	−4, 5
Category Switching Accuracy	0	−4, 4	−5, 5	1	−3, 4	−3, 5
Tower Test						
Total Achievement	1	−1, 4	−1, 4	2	−1, 6	−2, 7
Move Accuracy Ratio	1	−3, 5	−4, 6	1	−2, 3	−3, 4
Academic Achievement						
Woodcock-Johnson III						
Broad Reading	−2	−10, 7	−13, 9	3	−3, 9	−5, 11
Broad Math	1	−9, 11	−12, 14	−4	−15, 8	−18, 11
Broad Written Language	−1	−12, 11	−16, 14	1	−7, 8	−9, 10
Academic Fluency	1	−11, 13	−14, 16	3	−6, 12	−9, 15
Letter-Word Identification	−4	−14, 6	−17, 9	1	−7, 8	−9, 10
Reading Fluency	0	−12, 13	−16, 17	5	−5, 14	−7, 16
Calculations	1	−13, 16	−17, 20	−6	−22, 11	−27, 15
Math Fluency	1	−11, 12	−14, 16	1	−12, 14	−15, 17
Spelling	0	−11, 10	−14, 13	0	−7, 8	−9, 10
Writing Fluency	−2	−18, 15	−23, 19	0	−12, 13	−16, 17
Passage Comprehension	−3	−14, 8	−17, 11	0	−9, 8	−11, 11
Applied Problems	1	−13, 14	−16, 17	−2	−14, 9	−17, 12
Writing Samples	2	−14, 18	−19, 23	0	−15, 15	−19, 19
Word Attack	−2	−13, 9	−16, 12	−2	−9, 5	−12, 7
Punctuation and Capitals	−3	−22, 16	−28, 21	4	−17, 24	−23, 30

RC = reliable change; Results are only reported for cognitive measures with test-retest reliabilities above .50. When interpreting an individual patient's pattern of scores, test-retest differences falling at or below the lower limit of the RC interval or at or above the upper limit of the RC interval would be indicative of clinically meaningful change.

Table 4

Regression Equations for Neuropsychological Measures

Domain / Measure	R	SE_{est}	C	$B_{baseline}$	B_{age}	B_{onset}	$B_{testinterval}$
Intelligence							
Wechsler Intelligence Scale for Children – Fourth Edition							
Full Scale IQ	.916	6.537	12.299	.858			
Verbal Comprehension Index	.873	7.402	18.519	.781			
Perceptual Reasoning Index	.790	9.916	15.837	.847			
Working Memory Index	.813	10.035	23.765	.723			
Processing Speed Index	.769	9.531	21.854	.737			
Processing Speed Index w/ Modifier (4%)	.797	9.087	28.281	.731			−.493
Similarities	.826	1.627	2.224	.727			
Vocabulary	.869	1.669	1.167	.852			
Comprehension	.687	1.973	3.060	.613			
Word Reading	.788	2.125	1.715	.804			
Block Design	.788	1.906	1.997	.858			
Picture Concepts	.536	2.681	4.393	.501			
Picture Concepts w/ Modifier (5%)	.581	2.608	7.261	.490	−.270		
Matrix Reasoning	.534	2.716	3.580	.589			
Digit Span	.730	2.538	2.500	.720			
Letter-Number Sequencing	.695	2.559	2.491	.623			
Coding	.754	1.904	2.049	.693			
Symbol Search	.649	2.367	3.504	.565			
Symbol Search w/ Modifier (5%)	.687	2.285	4.853	.559			−.107
Cancellation	.705	2.075	2.628	.733			
Memory							
Children's Memory Scale							
Visual Immediate	.525	12.238	45.132	.566			
Visual Immediate w/ Modifier (7%)	.585	11.770	31.308	.559	1.404		

Domain / Measure	R	SE_{est}	C	$B_{baseline}$	B_{age}	B_{onset}	$B_{testinterval}$
Visual Delayed	.569	12.400	42.511	.628			
Verbal Immediate	.897	10.673	8.967	.943			
Verbal Delayed	.822	12.764	23.078	.806			
General Memory	.854	11.875	17.395	.891			
General Memory w/ Modifier (2%)	.867	11.501	4.532	.888	1.266		
Attention/Concentration	.900	8.752	8.223	.896			
Learning	.699	13.147	25.044	.773			
Delayed Recognition	.685	13.663	38.397	.586			
Stories - Immediate	.823	2.385	1.344	.913			
Stories - Delayed	.843	2.261	2.318	.802			
Stories - Delayed Recognition	.535	2.786	4.585	.447			
Stories - Delayed Recognition w/ Modifier (6%)	.590	2.689	1.055	.480	.314		
Faces - Immediate	.432	2.430	5.798	.398			
Faces - Delayed	.501	2.837	4.985	.557			
Word Pairs - Immediate	.687	2.877	2.317	.733			
Word Pairs - Immediate w/ Modifier (8%)	.743	2.676	6.407	.761	−.419		
Word Pairs - Learning	.828	2.404	2.106	.825			
Word Pairs - Total	.821	2.512	1.700	.866			
Word Pairs - Long Delay	.607	3.074	4.222	.594			
Word Pairs - Delayed Recognition	.701	2.753	3.373	.652			
Numbers – Total Score	.794	2.147	1.448	.769			
Sequences – Total Score	.851	1.887	1.354	.856			
Family Pictures - Immediate	.527	2.485	5.475	.481			
Family Pictures - Delayed	.591	2.581	4.337	.560			
Word List - Learning	.594	2.879	3.521	.468			
Word List - Delayed	.553	2.929	2.988	.577			
Language							
Expressive One Word Picture Vocabulary							
	.851	9.316	11.825	.885			

Domain / Measure	R	SE_{est}	C	$B_{baseline}$	B_{age}	B_{onset}	$B_{testinterval}$
Visuospatial							
Visual-Motor Integration	.701	9.419	17.028	.789			
Executive Functioning							
Wisconsin Card Sorting Test							
Perseverative Responses	.487	14.170	52.027	.516			
Delis-Kaplan Executive Functioning System							
Tower Test							
Total Achievement	.669	2.279	4.564	.678			
Total Achievement w/ Modifier (9% & 12%)	.812	1.846	−1.160	.797		.304	.228
Move Accuracy Ratio	.661	1.784	5.307	.488			
Verbal Fluency							
Letter Fluency	.748	2.258	1.578	.874			
Category Fluency	.640	2.664	3.239	.703			
Category Switching Correct	.474	2.495	5.311	.435			
Category Switching Accuracy	.451	1.958	6.568	.348			
Trails							
Letter Sequencing	.618	3.061	2.559	.695			
Number-Letter Switching	.761	2.630	2.816	.746			
Academic							
Woodcock Johnson – Third Edition							
Broad Reading	.953	5.807	7.742	.927			
Broad Reading w/ Modifier (1%)	.957	5.600	−.981	.945	.656		
Broad Math	.864	7.907	16.242	.818			
Broad Math w/ Modifier (3%)	.880	7.551	27.636	.807	−.998		
Broad Written Language	.912	7.122	15.850	.840			
Academic Fluency	.899	8.639	9.308	.923			
Letter-Word Identification	.904	6.588	14.424	.835			
Reading Fluency	.903	.811	3.366	.993			
Calculation	.733	10.313	30.876	.652			

Domain / Measure	R	SE_{est}	C	$B_{baseline}$	B_{age}	B_{onset}	$B_{testinterval}$
Calculation w/ Modifier (4.1%)	.761	9.962	44.585	.639	−1.183		
Math Fluency	.840	10.266	8.552	.912			
Spelling	.923	7.042	11.014	.889			
Writing Fluency	.798	9.940	24.469	.738			
Passage Comprehension	.873	6.993	17.549	.791			
Applied Problems	.830	.681	18.958	.793			
Writing Samples	.706	11.163	29.876	.708			
Word Attack	.854	5.924	26.723	.707			
Punctuation and Capitals	.713	14.938	23.861	.725			

Results are only reported for cognitive measures with test-retest reliabilities above .50. Numbers in parentheses after equations with modifiers represent the percent of variance accounted for by that particular modifier. R = reliability coefficient; SE_{est} = standard error of the estimate; C = constant; $B_{baseline}$ = unstandardized beta (slope) for baseline test score; B_{age} = age at baseline testing; B_{onset} = age at recurrent seizure onset; $B_{testinterval}$ = interval between baseline and repeat testing measured in months.

Table 5

Select Neuropsychological Test Results for Case Example

Cognitive Measure	Pre-op	Post-op	Change Score	RCI Cutoffs	SRB Predicted Post-op Score	SRB Difference as z-score*
WISC- IV						
Verbal Comprehension Index	81	79	−2	−16, 12	82	−0.38
Perceptual Reasoning Index	98	98	0	−14, 17	99	−0.84
Processing Speed Index	103	94	−9	−16, 17	98	−0.40
Children's Memory Scale						
Verbal Delayed	94	77	**−17**	**−14**, 30	99	**−1.72**
Visual Delayed	109	112	+3	−10, 33	111	0.08
EOWPVT	70	70	0	−13, 15	74	−0.41
Visual Motor Integration	67	91	**+24**	−16, **16**	70	**2.24**

* z-scores exceeding ±1.28 are significant with an 80% confidence interval and those exceeding ±1.64 are significant with a 90% confidence interval