*Original Article*

# Longitudinal Assessment of Neuropsychologic and Language Function in Children With Benign Rolandic Epilepsy

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## ABSTRACT

Previous studies of benign rolandic epilepsy have reported improvement in cognitive functioning over time. Their focus was the impact of paroxysmal electroencephalographic (EEG) activity on neuropsychologic function. Comprehensive longitudinal language assessment has not previously been undertaken. In a cross-sectional study, we demonstrated that some children with benign rolandic epilepsy have difficulties in verbal and visual memory and phonologic awareness. The current study evaluated a subgroup longitudinally to determine if difficulties improved. Twenty-eight patients underwent comprehensive longitudinal neuropsychologic and language assessments. The clinical features evaluated included seizure frequency, absolute age, medications, and a follow-up EEG. Differences in performance were analyzed using *t*-tests. Improvement in cognitive functioning, particularly in the areas of verbal memory, receptive language ability, and phonemic manipulation, was demonstrated. Visual memory and aspects of phonologic awareness showed no change. The improvements were not related to the clinical variables. It is important to recognize cognitive difficulties in children with benign rolandic epilepsy. Some difficulties can resolve; however, continued monitoring, particularly in areas of visual memory and phonologic awareness, is required. (*J Child Neurol* 2006;21:518–522; DOI 10.2310/7010.2006.00138).

Received July 28, 2005. Received revised Oct 6, 2005. Accepted for publication Nov 28, 2005.

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The research was supported by grants from The Financial Markets Foundation for Children and the Australian Brain Foundation.

The collection of electroencephalograms (EEGs) was from six EEG laboratories across metropolitan Sydney: Sydney Children's Hospital, The Children's Hospital at Westmead, Westmead Hospital, St George's Hospital, Liverpool Hospital, and Royal North Shore Hospital. Neuropsychologic and language assessments were carried out at The Children's Hospital at Westmead and Sydney Children's Hospital.

This research has been accepted for presentation at the World Congress of Neurology, Sydney, 5-11 November 2005.

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A previous study by our group investigated the cognitive profile of 42 children with benign rolandic epilepsy.[1] Patients were selected on the basis of strict inclusion and exclusion criteria for the syndrome. The sample was large and not biased by tertiary referral. The study demonstrated that a proportion of children with benign rolandic epilepsy have difficulties in verbal and visual memory and phonologic awareness when compared with normative data. Furthermore, a large number of these children had disproportionately lower scores in these areas compared with their overall intellectual and language ability. These results have significant implications for educational and social development. Phonologic awareness is an important base skill in the development of literacy,[2] and memory problems can impact on academic performance.[3] Specific electroencephalographic (EEG) features (spike frequency and location) were not correlated with memory indices or measures of phonologic awareness, suggesting that epileptiform activity might not be an important determinant of cognitive difficulties in benign rolandic epilepsy.

Previous literature has shown some improvement in neuropsychologic function over time[4–9]; however, the pattern of cognitive difficulties on the first assessment has been inconsistent. In addition, the longitudinal assessment of memory has been limited

**Table 1. Tests Used in the Assessment of Neuropsychologic and Language Function**

| Test | Cognitive Area |
|---|---|
| Neuropsychologic assessment | |
| Wechsler Intelligence Scale for Children (WISC-III)[12] | General intellectual functioning |
| Wide Range Assessment of Memory and Learning (WRAML)[13] | Immediate and short- and long-term memory of both verbal and visual material |
| Wechsler Individual Achievement Test (WIAT)[14] | Academic achievement |
| Trail Making Test[15] | Speed of information processing |
| FAS Test[16] | Verbal fluency, executive functioning |
| Semantic fluency[17] | Executive functioning |
| Rey Complex Figure[18] | Visual memory, visuoconstructive ability and executive functioning |
| Language assessment | |
| Clinical Evaluation of Language Fundamentals–3 (CELF-3)[19] | Receptive and expressive language ability |
| Peabody Picture Vocabulary Test–3 (PPVT-3)[20] | Receptive vocabulary |
| Boston Naming Test[21] with Australian norms[22] | Expressive vocabulary and word finding |
| Queensland University Inventory of Literacy (QUIL)[23] | Phonologic awareness |
| Test of Language Competence (TLC)[24] | Higher-level language |
| Verbal Motor Production Assessment (VMPAC)[25] | Motor speech production |

to evaluation by individual subtests and not a comprehensive battery, and there have been no longitudinal studies of language. To determine if the demonstrated difficulties in memory and phonologic awareness showed improvement, a subgroup of children from our previous study was followed longitudinally. The current study also aimed to determine if any change in cognition was related to clinical epilepsy variables.

## METHODS

### Recruitment

The methodology describing the recruitment process for the original cohort of 42 patients was previously described.[1] Patients were recruited from six EEG laboratories across metropolitan Sydney. Reports of EEGs containing centrotemporal discharges in children aged 3 to 15 years were selected between June 2000 and November 2003. One author (A.Be.) evaluated the EEGs and interviewed the presiding physician and parent or carer, obtaining relevant clinical data according to a written protocol. Patients were selected for inclusion in the study if they satisfied the clinical and electrophysiologic criteria of the syndrome of benign rolandic epilepsy according to the International League Against Epilepsy classification.[10] Strict exclusion criteria included a history of neurologic insult and impaired neurodevelopment or abnormality on neuroimaging. The 42 patients who agreed to participate in the original cross-sectional study were invited to take part in the longitudinal study with a repeat EEG and neuropsychologic and language assessment at least 12 months following initial assessment. To determine if the subgroup that chose to continue participation was representative of the original cohort, cognitive profiles were compared. Clinical information on each patient was collected at the time of the second neuropsychologic and language assessment. These data included age, the duration of epilepsy (time from the first documented seizure), seizure frequency, and the use of medication.

### Clinical Status

The clinical status of the patient was classified into two groups: those in remission and those still in the active phase of the syndrome. Remission was defined as both a normal sleep EEG and the absence of seizures for at least 12 months. The definition of remission was independent of medication use.

### EEG Methodology

The second EEG was recorded without sedation for 20 to 40 minutes using a digital system with the International 10-20 array of electrode placement. The EEG was evaluated for the presence of typical centrotemporal spikes.[10,11]

### Neuropsychologic and Language Assessment

Patients underwent a comprehensive neuropsychologic and language assessment at times 1 and 2. The tests used are listed in Table 1.[12–25] Raw scores were adjusted for age using normative data.

### Statistical Analysis

All statistical analyses were conducted using the *Statistical Package for the Social Sciences*, version 11 (SPSS Inc, Chicago, IL). Owing to the exploratory nature of the study and the relatively small number of subjects, the probability for Type I error was set at .05 for each test. The difference between the neuropsychologic and language test means at times 1 and 2 was examined using a paired-sample *t*-test. The results are expressed as tests showing a significant change from time 1 to time 2. In addition, the change in performance of those tests with group means significantly below normative means in the cross-sectional study is presented.[1] A difference score was calculated for each test by subtracting the subject's score at time 1 from the score at time 2. The correlation between the time 1 and time 2 scores was also calculated as a measure of the consistency of responses on the two occasions. To determine if the age of the child impacted on the amount of change in cognitive functioning, a correlation with the difference scores was evaluated using Pearson's *R*. The effect of medication at times 1 and 2 on the amount of improvement in cognitive functioning over time was assessed using independent-sample *t*-tests. The effect of clinical status (remission or not) on cognitive scores was assessed using independent-sample *t*-tests.

## RESULTS

### Sample Demographics

Twenty-eight of the original 42 patients[1] agreed to continue participation. The most frequent reason given for withdrawal was concern about the further time commitment. There were no differences between the group that continued participation and the

**Table 2. Neuropsychologic Tests Showing Significant Change From Testing at Time 1 to Time 2**

| Test | Mean Time 1 (SD) | Mean Time 2 (SD) | Change Scores | P Value | Correlation |
|---|---|---|---|---|---|
| WRAML Sentence Memory | 8.33 (2.95) | 9.41 (2.68) | 1.08 | .018 | 0.698 |
| WRAML Number Letter | 7.59 (2.29) | 8.52 (2.73) | 0.93 | .012 | 0.687 |
| WRAML Verbal Memory Index | 91.74 (15.62) | 97.63 (13.90) | 5.89 | .002 | 0.820 |
| WRAML General Memory Index | 93.96 (14.02) | 97.80 (13.23) | 3.84 | .030 | 0.816 |

WRAML = Wide Range Assessment of Memory and Learning.

group that declined on measures of overall intellectual functioning or total language ability at time 1. However, the group that did not continue performed better on one language subtest, the Clinical Evaluation of Language Fundamentals–3 (CELF-3) Semantic Relationships ($t_{(24)} = 2.663$; $P = .014$). There were no significant differences between the groups on tests of memory and phonologic awareness. The groups were also similar in terms of gender, age, age at first documented seizure, the number of seizures, and the length of epilepsy.

### Study Duration

Seventeen patients had the two assessments between 12 and 18 months apart, eight patients between 18 and 24 months, and three patients at longer intervals (2 years 6 months, 3 years 2 months, and 5 years 4 months, respectively).

### Evolution of Neuropsychologic and Language Function

Overall, test results improved from the first to the second assessment. No test had a significantly lower mean at the second assessment. Table 2 shows the neuropsychologic tests that changed significantly from time 1 to time 2, and Table 3 shows the language tests that changed significantly. Table 4 lists the neuropsychologic and language tests in which the group means were significantly below normative means in the previous cross-sectional study.[1] It shows the change in performance in these tests from time 1 to time 2 in the cohort of the longitudinal study.

### Medication

Fourteen children were on medication at both time 1 and time 2. Five children were taking medication at time 1 but had ceased at time 2. One child commenced medication between the two assessments. Eight children were not taking medication at either assessment. Children taking medication at either assessment showed significantly more improvement on one subtest from the Wide Range Assessment of Memory and Learning, Story Memory Recall ($t_{(25)} = 2.162$; $P = .040$) and also Trail Making Test B ($t_{(20)} = 2.538$; $P = .020$). Medication did not account for the significant improvements seen in memory and language skills.

### Clinical Status

Six patients met the criteria for remission. Seventeen children were classified as being in the active phase of the syndrome. Three subjects did not consent to a second EEG. Two patients had EEGs recorded only in wakefulness, with no discharges seen. These five patients were not used in the analysis of clinical status, leaving 23 patients. The group in remission scored significantly lower on a Wide Range Assessment of Memory and Learning subtest, Sentence Memory ($t_{(21)} = 2.772$; $P = .011$). There were no other significant group differences.

### Impact of Absolute Age on Cognitive Performance

The children who were older at the second assessment showed significantly greater improvement on the Wechlser Intelligence Scale for Children (WISC) Verbal IQ ($r = .449$, $P = .021$), WISC Picture Completion ($r = .395$, $P = .046$), and Ambiguous Sentences ($r = .393$, $P = .047$). However, children who were younger at the second assessment showed more improvement on two tests of phonologic awareness: Non-Word Reading ($r = –.407$, $P = .035$) and Phoneme Detection ($r = –.382$, $P = .047$).

## DISCUSSION

In the initial study, we found that some children with benign rolandic epilepsy have difficulties in the areas of memory and phonologic awareness.[1] In the current longitudinal study, we demonstrated improvement in cognitive functioning, particularly in the areas of verbal memory and receptive language ability. Significant improvement in phonologic awareness was restricted to one subtest. The remaining four subtests of phonologic awareness and tests of visual memory did not change. The improvement in cognition was not related to clinical status. The test–retest reliability of the assessment tools is high, and there was a minimum of 12 months between assessments. Improvement in performance is thus unlikely to be due to practice effects.

Previous studies conducting serial assessments of children with benign rolandic epilepsy found improvement in varied aspects of cognitive functioning.[4–6,8,9] Differing methodologies, including ter-

**Table 3. Language Tests Showing Significant Change From Testing at Time 1 to Time 2**

| Test | Mean Time 1 (SD) | Mean Time 2 (SD) | Change Scores | P Value | Correlation |
|---|---|---|---|---|---|
| CELF Receptive Language | 106.00 (14.58) | 110.74 (16.13) | 4.74 | .012 | 0.829 |
| CELF Concepts and Directions | 10.48 (2.56) | 11.56 (2.72) | 1.08 | .023 | 0.622 |
| CELF Semantic Relationships | 10.50 (2.68) | 11.94 (2.07) | 1.44 | .011 | 0.619 |
| QUIL Phoneme Manipulation | 9.65 (2.12) | 10.96 (2.95) | 1.31 | .014 | 0.550 |
| VMPAC Sequencing | 94.81 (4.36) | 97.56 (3.63) | 2.75 | .002 | 0.575 |

CELF-3 = Clinical Evaluation of Language Fundamentals–3; QUIL = Queensland University Inventory of Literacy; VMPAC = Verbal Motor Production Assessment.

**Table 4. Change in Performance for Tests With Group Means Significantly Below Normative Means at Time 1**

| Test | Mean Time 1 (SD) | Mean Time 2 (SD) | Change Scores | P Value | Correlation |
|---|---|---|---|---|---|
| WRAML | | | | | |
| Sentence Memory | 8.33 (2.95) | 9.41 (2.68) | 1.08 | .018 | 0.698 |
| Number Letter | 7.59 (2.29) | 8.52 (2.73) | 0.93 | .012 | 0.687 |
| Verbal Memory Index | 91.74 (15.62) | 97.63 (13.90) | 5.89 | .002 | 0.820 |
| Visual Memory Index | 94.88 (12.30) | 94.28 (11.51) | –0.6 | .794 | 0.548 |
| General Memory Index | 93.96 (14.02) | 97.80 (13.23) | 3.84 | .030 | 0.816 |
| Rey Figure Delay | –.87 (.99) | –0.66 (0.64) | 0.21 | .351 | 0.460 |
| QUIL | | | | | |
| Non-Word Spelling | 9.30 (3.76) | 9.81 (3.27) | 0.51 | .341 | 0.696 |
| Non-Word Reading | 8.93 (3.41) | 9.56 (3.09) | 0.63 | .194 | 0.719 |
| Visual Rhyme Detection | 7.74 (3.06) | 7.91 (4.09) | 0.17 | .854 | 0.245 |
| Phoneme Manipulation | 9.65 (2.12) | 10.96 (2.95) | 1.31 | .014 | 0.550 |
| TLC Ambiguous Sentences | 8.73 (2.85) | 8.96 (3.44) | 0.23 | .703 | 0.542 |

QUIL = Queensland University Inventory of Literacy; TLC = Test of Language Competence; WRAML = Wide Range Assessment of Memory and Learning.

tiary referral bias and limited assessment batteries, have yielded a heterogeneous pattern of deficit. These longitudinal studies have focused on the hypothesis that interictal EEG abnormalities impact on cognitive functioning. In contrast, the current study focused on comprehensive evaluation of neuropsychologic and language performance over time in a representative cohort of patients with benign rolandic epilepsy recruited from EEG laboratories. This emphasis was chosen because our previous research showed a specific pattern of difficulty in memory and phonologic awareness independent of spike burden or lateralization.[1]

Baglietto et al, in a study of nine patients, found difficulties in a broad range of cognitive domains, including intellectual ability, sustained attention, visuomotor coordination, visuoperceptual skills, naming, and immediate visual memory at the time of the initial assessment.[8] At the second evaluation (between 12 and 24 months after the first assessment), the authors found no difference in neuropsychologic function between controls and the subjects with benign rolandic epilepsy. The assessments of memory and language were not comprehensive, limited to three subtests in each area. D'Alessandro et al found initial difficulties evident in attention, language, and visuomotor coordination tasks.[5] Language assessment was again confined to three subtests. The follow-up assessment was restricted to 11 patients and only reevaluated areas of difficulty. The 11 patients showed no difference to a control population when assessed at least 4 years following normalization of the EEG. Deonna et al, in a study of 22 patients, did not find a specific group pattern of cognitive deficits.[6] In individual case assessments, areas of difficulty noted improved or normalized with serial assessment.

Similar to our study, several authors found residual deficits at the time of the final assessment. Metz-Lutz et al, at the initial neuropsychologic evaluation, noted difficulties in short-term memory, learning, and attention, with improvement but not normalization at 18 months.[9] Lindgren et al reported residual executive difficulties at 2.5 to 3 years, with improvement in both verbal learning and delayed recall.[7] Massa et al carried out a longitudinal study evaluating the neurophysiologic criteria that predicted an atypical evolution in benign rolandic epilepsy.[4] The small group of 10 patients with an unfavorable evolution demonstrated transient worsening of some aspects of neuropsychologic functioning, with only partial recovery. In contrast, the majority of patients in the study did not differ in behavioral or neuropsychologic function in three assessments over time. The results of our study, together with the above findings, emphasize that some children with benign rolandic epilepsy require continued monitoring of neuropsychologic and language functioning with appropriate intervention.

In contrast to the above studies, we conducted a comprehensive longitudinal battery of memory evaluation, including assessment of immediate, short-term, and long-term memory of both verbal and visual material. In our initial study, memory deficits were found for both verbal and visual material.[1] In the present study, the improvement in memory tasks was confined to verbal material. Development of memory abilities in children is currently not well understood. Busch et al suggested that verbal and nonverbal memory tasks require different skills, proposing that nonverbal memory tasks depend on executive functioning.[26] The latter continue to develop into adolescence. This hypothesis might partly explain why visual memory skills, as opposed to verbal memory skills, did not significantly improve.

This is the first study to assess language ability longitudinally. General receptive language function and motor speech production showed improvement. As verbal memory is one component of effective language processing, improved memory skills might have impacted on language test performance. One of the five subtests of phonologic awareness (phoneme manipulation) showed significant improvement. However, the majority of difficulties in phonologic awareness had not significantly improved overall. Two subtests of phonologic awareness showed significantly greater improvement in younger children compared with older children. This could be due to the greater degree of difficulty in the tasks completed by older children, which, when combined with the prolonged lack of development of their phonologic awareness skills, gives a decrease in age-scaled scores. Some childhood epilepsy syndromes, such as Landau-Kleffner syndrome, can show persistent abnormality in phonemic decoding.[27,28] Further monitoring of patients with residual difficulties in phonologic awareness is needed to determine if these deficits will resolve in benign rolandic epilepsy.

The literature has reported improvement in or resolution of cognitive function with normalization of the EEG or a significant reduction in paroxysmal activity. Some authors have concluded, therefore, that paroxysmal activity impacts on cognitive functioning.[4–6,8] In contrast, our previous study showed no correlation between parameters of spike frequency and lateralization and difficulties in memory and phonologic awareness. The current longitudinal study has found improvement on memory and receptive

language measures independent of seizure status or the presence of paroxysmal activity in the sleep EEG. Again, our findings do not support the hypothesis that paroxysmal activity is causal.

The study is unique in several aspects. The population is representative of typical benign rolandic epilepsy, with careful selection of patients recruited through EEG laboratories and not biased by tertiary referral. Patients satisfied the criteria of the International League Against Epilepsy classification,[10] and strict exclusion and inclusion criteria were employed. Using a comprehensive battery of neuropsychologic and language tests, the study focused on the longitudinal evaluation of these aspects. The current study demonstrates improvement in memory and receptive language skills. Awareness of transient cognitive difficulties is important, and the problems should be addressed. Further assessment is needed to determine if difficulties in visual memory and phonologic awareness completely resolve. At the time of the first assessment, minimal association between paroxysmal activity and cognitive function was demonstrated; again, in the current study, improvement in receptive language and memory function was independent of clinical and EEG variables.

### *Acknowledgments*

We would like to thank the pediatricians and families involved.

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