



Verbal memory and literacy outcomes one year after pediatric temporal lobectomy: A retrospective cohort study



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ABSTRACT

Objective: In children with temporal lobe epilepsy (TLE), temporal lobectomy (TL) is a treatment of choice for those children with seizure that are difficult to control with medication. Semantic memory is dependent on functional integrity of the temporal lobes and is thought to be critical for development of literacy skills. However, little is known about semantic memory and literacy outcomes post-TL in children.

Method: In this retrospective cohort study, 40 children with TLE were administered tests of memory and literacy pre-TL and 1 year post-TL in one hospital between 1996 and 2011.

Results: One year post-TL, 60% of the children became seizure-free. A significant decline was found in one aspect of semantic memory (naming) in children who underwent left TL. In addition, a significant drop was also evident in one aspect of literacy (reading accuracy), irrespective of the side of surgery. These declines were related neither to each other nor to epilepsy variables including seizure outcome.

Conclusions: This is the largest pediatric outcome study of memory and literacy skills to date and shows that TL is associated with a risk of a mild drop in specific aspects of semantic memory (naming, following left TL) and reading accuracy, while other areas of memory and literacy remain unchanged.

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1. Introduction

Children with temporal lobe epilepsy (TLE) are at risk of memory deficits (see [1] for review) and academic underachievement [2–6]. Deficits in episodic memory, new learning, and recall of information after delays have been well documented in this patient population (i.e., [7–9]). In contrast, deficits in semantic memory, the recall of factual information, general knowledge, naming, and word meaning have come to light only recently [10,11]. Interestingly, episodic memory and semantic memory relate differently to literacy skills in children with TLE [12]; while semantic memory has strong relations with a range of literacy skills (reading comprehension, reading accuracy, and spelling accuracy), episodic memory has weak relations with reading and spelling accuracy and none with reading comprehension. This finding of semantic, rather than episodic, memory playing a prominent role in literacy skills is consistent with the adult neuropsychological literature.

For example, patients with semantic dementia who have impaired semantic memory, but relatively preserved episodic memory, often (although not always [13–15]) present with reading difficulties, [16–23].

Turning our attention to cognitive models of reading, we note that leading cognitive models of reading, the Dual Route/Dual Route Cascaded (DR: [24,25]; DRC: [26,27]) model and the Parallel Distributed Processing (PDP: [28,29]) model, both include semantic, but not episodic, nodes. Nevertheless, according to the DRC model, reading aloud can, but does not have to, involve the semantic system. By contrast, according to the PDP model, the semantic system is involved when reading aloud, especially when reading infrequent irregular words. Taken together, findings that semantic memory plays a role in reading of children with TLE and is associated with reading difficulties in patients with semantic dementia are primarily consistent with the PDP model.

Finally, it is of interest to observe the adult neuropsychology literature, findings of which suggest that whilst different brain structures underpin semantic and episodic memory, common brain structures support semantic memory and reading. While episodic memory is primarily dependent on the mesial temporal structures and the hippocampus in particular (e.g., [30–32]), semantic memory and reading are both related to the integrity of the temporal neocortex [33,34].

Many children with unilateral onset TLE will undergo a temporal lobectomy (TL), as their epilepsy is often intractable to pharmacological,

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but responsive to surgical treatment [35]. Typically, TL involves resection of the hippocampus (which is critical for episodic memory) and removal of the anterior temporal neocortex (which is purported to represent a semantic memory hub [36]). In adults, a resection of a dominant temporal lobe has been associated with a decline in verbal episodic memory (see [37] for review). Findings have been less consistent in children than in adults. For example, in a review of outcomes after TL [38], eight of the thirteen studies found no significant change in memory, four studies uncovered a deterioration (with mixed findings regarding the relation to laterality), and one study documented an increase in verbal memory (after right TL).

Episodic memory outcomes, however, may not be representative of semantic memory outcomes, as we found that episodic memory and semantic memory could be impaired independently of one another pre-surgery in children with TLE [10]. A recent review of research with adults revealed a significant decline on one task of semantic memory, confrontational naming, measured with the Boston Naming Test [39] in 19 of the 21 studies [40]. In eleven of these studies, predictors of the decline were examined. Late age at onset (examined in 6 studies) and the absence of hippocampal sclerosis (3 studies) were associated with the decline. The one study which examined the impact of these two factors concurrently found the latter to be a more significant predictor of semantic memory outcome [41,42], which is surprising, as the anterior temporal neocortex, rather than the hippocampus, is thought to be critical for semantic memory [36].

As children considered for TL are likely to have earlier age at epilepsy onset compared with adults, a risk of semantic memory decline may be lower in children relative to adults. Indeed, Blanchette and Smith [43] found no change in semantic memory (recall of factual information and word meaning) post-TL in 10 children and no effect of side of resection, but no confrontational naming test was used. Jambaque and colleagues [7] found a significant improvement after TL (including hippocampotomy) in verbal episodic memory, as well as in naming, but no changes in recall of factual information or word meaning in 20 children. The relations between improvements in verbal episodic memory and verbal semantic memory (naming) were not examined in that study. The increase in either aspect of verbal memory was not related to the age at seizure onset or side of surgery. Nevertheless, while the increase in episodic memory was greater in children who had evidence of previous hippocampal damage, the increase in semantic memory was greater in children who were free of previous hippocampal damage. This dissociation raises a possibility that changes in semantic memory and episodic memory were independent of one another. Similarly, dissociation between episodic memory and semantic memory was found in a study by Smith and Lah [10] that involved children with TLE who were candidates for surgery; the factor analysis revealed two factors (semantic and episodic), and children could be impaired in either episodic memory or semantic memory alone.

As semantic memory has been found to be closely related to literacy skills in children with TLE [12], in children with reading disability [44], and in typically developing children [44,45], it is likely that semantic memory outcome will be related to literacy skills postsurgery. On the one hand, the adult neuropsychological literature indicates that the resection of the temporal neocortex could place children at risk of a decline in the semantic memory and literacy skills. On the other hand, elimination of seizures and reduction of antiepileptic medication and their side effects may increase school attendance and result in children being more receptive to learning, which could promote development of literacy skills. However, no changes in reading and spelling skills (rather than an increase) and no impact of side of resection were found in the studies that involved children who underwent surgery for epilepsy [43,46]. We found no study that examined both semantic memory and episodic memory as well as academic skills in children with TLE pre-TL to post-TL.

In this study, we aimed to (i) investigate presurgical to postsurgical changes in verbal memory (semantic and episodic) and literacy

(reading accuracy, reading comprehension, and spelling) and to (ii) examine relations between changes in memory and literacy. We predicted that (i) changes in verbal episodic and semantic memory would not be related and that (ii) changes in semantic memory, but not in episodic memory, would be related to changes in literacy. In addition, we explored whether epilepsy factors contributed to changes in memory and literacy.

2. Methods

2.1. Participants

The study included 40 school-age children and adolescents who underwent unilateral temporal lobe surgery for treatment of intractable TLE (as determined by prolonged video-EEG monitoring, MRI, and, in some cases, magnetoencephalography and PET) at the Hospital for Sick Children (Toronto, ON, Canada) between 1996 and 2011. Over 90% of the operations were done by the same neurosurgeon; however, the surgical approach was tailored to the individual case, with the amount of resection determined by factors such as the size of the epileptogenic zone, the site and extent of structural lesions, and the proximity to language areas. The hippocampus was spared in 10 patients and was resected in 30 patients. The resection of the hippocampus was complete in 25 patients and incomplete in 4 patients. In one patient, it was impossible to determine whether the hippocampal resection was complete or not. Inclusion criteria were as follows: (1) seen for clinical neuropsychological assessments presurgery and 1 year postsurgery, (2) free of other medical diagnoses/treatments (such as stroke or cranial radiation) that could impact their neuropsychological functions, (3) underwent assessment of at least one literacy skill using the Wechsler Individual Achievement Test ([47,48]: WIAT or WIAT-II) or the Wide Range Achievement Test ([49]: WRAT-3), and (4) had performance IQ (PIQ) above 69. Verbal IQ was not used as an inclusion variable because one of the dependent variables, the semantic memory measure (see below), was taken from the verbal scale of the intelligence test. In 33 of the 40 participants, laterality of speech representation was established using fMRI, magnetoencephalography, or the intracarotid amobarbital test. Thirty children were found to have left-hemisphere speech representation, and three children had bilateral (two participants with left TLE and one participant with right TLE) hemisphere speech representation. All children who did not undergo language laterality testing ($n = 7$) were right-handed.

2.2. Materials and procedures

The study was approved by the Research Ethics Board of the Hospital for Sick Children, Toronto, Canada. Episodic memory was assessed by the delayed recall score on a word list recall task in which learning of words is assessed over five trials and recall is demanded following a 20-minute delay. In our previous study on memory in children with TLE, we found that this measure had high loading on the episodic memory factor and no loading on the semantic memory factor [10]. Two measures of semantic memory were used, both of which have been shown previously to load on a semantic memory factor, but not on an episodic memory factor, in children with TLE [10]. Word knowledge was assessed with the Vocabulary subtest of the Wechsler Intelligence Scale, and naming was evaluated with one of three standardized measures (see Table 1) that required children to name pictures of objects. Reading accuracy, reading comprehension, and spelling accuracy were assessed using standardized tests of academic skills. Table 1 presents the standardized tests that were administered presurgery and 1 year postsurgery in these various domains. Age-scaled scores obtained from the manuals were converted to z-scores. Because the data were collected for clinical purposes over an extended time period, different or updated test versions were administered. There were no significant differences in performance across these versions ($p > .05$; see

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