



## Review

## Reading in children with temporal lobe epilepsy: A systematic review

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## ABSTRACT

**Objective:** Children with epilepsy have higher rates of reading difficulties compared to the general population. Reading difficulties are associated with lower academic attainments, higher school drop-out rates, greater risk of unemployment, lower income, and poorer adjustment. We examined the literature dealing with reading in children with the most common type of focal epilepsy, temporal lobe epilepsy (TLE), in relation to: presence of reading difficulties, contributing factors, and efficacy of treatments for reading difficulties.

**Methods:** We searched databases (MEDLINE, EMBASE, PsycINFO and PubMed) for studies published before September 2016. Included studies (i) reported on a group of children with TLE, (ii) used a standardized reading test or included a control group, (iii) involved original research published in peer reviewed journals in the English language.

**Results:** Of 2018 citations obtained through literature searches, six met inclusion criteria. Reading accuracy and/or reading comprehension were assessed using different tests. All but one study found statistical evidence of reading difficulties in children with TLE. Only two studies examined relations between cognitive deficits and reading. One found that memory contributed to reading accuracy and comprehension. Another found evidence of a small decline in reading accuracy, which was not associated with a decline in memory post-surgery. Several studies were underpowered, giving false negative findings and not allowing relations between epilepsy factors, underlying cognitive deficits, and reading to be adequately examined. No study examined efficacy of reading intervention in this patient population.

**Significance:** We showed that reading difficulties that are present in children with TLE are under researched, yet they have significant functional consequences through childhood and into adulthood. There is an urgent need to identify risk factors and investigate efficacy of treatments for reading difficulties in children with TLE, as this will enable early identification and evidence-based treatment to be delivered in clinical practice.

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## 1. Introduction

Reading difficulties are more common in children with epilepsy (i.e., 12.8 to 32.2% [1]) compared to the general population (i.e., 6.0% to 9.0% [2]). Children with temporal lobe epilepsy (TLE) are likely to be particularly vulnerable to reading difficulties for two main reasons. First, pathology/seizure focus are often not restricted to the hippocampus, but also involve the temporal neocortex (e.g., Jambaqué and colleagues [3]), which is an integral part of the reading network that involves (but is not limited to) the left lateral superior, middle, and inferior temporal neocortex (see Richlan et al. [4] for meta-analysis). Second, seizures in TLE are often difficult to control with medication. As such,

seizures can interfere with knowledge and skills acquisition, and reduce school attendance.

Surgical treatment for intractable TLE, which traditionally involves resection of the anterior temporal neocortex, may increase the risk of reading difficulties, as damage of this brain region is associated with deficits in reading of irregular words (surface dyslexia) and semantic memory deficits in adults with semantic dementia [5]. We note, however, that surgery for TLE, could also have a positive impact on reading, as the control of seizures, which is critical for development of reading skills, also increases school attendance post-surgery [6]. Moreover, this increased school attendance may be particularly beneficial for children (such as those in early primary school) whose regular school curriculum is focused on the acquisition of reading skills.

In addition to epilepsy-related factors, neurocognitive deficits could also contribute to reading difficulties. For example, difficulties with episodic memory, learning, and/or recall of newly-learned material in

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testing that are common in children with TLE (i.e., Nolan et al. [7]) could impact on acquisition of academic skills. The first study to examine the relationship between episodic memory and reading skills in children with TLE, however, found that episodic memory did not contribute significantly to reading comprehension and explained only 5% of variance in reading accuracy [8]. In contrast, semantic memory deficits remained unrecognized in children with TLE until recently [9,10]. Yet, semantic memory was found to explain 49% of the variance in reading comprehension and 39% of the variance in reading accuracy in children with TLE [8].

For children with TLE who are found to have reading difficulties, it is important to determine whether they will benefit from treatments that have been found to improve reading and normalize brain activation during reading tasks in children with reading difficulties who are free of epilepsy [11]. Children with TLE may be less responsive to reading treatments, as functional integrity of the very brain regions affected in TLE and/or surgical treatment is predictive of reading treatments' effectiveness. For instance, a recent magnetoencephalography study which involved children who had reading difficulties but were free of epilepsy showed that higher activation in the left middle and superior temporal lobes (alongside ventral occipitotemporal and the right mesial temporal cortex) pre-treatment predicted greater improvements in word reading post-remedial reading treatment at one-year follow-up [12].

Ideally, studies on reading in children with TLE would also consider cognitive theories and a body of knowledge arising from studies of reading in typically developing children and children with reading difficulties who are free of epilepsy. This body of work has shown that reading is a complex skill that requires accuracy and comprehension. Development of reading accuracy skills demands acquisition of (i) the ability to translate letters into sounds – phonological decoding skills [13,14] and (ii) word recognition – lexical skills [15]. Selective deficits in the acquisition of phonological decoding and lexical skills result in phonological and surface dyslexia, respectively [16]. Adequate reading accuracy is necessary, but not sufficient, for development of reading comprehension, which is closely related to semantic memory [17]. For example, children with specific reading comprehension difficulties, but adequate reading accuracy, were found to have significantly reduced semantic skills relative to control children matched for reading decoding skills [18]. Thus, assessment of reading should involve testing of reading accuracy and comprehension using age-appropriate instruments. Moreover, assessment of reading accuracy should test phonological decoding and lexical skills separately, which would increase diagnostic accuracy and inform specific interventions.

Research into reading in children with TLE is critical, as children with reading difficulties have lower academic attainments [19] and higher drop-out rates in high school [20] relative to their peers. In adulthood, people with reading difficulties have a significantly greater risk of unemployment [21], lower income [22] and poorer social and psychological adjustment (see Maughan [23]) compared to people without reading difficulties. Given the functional significance of reading for academic and vocational outcomes, it is important to establish which children with TLE are at risk of reading difficulties, inform parents and children about possible risks or benefits of surgery for development of reading, and provide evidence-based treatments for reading difficulties to children with TLE. Thus the aims of the current study were to systematically examine the literature dealing with reading in children with TLE and provide evidence of relevance for clinical work in relation to epilepsy and cognitive factors that are associated with reading difficulties in children with TLE and effective treatments of reading difficulties in this patient population.

## 2. Methods

### 2.1. Literature searches and study selection

Four databases were initially searched in November 2014: MEDLINE, EMBASE, PsycINFO, and PubMed. The searches were limited to English

language. The searches were updated using the same strategies in August 2016. Search details were as follows:

Database: Medline

Search 1 (18.11.2014): Ovid Medline (R) 1946 to October Week 4 2014

Search 2 (05.08.2016): Medline via OvidSP limit yr = "2014–current" (July Week 4 2016)

Search terms 'exp epilepsy/' AND ('exp reading/' OR 'exp dyslexia/') AND Limited to English language

Database: Embase

Search 1 (18.11.2014): Elsevier B.V.

Search 2 (05.08.2016): Embase via Ovid SP limit yr = "2014–current" (2016 August 04)

Search terms 'epilepsy'/exp AND ('reading'/exp OR 'dyslexia'/exp) AND [English]/lim

Database: PsycINFO

Search 1 (18.11.2014): OvidSP – 1806 to November Week 3 2014

Search 2 (05.08.2016): PsycINFO via OvidSP limit yr = "2014–current" (July Week 4 2016)

Search terms 'exp Epilepsy/' AND ('exp Reading' OR 'exp dyslexia') AND Limited to English language

Database: PubMed

Search 1 (18.11.2014)

Search 2 (05.08.2016): filter activated: publication date from 2014/10/30 to 2016/12/31

Search terms ([MeSH Terms] OR [All Fields]): ((Reading) OR Dyslexia) AND Epilepsy AND English[lang].

Studies included in the current review (i) reported original empirical research (i.e., not reviews, meta-analyses, editorials or letters), (ii) were conducted with a group of patients (i.e., not case studies), (iii) were published in peer-reviewed journals, (iv) included patients with TLE, (v) reported data (*M*, *SD*) of patients with TLE separately, if other patient groups were included, (vi) involved children and adolescents with TLE and reported data for children and adolescents separately, if adults with TLE were also included, and (vii) assessed reading using at least one reading task that was standardized or compared scores of participants with TLE to a control group, if non-standardized reading tests were used (i.e., not based on parental interview, school reports or clinical impression alone). The reference lists of articles that met the inclusion criteria were examined for studies not identified in the main search.

Two independent raters marked (i) all titles and abstracts obtained in the search against the inclusion criteria and (ii) selected full texts in both searches. Disagreements were resolved by discussion and consensus.

We used the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement and guidelines to summarize evidence and report results [24].

### 2.2. Quality appraisal

We appraised methodological quality of studies included in this review with the adapted version of the Downs and Black [25] checklist, which can be used to assess quality of intervention studies as well as observational studies. The checklist assesses studies on the quality of reporting, internal validity, external validity, and power. The checklist was found to have good test–retest reliability ( $r = .88$ ), inter-rater reliability ( $r = .75$ ), and internal consistency (Kruider–Richardson formula  $20 = .89$ ). The appraisals of studies included in our review were completed by two reviewers independently. Any discrepancies in rating were resolved via discussion.

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