AUTOBIOGRAPHICAL MEMORY IN CHILDREN WITH EPILEPSY

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ABSTRACT

Autobiographical memory involves the recall of personal facts (semantic memory) and re-experiencing of specific personal events (episodic memory). An increasing amount of research has explored autobiographical memory in adults with epilepsy, however little work has been done in children with epilepsy. In the current study 10 children with generalized and focal epilepsy and 10 age and sex-matched controls were administered the Children's Autobiographical Memory Interview. Children with epilepsy showed deficits in the recall of episodic, but not semantic autobiographical memory in comparison to controls. Children with generalized epilepsy showed impairments in episodic autobiographical memory in contrast to patients with focal epilepsy. Exploratory analyses revealed that verbal memory and language, and age of first seizure were related to episodic autobiographical events. These results have implications for the adjustment of children with epilepsy, so that earlier diagnosis and intervention programs may be placed in order to allow these children to function maximally.

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Introduction

Autobiographical memory entails the recollection of personal events from one's past and involves the interaction between two kinds of knowledge pertaining to oneself: factual knowledge, referred to as semantic memory, and specific personal events, referred to as episodic memory (Tulving, 1972). As a complex form of memory, autobiographical memory has been associated with activation in the hippocampus (Moscovitch, 2008). The hippocampus is a medial temporal lobe structure, which plays a pivotal role in the formation, consolidation and retrieval of memories (Eldridge, Knowlton, Furmanski, Bookheimer & Engel, 2000). Numerous studies have shown that patients with hippocampal damage, due to various types of neurological disorders, exhibit deficits in overall memory recall, including autobiographical memory (Maguire, Vargha- Khadem & Miskin, 2001; Addis, Moscovitch & McAndrews, 2007). Patients with epilepsy are a particularly susceptible population as recurring seizures may damage the hippocampus and associated brain regions, leading to memory deficits (Spencer, Spencer, Williamson & Mattson, 1990). An increasing amount of research has explored autobiographical memory in adults with epilepsy (Addis et al., 2007; Levine, Svododa, Winocur, & Moscovitch, 2002; St-Laurent, Moscovitch, Levine & McAndrews, 2009; Steinvorth, Levine, & Corkin, 2005, Piolino et al., 2008). However, autobiographical memory in childhood is not particularly well understood in those that have epilepsy.

The lack of research into autobiographical memory within a pediatric epilepsy population represents a notable gap that needs to be addressed for several reasons. When assessing potential memory deficits in children with epilepsy, clinicians should be able to rely on research conducted specifically with pediatric epilepsy populations, rather than adults, as the impact of seizures and their underlying abnormal neural substrates are different in the developing and

mature brain (Smith, 2010). For example, in children, epilepsy occurs within a more dynamic nervous system and the neuropsychological implications reflect ongoing maturational changes, plasticity at the behavioral and structural level, and the impact of environmental and social factors on development (Fletcher & Taylor, 1984). Second, epilepsy will have different effects on cognitive functioning in adult versus child populations. In the developing brain, potential autobiographical memory impairments may lead to a loss of cognitive function. This in turn may adversely impact academic functioning or will limit their independence and productivity during adulthood (Butler & Zeman, 2008). Moreover, ample research has suggested that verbal memory is compromised in children with epilepsy (Menlove & Reilly, 2015). There remains a possibility that deficits in autobiographical memory may partly contribute and interact with other memory complaints, like verbal memory, in children with epilepsy. Verbal memory may be more readily and adequately addressed by standardized memory assessments, which typically only test recall after a maximum delay of 30 minutes that could potentially mean that autobiographical memory deficits remain undetected (Gascoigne, 2014).

Epilepsy Background

The neurological disorder of epilepsy is characterized by predominantly unpredictable and recurrent interruption of normal brain function through epileptic seizures (Fisher et al., 2005). Seizures are characterized by abnormal and sudden surges of electrical activity, which may be accompanied by altered consciousness and/or other behavioral manifestations (Gascoigne, 2014). Epilepsy is about twice as common in children as in adults, about 700 per 100,000 in children under the age of 16 years compared to 330 per 100,000 in adults (Akalan & Di Rocco, 2012).

Epilepsy is not a singular disease, but rather represents a diverse group of disorders with varied underlying causes and etiologies. As such, a widely accepted classification system published by the International League Against Epilepsy (ILAE) is used to classify epilepsies on the basis of whether they are "generalized" or "focal" in origin (i.e. generalized versus focal epilepsy) [Commission on Classification and Terminology of the International League Against Epilepsy (ILAE, 1989)]. Figure 1 shows the newly developed classification system of seizure types by the ILAE (Fisher et al., 2017). Focal epilepsy is defined as seizures originating within networks limited to one hemisphere. They may be discretely localized or more widely distributed. Generalized onset seizures are defined as originating at some point within, and rapidly engaging, bilaterally distributed networks (Fisher et al., 2017). "Unknown-onset" is not a characteristic of a seizure, but a convenient placeholder and with further information or future observed seizures; a reclassification into focal or generalized- onset categories may become possible (Fisher et al., 2017).

Any focal seizure can further be characterized by whether awareness is retained or impaired. Focal seizures are further characterized by motor onset signs and symptoms: atonic, automatisms, clonic, epileptic spasms, or hyperkinetic, myoclonic, or tonic activity (see Appendix A for definitions of signs and symptoms). Nonmotor-onset seizures can manifest as autonomic, behavior arrest, cognitive, emotional, or sensory dysfunction. The seizure type "focal to bilateral tonic–clonic" is in a special category because of its common occurrence and importance, even though it is reflective of a propagation pattern of seizure activity rather than a unique seizure type (Fisher et al., 2017).

Generalized-onset seizures are divided into motor and nonmotor seizures. Level of awareness is not used as a classifier for generalized seizures, since the large majority of

generalized seizures are associated with impaired awareness (Fisher et al., 2017). Generalized motor seizure characteristics comprise atonic, clonic, epileptic spasms, myoclonic, myoclonic–atonic, myoclonic–tonic–clonic, tonic, or tonic–clonic. Nonmotor (absence) seizures are typical or atypical, or seizures that present prominent myoclonic activity or eyelid myoclonia. Seizures of unknown onset may have features that can still be classified as motor, nonmotor, tonic–clonic, epileptic spasms, or behavior arrest. A seizure might be unclassified due to inadequate information or inability to place the seizure in other categories (Fisher et al., 2017).

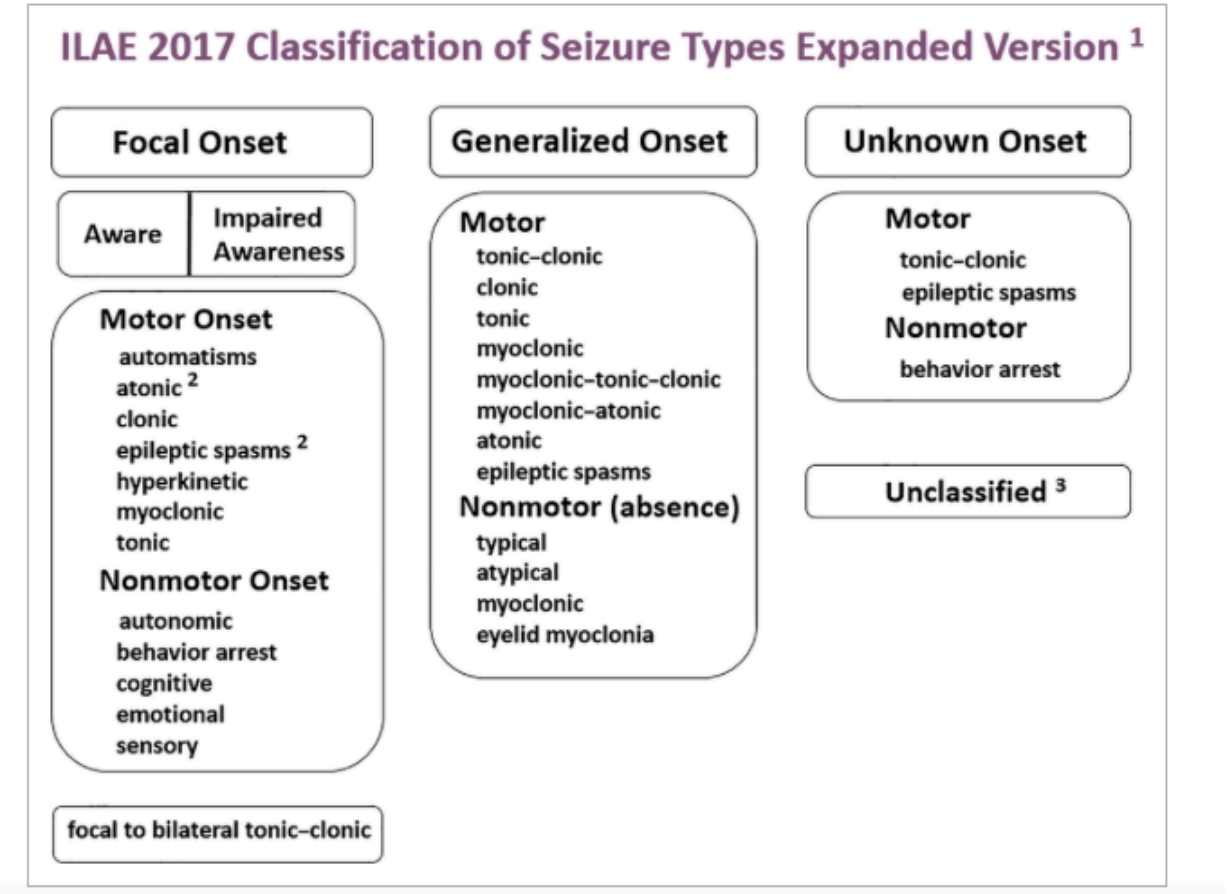

Figure 1. ILAE 2017 classification of seizure types

Epilepsy and Cognitive Outcomes

Recurring seizures are detrimental to many different cognitive functions. Cognition includes a variety of skills such as intelligence, attention, learning, remembering, reasoning, judging, planning, and expressing and understanding language (Smith, 2010). In a recent review by Kim & Ko (2016), it was noted that cognitive impairments are common in 45% of children with epilepsy. More specifically, in children that predominantly have generalized seizures through syndromes such as idiopathic generalized epilepsy, there is a 25% risk of overall intellectual disability. A further 20-50% have learning disabilities despite normal intelligence (Henkin et al., 2005). The cognitive impairments detected in children with generalized epilepsy involve deficits in visual sustained attention, verbal and nonverbal memory, verbal fluency, execution of visual-motor function and language (Kim & Ko, 2016).

In focal epilepsy, there is more variability in the types of cognitive impairments as seizures originate in different brain areas. The most common types of focal epilepsy in childhood include: frontal lobe epilepsy, where attention deficits and impairment of executive functions such as planning, organizing, and problem solving are frequently described (Braakman et al., 2012); and temporal lobe epilepsy, where episodic memory deficits and inattention deficits are typically reported (Rzezak et al., 2007). Benign rolandic epilepsy is also common in childhood and is marked by attention impairments, learning difficulties, and memory impairment in the presence of overall normal intelligence (Kwon, Seo, & Hwang, 2012). Reading disability and phonological processing difficulties are reported in children with this form of focal epilepsy as well (Goldberg-Stern et al., 2010). Overall in sum, Kim & Ko (2016) noted that across all forms of epilepsy, children typically face wide spread challenges predominantly with processing speed, attention, and memory impairments.

These cognitive challenges that children with epilepsy face may be attributed to both the seizures themselves and epilepsy-related factors. Anti-epilepsy drugs (AEDs) are the major therapeutic intervention in epilepsy, and neurologists have to consider the risk-to-benefit ratio and assess the patient's cognitive condition before starting treatment (Kim & Ko, 2016). Children may be at a higher risk for developing cognitive side effects from AEDs and epilepsy surgery (Ijiff & Aldenkamp, 2013; Loring & Meador, 2004), with the most consistent and marked adverse effects affecting attention and memory (Kim & Ko, 2016). More specifically, barbiturates and benzodiazepines have been found to have impairing effects on memory (Kim & Ko, 2016). In general, increasing the number of AEDs and dosage increase the risk of cognitive side effects. Several other epilepsy-related variables have also been shown to increase a risk of learning and memory, such as earlier age of seizure onset (Kaaden & Helmstaedter, 2009) and higher proportion of life spent with epilepsy (Jokeit &Ebner, 1999; Jokeit & Ebner, 2002). Other factors such as seizure severity and frequency (Helmstaedter & Elger, 2009) have been found to negatively impact learning and recall of information in children with epilepsy.

Research into memory impairments in children with epilepsy has been extensive. A number of studies have reported deficits in short-term verbal and nonverbal recall in both children with generalized and focal epilepsies (Jambaque, Dellatolas, Dulac, Ponsot, & Signoret, 1993; Nolan et al., 2004; Cohen, 1992). A review by Menlove & Reilley (2015) noted that verbal learning and memory is compromised in children with epilepsy, which had deleterious consequences for school achievement and health-related quality of life (Fuentes & Smith, 2015). Although learning and recall of verbal and nonverbal information after short delays have been examined in children with epilepsy, long-term memory ability beyond a standard 30-minute

delay, which encompasses autobiographical memory, remains under-researched in this population.

Epilepsy and Autobiographical Memory

Autobiographical memory is a multifaceted high-order cognitive process that has been deemed as a central element of human functioning (Nelson & Fivush, 2004). As a complex form of cognition, autobiographical memory serves many purposes (Conway & Pleydall-Pearce, 2000). It provides a means through which one may access general knowledge, interpret behaviour in a social context, exchange experiences, and remain oriented in a shared social world (Nelson & Fivush, 2004). Autobiographical memory also operates to define the self and to provide the self with continuity and stability (Conway & Pleydell-Pearce, 2000).

Studies have also found that adults with epilepsy have difficulties in autobiographical memory recall in comparison to controls (Addis et al., 2007; Viskontas, McAndrews & Moscovitch, 2000). Impairments have been found in epilepsy patients in the recall of episodic but not semantic memories (O' Connor et al., 1999; Addis et al., 2007), and both episodic and semantic memories (Herfurth, Kasper, Schwarz, Stefan, & Pauli, 2010). As a result, there have been well-established findings that adults with epilepsy suffer from autobiographical memory deficits relative to healthy controls in relation to episodic memory deficits, however not for semantic autobiographical memory.

Only two studies to-date however have assessed autobiographical memory deficits in children with epilepsy. A study by Gascoigne and colleagues (2013) was the first to systematically examine autobiographical memory in children with temporal lobe epilepsy. Using the Children's Autobiographical Memory Interview (cAMI; Willoughby, Desrocher, Levine, &

Rovet, 2012). 21 children with focal epilepsy, namely temporal lobe epilepsy, and 24 healthy age and sex-matched controls recalled two separate autobiographical events under conditions of free recall or with prompts to assist in retrieval. Compared to controls, children with temporal lobe epilepsy recalled fewer episodic details, but only when no retrieval prompts were provided. There was no difference between the groups in number of semantic autobiographical details.

Similar findings were discovered in a second study of children with idiopathic generalized epilepsy (Gascoigne et al., 2015). The study aimed at examining whether primary generalized seizures were associated with deficits in the recall of autobiographical memories in children. Eighteen children with generalized epilepsy and 42 age and sex-matched healthy controls were administered the cAMI. It was found that compared to controls, children with generalized epilepsy recalled significantly fewer episodic details, even when retrieval prompts were provided, but no differences were found between semantic autobiographical details. It was also found that age at epilepsy diagnosis was related to episodic autobiographical memory, where children diagnosed later recalled more episodic details. These findings suggest epilepsy-related factors such as proportion of life with epilepsy directly impact autobiographical memory recall (Gascoigne et al., 2015).

These two studies suggest that children with both focal and generalized epilepsy are likely to be at risk of autobiographical memory impairments, with the generalized subtype having a more profound impairment, as these patients did not benefit from retrieval cues. Identifying these difficulties is clinically significant, as autobiographical memory has been found to play a significant role in everyday life and adaptive functioning (Gascoigne et al., 2013).

One issue in the existing studies of autobiographical memory in children with epilepsy is that patients were recruited from specialized tertiary health care facilities, which limits the generalizability of the findings. Children in such settings are often candidates for surgery, and may be particularly impaired in various types of memory owing to the intractability of their seizures. Thus, it is important that there is replicability in community-based samples of pediatric epilepsy in order to better understand these autobiographical memory deficits. In addition, the cognitive processes that facilitate autobiographical memory are poorly understood in children. In the adult literature, participants who scored higher on verbal memory and language tests had better retention for personal autobiographical events (Janssen et al., 2015). The role of verbal memory and language in the recall of autobiographical events is unknown in children and adolescents with epilepsy. Given the overwhelming research documenting deficits in verbal memory and language in children with epilepsy (Menlove & Reilly, 2015; Helmstaedter & Elger, 2009; Fuentes & Smith, 2015), exploring the association these functions may have with autobiographical recall is important for understanding whether common neuropsychological deficits in epilepsy affect the recall of personal autobiographical events.

Summary

The lack of research into autobiographical memory deficits within a community-based pediatric epilepsy population represents a notable gap that needs to be addressed. The primary aim of this study was to examine autobiographical memory in a community-based sample of 10 children with epilepsy and 10 age- and sex-matched children without epilepsy using the Children's Autobiographical Memory Interview (cAMI; Willoughby et al., 2012). The cAMI employs a standarized, reliable system by which to derive measures of episodic and semantic memory from participants' transcribed autobiographical protocols, and therefore allows for the

direct comparison of episodic and semantic recall in patients and controls. Furthermore, memory deficits were explored in different sub-types of epilepsy in order to expand the limited knowledge of autobiographical recall in this specific neurological population. A secondary goal of this study was to explore the relationship between autobiographical memory and verbal memory and language. A battery of neuropsychological tests was administered to explore these domains of functions. This exploratory analysis will add to our understanding of the role verbal memory and language may play in the retrieval of autobiographical events. Autobiographical memory serves to be a major element of functioning as it plays a central role in our sense of self, operating to define and to provide the self with continuity and stability (Conway & Pleydell-Pearce, 2000). McAdams (2001) found that during late teens and mid-twenties individuals begin to organize their autobiographical memories in life narratives in order to achieve a sense of unity and purpose. Children with epilepsy who have deficits in autobiographical memory recall may have trouble achieving this milestone. Therefore, this research has implications for the adjustment of children and youth with epilepsy, and will lead to intervention programs to improve memory in this population.

Research Objectives and Hypotheses

The primary aim of this study was to examine autobiographical memory in a community-based sample of children with epilepsy, and age- and sex-matched children without epilepsy.

Specifically, the present study addresses the following questions:

1. a) Do children with epilepsy have deficits in autobiographical memory recall compared to healthy age and sex-matched controls? b) Are there any differences in autobiographical memory

recall between different subtypes of epilepsy? c) Are there any relations between epilepsy-related factors and autobiographical memory recall?

2. a) Is verbal memory and language performance associated with the recall of autobiographical memory events?

In light of the findings in the autobiographical memory literature, the following hypotheses were put forward:

1a. Children with epilepsy will exhibit overall fewer details for episodic components but not sematic components of autobiographical events relative to controls, as measured by the cAMI. (Gascoigne et al., 2013; Gascoigne et al., 2015).

1b. There will be differences between epilepsy subtypes in episodic components but not semantic components of autobiographical events (Gascoigne et al., 2013; Gascoigne et al., 2015). Those with generalized epilepsy will recall fewer episodic details than those with focal epilepsy.

1c. There will be relationships between age of seizure-onset and autobiographical memory recall (Gascoigne et al., 2015).

2. Verbal memory and language scores will be associated with episodic autobiographical events (Janssen et al., 2015).

Method

Participants

Ten children with epilepsy were recruited for the present study by the study recruiter. The tester was blind to the group status of participants. Inclusion criteria for the epilepsy group were:

i) documented case of epilepsy as determined through parental reports and meeting the criteria set by the International League Against Epilepsy (Commission on Classification and Terminology of the International League Against Epilepsy, 2017), ii) aged 6 to 16 years at the time of assessment, iii) fluency in English. Exclusion criteria for the epilepsy group included: i) Full Scale Intelligence Quotient (FSIQ) <70; ii) presence of a major neurological disorder severely impairing vision and hearing; iii) significant neurodevelopmental disorder such as autism spectrum disorder with a verbal IQ (VIQ) <70, but not learning disability or ADHD. Of the ten children with epilepsy, five children had generalized epilepsy and 5 children had focal epilepsy, allowing for equal comparisons of epilepsy subtypes. Of the 5 children with focal epilepsy, three children had seizures emanating from exclusively the rolandic regions of the brain. One participant had seizures in addition to the rolandic regions, emanating from the occipital lobe. One participant had temporal lobe seizures. The average age of first seizure for the children with generalized epilepsy was 2.50 years (SD=2.42), and 6.00 years (SD=4.50) for the children with focal epilepsy. The epilepsy groups did not differ in terms of seizure frequency and reported predominantly 0-5 seizures a month. Seizure severity ratings also did not differ, and ranged from not at all severe to very severe. Of the generalized epilepsy group, two patients had existing learning disability diagnoses, one had an ADHD diagnosis and one had a high functioning autism diagnosis. In the partial epilepsy group, one patient had a high functioning autism diagnosis. All participants were taking anti-epileptic drugs (AEDs) at the time of assessment, except two patients, one in the generalized epilepsy group and the other in the focal epilepsy group. Two patients from the generalized epilepsy group had a history of surgery with left temporal lobectomies, whereas all other participants had not undergone surgery.

Ten age and sex-matched controls were recruited for the study. Inclusion criteria for the control group were: i) free of epilepsy and aged 6 to 16 years at the time of assessment ii) fluency in English. Exclusion criteria for the control group included: i) Full Scale Intelligence Quotient (FSIQ) <70; ii) presence of a major neurological disorder severely impairing vision and hearing; iii) significant neurodevelopmental disorder such as autism spectrum disorder, learning disability, or ADHD. All participants were recruited through advertisements posted online on Facebook and Craigslist, at participating organizations (e.g. Epilepsy Toronto), through peer networks and printed advertisements in hospital and community clinics.

Measures

Information on epilepsy variables was collected through parental reports including: age of first seizure, number and type of AEDs, history of surgery, and seizure frequency and severity. Maternal education was measured by the average number of years of schooling.

Neuropsychological Measures.

The standardized clinical neuropsychological instruments used in this study were chosen to assess verbal memory and language, as well as overall intelligence. Scores were age and sex-normed as per test manual and standard scores were reported. Table 1 provides a summary of the neuropsychological measures used in the study.

i) The Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011) is a screener of general cognitive ability. Overall reliability for composites of the WASI meet or exceed .90 across a sample of children. The two subtest version that estimates Full Scale Intelligence Quotient (FSIQ) was used. The WASI-II vocabulary scaled score was also used to measure language functioning.

ii) The Children's Memory Scale (CMS; Cohen, 1997) assesses short and long term verbal memory, using the Stories & Word Pairs subtests. Overall reliability for composites of the CMS meet .91, making it to be a psychometrically sound instrument to test verbal memoy (Skaalid, 1999).

Table 1. Clinical neuropsychological instruments.

Domain	Test: subtest	Score used
Intelligence	1) WASI-II: Vocabulary & Matrix Reasoning	1) Two subtests to estimate Full Scale Intelligence Quotient (FSIQ)
Verbal Memory	1) CMS: Stories & Word Pairs	1) Verbal Immediate; Verbal Delayed; Delayed Recognition
	2) CVLT-C	2) List A Total Trials 1-5; List A Short- Delay Free Recall; List A Short-Delay Cued Recall; List A Long-Delay Free Recall; List A Long-Delay Cued Recall
	3) D-KEFS: Verbal Fluency	3) Letter Fluency; Category Fluency; Category Switching Total Responses; Category Switching Accuracy
Language	1) EVT-2	1) Age scaled score
	2) PPVT-4	2) Age scaled score
	3) WASI-II Vocabulary	3) Age scaled score

iii) California Verbal Learning Test - Children's Version (CVLT-C; Delis et al., 1994), is a measure of verbal learning and memory. Children recall a list of 15 words after a short or long delay with or without cues. It has been shown to have acceptable overall reliability (.72 to .85) in childen with epilepsy (Griffiths et al., 2007).

iv) The Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) assesses key components of executive functions within verbal modalities. The verbal fluency subtest has been shown to have good reliability meeting .80 (Swanson, 2005). There is a well-reported association of verbal memory impairments and executive dysfunction in multiple clinical populations including epilepsy (Duff, Schoenberg, Scott, & Adams, 2005), thus incorporating a test of executive functioning was important.

v) The Expressive Vocabulary Test - 2nd edition, (EVT-2, Williams, 2007) is designed to measure expressive vocabulary and word retrieval in English-speaking children and adults. The EVT-2 has been deemed to be a good screening device for language functioning in children, with an overall reliability meeting .95 (Williams, 2007).

vi) Peabody Picture Vocabulary Test - 4th edition (PPVT-4, Dunn & Dunn, 2007) is a test that screens verbal ability and assesses receptive vocabulary knowledge and comprehension of spoken English. Like all other measures, the PPVT-4 is also psychometrically sound, has been used extensively in the epilepsy literature and meets overall realiability at .92 (Hayward et al., 2008).

Children's Autobiographical Memory Interview (cAMI).

The Children's Autobiographical Interview was used to assess autobiographical memory in participants (cAMI, Willoughby et al, 2012). For the cAMI task, participants were required to recall two autobiographical memories that occurred one month prior to the assessment. All participants administered the cAMI were also provided with a sample list of life events, in order

to help them identify appropriate events to describe in the assessment; participants were free to recall any event, irrespective of the suggestions contained in the list (see Appendix B & C).

The cAMI has three distinct phases: free recall, general probe, and specific probe. In the Free Recall condition, participants describe the memory in as much detail as possible in a 5-minute time span. General probes were provided in order to encourage the recall of additional details. In the event of a vague or non-specific memory being recalled, participants were asked to clarify the event during this condition. Finally, in the Specific Probing condition, specific questions were asked regarding the memory (e.g., "When did this event take place?") from a standardized series of questions about the event, pertaining to time, location, sensory/perceptual and emotional/cognitive details. On completion of all conditions of the cAMI, participants were asked to rate each memory on each of the following domains: ability to visualize the event (1=cannot see it at all, 7= really clear), change in emotions before to after the event (1= no change, 7=lots of change), current personal importance of the event (1=not important, 7=most important event), personal importance at time of event (1=not important, 7=most important event), frequency of memory rehearsal (1=once every few years, 7=everyday), confidence about the recollection (1=not sure, 7=really sure) and memory strength (1=not strong, 7=really strong) (see Appendix D)

The recall of both memories was recorded and transcribed (see example in Appendix E.) Each memory was scored according to the Autobiographical Interview Scoring manual (Levine et al., 2002). Two main types of details were identified within each memory: (i) episodic details, that pertain directly to the main episode and are placed in a particular spatio-temporal context, suggestive of the re-experiencing of the main event and (ii) semantic details, representing general autobiographical information that is not integral to the main event. Episodic details were

assigned to one of five episodic detail subcategories: a) event b) place c) time d) perceptual and e) emotion/thought. The semantic details were assigned to one of the two non-episodic detail subcategories: a) semantic facts or b) other which encompassed event, time, place, perceptual, or thought/ emotion details that pertain to other events not identified as the main event in the recollection, unsolicited repetition of details or metacognitive statements. Details were summed to form a total episodic and semantic detail composite score across each phase of the cAMI. For each participant, the autobiographical memory detail scores and participant self-reports were averaged across their two memories. Appendix F provides a comprehensive list of descriptions and examples of each detail category. Each transcribed memory was scored by one experimenter (RS) who had previously completed training by scoring a practice set of memories achieving reliability with the supervisor (MD).

General Procedure

All procedures were approved by the Human Participants Review (Ethics) Sub-Committee of York University. Parents/ guardians provided written informed consent for their child's participation in this study, and participants in this study also provided informed assent. All assessments took approximately 2.5 hours. Testing took place in an enclosed quiet area of York University while parent/guardians completed questionnaires. The researcher completed all testing. All participants were reimbursed for their travel to York University. Upon completion of the assessment, participants received a movie coupon for Cineplex Theatres and parents received a research report after completion of the testing session.

Results

All data was analyzed using SPSS 23 statistics software. Preliminary analyses investigated all variables for outliers (i.e. 3 SD>M) and normality of distributions using the Shapiro-Wilk test. For variables that were normally distributed, between-group differences were examined using independent t-tests and means were reported. Where normality assumptions were not met Mann Whitney U tests were used to examine between-group differences and medians were reported. Effects sizes (eta-squared) were calculated for between-group differences that were significant. Chi-square tests were used between groups on categorical variables such as sex distribution. Spearman's rho was used for correlational analyses to examine relationships between autobiographical memory and verbal memory and language scores. All tests were set to an $\alpha < .05$. This alpha level was selected because it has been suggested that it is more acceptable to be liberal in small sample-sized studies (Evans & Ildstad, 2001). In fact Perneger (1998) suggests that adjusting statistical significance for the number of tests that have been performed on study data—the Bonferroni method—creates more problems than it solves, as the likelihood of type II errors is also increased.

Background demographic, cognitive and clinical variables

The epilepsy and control groups did not differ significantly in age, sex distribution or maternal education (see Table 2). The groups also did not differ significantly on Full Scale IQ. However, compared to the control group, the epilepsy group was found to have lower scores in category switching on the D-KEFS verbal fluency subtest falling in the low average range ($p = 0.01$; $\eta^2 = 0.36$).

Furthermore, the generalized and focal epilepsy groups did not differ on any demographic variables, including age, sex distribution, and maternal education. However,

compared to the focal epilepsy group, the generalized epilepsy group was found to have lower FSIQ scores (p= 0.02; η^2 = 0.65). Although the FSIQ of the generalized group was significantly lower than that of focal epilepsy group, lower FSIQ in generalized epilepsy is commonly observed in this neurological condition in children (Gascoigne, et al., 2015; Nolan et al., 2004; Singhi, Bansal, Singhi, Pershad, 1992). Moreover, compared to the focal epilepsy group, the generalized epilepsy group was found to have significantly lower scores in verbal immediate memory on the CMS (p= 0.03; η^2 = 0.54) and in category fluency (p= 0.03; η^2 = 0.76) and switching (p= 0.03; η^2 = 0.69) on the D-KEFS verbal fluency subtest. The generalized epilepsy group also had significantly lower scores in total free recall (p= 0.02; η^2 = 0.68), short-delay free recall (p= 0.03; η^2 = 0.63) and short-delay cued recall (p= 0.03; η^2 = 0.55) on the CVLT-C. Finally, significant group differences were found between the two groups in receptive vocabulary on the PPVT-4 (p= 0.03; η^2 = 0.53), and vocabulary on the WASI-II (p= 0.01; η^2 = 0.71), with the generalized epilepsy group having lower scores than the focal epilepsy group. Thus, overall, the generalized epilepsy group had lower scores on 9 out of 15 neuropsychological outcomes.

The generalized and focal epilepsy groups did not differ significantly on any clinical variables, including the presence of any comorbid disorders, the age of first seizure, years spent with epilepsy, number and type of AEDs, surgical history, or seizure frequency and severity. The presence of comorbid disorders and younger age of first seizure in the generalized epilepsy group trended towards significance (p = 0.06).

Table 2: Demographic, Cognitive and Clinical Data

	Controls (N=10) Mean (SD)	Epilepsy (N=10) Mean (SD)	Test of Significance	*p*	Focal Epilepsy (N=5) Median (IQR)	Generalized Epilepsy (N=5) Median (IQR)	Test of Significance	*p*
Age (Years)	9.60 (2.50)	10.10 (2.28)	$t_{(18)}$= -0.47	0.65	10.00(4.00)	8.00 (5.00)	U =7.00	0.31
Sex (Male/Female)	4/6	6/4	χ^2= 0.80	0.37	3/2	3/2	χ^2= 0	1.00
Maternal Education (Years)	15.10 (3.35)	14.89 (2.80)	$t_{(17)}$= 0.15	0.88	13.00(4.00)	17.50 (4.75)	U =6.00	0.41
FSIQ	100.70(7.53)	94.00 (20.83)	$t_{(11.31)}$= 0.96	0.36	110.00(15.00)	79.00 (27.00)	U =1.00	**0.02**
CMS								
Verbal Memory Immediate SS	86.00(14.87)	79.90(18.23)	$t_{(18)}$= 0.82	0.42	97.00(19.00)	63.00(25.00)	U =2.00	**0.03**
Verbal Memory Delayed SS	90.44 (13.12)	89.50 (19.62)	$t_{(15)}$= 0.12	0.91	97.00(28.00)	78.00(23.00)	U = 4.00	0.39
Delayed Recognition SS	91.00(16.27)	87.88(24.15)	$t_{(15)}$= 0.32	0.76	103.00 (21.5)	75.00 (27.50)	U =4.50	0.39
D-KEFS								
Letter Fluency SS	11.13(4.05)	8.00(3.89)	$t_{(14)}$= 1.57	0.14	10.50(5.00)	5.00(6.00)	U =1.00	0.06
Category Fluency SS	11.00(3.59)	7.75(3.37)	$t_{(14)}$= 1.87	0.08	10.50(3.00)	5.50(4.00)	U =0	**0.03**
Category Switching Responses SS	12.63(3.96)	7.38(3.50)	$t_{(14)}$= 2.81	**0.01**	9.00(5.00)	5.50(6.00)	U =0.50	**0.03**
Category Switching Accuracy SS	12.50(3.51)	9.00(3.67)	$t_{(14)}$= 1.95	0.07	11.50(3.00)	8.50(6.00)	U =1.00	0.06
CVLT-C								
List A Total Trials Free Recall Raw Score	40.10(12.35)	37.00(12.70)	$t_{(17)}$= 0.54	0.60	45.00(11.00)	23.00(17.00)	U =0.50	**0.02**
List A Short-Delay Free Recall Raw Score	9.10(3.84)	7.56(4.80)	$t_{(17)}$= 0.78	0.45	12.00(4.00)	3.00(8.00)	U =1.00	**0.03**
List A Long-Delay Free Recall Raw Score	8.20(3.71)	7.67(4.39)	$t_{(17)}$= 0.29	0.78	10.00(4.00)	3.50(9.00)	U =3.00	0.11
List A Short-Delay Cued Recall Raw Score	8.80(3.49)	7.56(4.85)	$t_{(17)}$= 0.65	0.53	12.00(6.00)	3.00(7.00)	U =1.50	**0.03**
List A Long-Delay Cued Recall Raw Score	9.20(3.85)	8.33(4.64)	$t_{(17)}$= 0.27	0.66	12.00(2.00)	4.00(9.00)	U =4.00	0.19
EVT-2 SS	99.60 (5.56)	90.60(16.17)	$t_{(11.10)}$=1.67	0.11	96.00(20.00)	79.00(36.00)	U =7.00	0.31
PPVT-4 SS	105.20(12.71)	95.80(16.02)	$t_{(18)}$=1.45	0.16	111.00(19.00)	85.00(24.00)	U =2.00	**0.03**
WASI-II Vocabulary SS	11.60(0.52)	9.10(5.59)	$t_{(9.15)}$=1.41	0.19	15.00(5.00)	4.00(8.00)	U =0.50	**0.01**
Comorbid Disorders (Yes/No)	-	-	-	-	1/4	4/1	χ^2= 3.60	0.06
Age of fist seizure (Years)	-	-	-	-	6.00(4.50)	2.50(2.42)	U =3.00	0.06
Years spent with epilepsy	-	-	-	-	3.00(6.00)	7.00(5.25)	U =7.00	0.31
Number of AEDs	-	-	-	-	1.00(0.50)	1.00(0.50)	U =12.50	1.00

Type of AEDs	-	-	-	-				
Valproic Acid	-	-	-	-	3	2	χ^2= 5.00	0.29
Lamotrigine	-	-	-	-	1	0		
Oxcarbazepine	-	-	-	-	0	1		
Clobazam	-	-	-	-	0	1		
Surgery (Yes/No)	-	-	-	-	0/5	2/3	χ^2= 2.50	0.11
Seizure Frequency	-	-	-	-			χ^2= 0	1.00
0-5 per month	-	-	-	-	3	3		
5-10 per month	-	-	-	-	1	1		
10+ per month	-	-	-	-	1	1		
Seizure Severity	-	-	-	-				
Not at all severe	-	-	-	-	1	0	χ^2= 2.33	0.51
A little severe	-	-	-	-	1	3		
Moderately severe	-	-	-	-	2	1		
Very severe	-	-	-	-	1	1		

AEDS: Anti-Epileptic Drug; CMS: Children's Memory Scale; CVLT-C: California Verbal Learning Test-Children's Version; D-KEFS: Delis-Kaplan Executive Function System; EVT: Expressive Vocabulary Test-2; FSIQ: Full Scale Intelligence Quotient; IQR: Inter-Quartile Range; PPVT: Peabody Picture Vocabulary Test-4; SS: Standard Score; WASI-II: The Wechsler Abbreviated Scale of Intelligence

Children's Autobiographical Memory Interview (cAMI): Epilepsy versus Controls

Scores obtained across the three stages of the cAMI are presented in Table 3. Mann Whitney U tests showed that the epilepsy group recalled significantly fewer episodic details than the control group in the Free Recall condition (p= 0.01; η^2 = 0.42). However, no between-group differences in the recall of episodic details were found during either the General Probe or Specific Probe conditions. Furthermore, no between-group differences were found for the recall of semantic details during the Free Recall, General Probe, or Specific Probe stages.

Table 3: Children's Autobiographical Interview: Children with Epilepsy vs Controls

	Controls (N=10) Median(IQR)	Epilepsy (N=10) Median(IQR)	Test of Significance	*p*
Free Recall				
Episodic	24.00(18.00)	11.00(9.00)	*U* =12.50	**0.01**
Semantic	2.00(5.00)	2.00(5.00)	*U* =40.00	0.48
General Probe				
Episodic	5.00(6.00)	6.00(12.00)	*U* =42.50	0.58
Semantic	0.00 (0.00)	1.00(3.00)	*U* =29.00	0.12
Specific Probe				
Episodic	21.00(17.00)	19.00(17.00)	*U* =44.50	0.68
Semantic	3.50(6.00)	5.00(4.00)	*U* =46.00	0.80

Generalized versus Focal Epilepsy

Total episodic and semantic scores obtained by the generalized and focal epilepsy groups on the cAMI across the three recall conditions are presented in Table 4. Mann-Whitney U tests revealed that the generalized epilepsy group recalled significantly fewer episodic details than the focal epilepsy group in the Free Recall (p= 0.03; η^2 = 0.49), and General Probe (p= 0.01; η^2 = 0.71), stages of the interview. In contrast, no differences were found between the generalized and focal epilepsy groups in the recall of episodic details in the Specific Probe stage. Furthermore, no differences were found in the recall of semantic details at either the Free Recall, General Probe, or Specific Probe stages.

Table 4: Children's Autobiographical Interview: Generalized Epilepsy vs Focal Epilepsy

	Focal Epilepsy (N=5) Median(IQR)	Generalized Epilepsy (N=5) Median(IQR)	Test of Significance	*p*
Free Recall				
Episodic	14.00(8.00)	7.00(9.00)	*U* =2.50	**0.03**
Semantic	2.00(6.00)	0.00(4.00)	*U* =7.50	0.31
General Probe				
Episodic	13.00(10.00)	3.00(6.00)	*U* =0.50	**0.01**
Semantic	1.00(3.00)	0.00(3.00)	*U* =7.50	0.31
Specific Probe				
Episodic	23.00(23.00)	12.00(13.00)	*U* =5.00	0.15
Semantic	4.00(5.00)	6.00(4.00)	*U* =9.00	0.55

As no between-group differences were found for the recall of semantic details during any stage of recall, and to reduce the number of unnecessary comparisons, we only undertook further analyses on the recall of episodic details.

Participants' self-ratings on cAMI

No between-group differences between the epilepsy and control groups were found on the participants' ratings of the phenomenological qualities of recalled events. No significant group differences were found between the generalized and focal epilepsy groups either (see Table 5).

Relations between epilepsy-related factors and cAMI

Higher recall of episodic details during the Free Recall stage correlated with older age at first seizure (r_s=0.77, p= 0.01). While in the same direction, correlations between age of first seizure and recall in the General Probe (r_s=0.49, p= 0.15) or Specific Probe stages (r_s=0.54, p= 0.11) did not reach significance. Finally, no significant correlations were found between the recall of episodic details at any stage of the cAMI and years spent with epilepsy, seizure severity, seizure frequency, number and type of AEDs, or surgery history.

Relations between performance on the cAMI and verbal memory and language scores

Across the epilepsy groups, correlational analyses were undertaken to examine relations between the recall of episodic details on the cAMI and scores obtained on verbal memory and language tests (see Table 6). Significant correlations were found between the recall of episodic details in the Free Recall stage of the cAMI and scores obtained in verbal memory delayed on the CMS (r_s=0.86, p= 0.01), category switching accuracy on the D-KEFS (r_s=0.78, p= 0.02), total free recall (r_s=0.89, p= 0.01), long-delay free recall (r_s=0.88, p= 0.01), long-delay cued recall (r_s=0.90, p= 0.01), and short-delay cued recall

(r_s=0.98, p= 0.01) on the CVLT-C. Significant correlations were also found between the recall of episodic details in the General probe stage and scores obtained in verbal memory immediate (r_s=0.69, p= 0.03) on the CMS and total free recall (r_s=0.75, p= 0.02), short-delay cued recall (r_s=0.71, p= 0.03), and long-delay cued recall (r_s=0.68, p= 0.04) on the CVLT-C. Verbal memory delayed on the CMS (r_s=0.93, p= 0.01), total free recall (r_s=0.68, p= 0.04), and short-delay cued recall (r_s=0.73, p= 0.03), on the CVLT-C and the recall of episodic details in the Specific probe phase were also significantly correlated. In terms of language scores, a significant correlation was found between vocabulary on the WASI (r_s=0.68, p= 0.03) and the recall of episodic details in the Free Recall phase of the cAMI.

Discussion

To our knowledge, this is the first study to examine the recall of autobiographical memories in a community-based sample of children with epilepsy, and to compare their performance to age-and sex-matched children without epilepsy. This is also the first study to compare autobiographical memory in generalized and focal epilepsy in a single study, and to also explicitly explore the effects of verbal memory and language on autobiographical memory recall. The study yielded several interesting findings. First, in line with our hypothesis, children with epilepsy showed deficits in the recall of episodic, but not semantic autobiographical memory in comparison to controls. Deficits in episodic autobiographical memory were particularly pronounced among youth with generalized epilepsy in comparison to patients with focal epilepsy. We also found that verbal memory and language was associated with autobiographical events in patients with epilepsy.

Table 5: Children's Autobiographical Interview: Participants' Ratings of Phenomenological Qualities, by Group

	Control (n=10) Mean (SD)	Epilepsy (n=10) Mean (SD)	t	p	Partial Epilepsy (n=5) Mean (SD)	Generalized Epilepsy (n=5) Mean (SD)	t	p
How much did your feelings change from before to after this event happened?	4.60 (1.74)	5.35 (2.22)	-0.84	0.41	5.40 (1.39)	5.30 (3.03)	-0.07	0.95
How important is this event to you now?	5.45 (1.32)	5.70 (2.15)	-0.31	0.76	6.10 (0.89)	5.30 (3.03)	-0.57	0.59
How important was this event to you then?	6.20 (0.98)	5.60 (2.26)	0.77	0.45	6.10 (1.24)	5.10 (3.05)	0.15	0.52
How clearly can you see this event when you imagine it again?	5.65 (0.78)	5.15 (2.22)	0.67	0.51	5.00 (1.37)	5.30 (3.03)	0.26	0.85
How many times do you think of this event?	5.00 (1.15)	4.00 (2.44)	1.17	0.26	3.80 (1.64)	4.20 (3.25)	0.25	0.81
How sure are you of what you remembered just now?	5.10 (1.26)	4.40 (2.54)	0.78	0.45	5.20 (1.44)	3.60 (3.29)	-1.00	0.36
How strong is your memory of the event?	5.60 (1.17)	5.00 (2.54)	0.68	0.51	5.30 (1.89)	4.70 (3.27)	-0.36	0.73

Table 6: Spearman's Correlations (r_s) between cAMI stages, and verbal memory and language scores

	Free Recall	General Probe	Specific Probe
CMS			
Verbal Memory Immediate	0.62	0.69*	0.57
Verbal Memory Delayed	0.86**	0.66	0.93**
Delayed Recognition	0.34	0.31	0.43
D-KEFS			
Letter Fluency	0.64	0.64	0.53
Category Fluency	0.69	0.70	0.49
Category Switching Responses	0.70	0.46	0.52
Category Switching Accuracy	0.78*	0.45	0.42
CVLT-C			
List A Total Trials Free Recall	0.89**	0.75*	0.68*
List A Short-Delay Free Recall	0.62	0.54	0.44
List A Long-Delay Free Recall	0.88**	0.44	0.55
List A Short-Delay Cued Recall	0.98**	0.71*	0.73*
List A Long-Delay Cued Recall	0.90**	0.68*	0.59
EVT-2	0.57	0.60	0.44
PPVT-4	0.55	0.30	0.34
WASI-II Vocabulary	0.68*	0.60	0.36

Note. * p=<.05, ** p=<.01

Background demographic, cognitive and clinical variables

When comparing the epilepsy and control groups on neuropsychological scores, the patients with epilepsy had lower scores in category switching in the D-KEFS verbal fluency subtest. Executive function deficits are common cognitive concerns in childhood epilepsy, particularly in domains of flexibility and shifting (MacAllister, Vasserman, Rosenthal & Sherman, 2014). Impairment on generative fluency tasks, namely tasks of verbal fluency are common in children with epilepsy (Rzezak et al., 2007). Deficits in executive function are a fairly universal feature in childhood epilepsy syndromes and are predominant in both generalized and focal epilepsies (You et al., 2013). We found that children with generalized epilepsy displayed poorer performance on all scores of executive functioning, as measured by the verbal fluency task. These findings are in line with prior literature showing that individuals with idiopathic generalized epilepsy have poorer performance on tests of executive functioning, and experience greater difficulty with more complex tests than individuals with temporal lobe epilepsy (You et al., 2012). Given the relationship between executive functions and verbal memory (Duff et al., 2005), it is of no surprise that the children with generalized epilepsy in the current study also displayed poorer performance overall on the CVLT-C. Significant differences were found in the total number of words recalled, and the number of words free recalled and cued recalled after a short-delay. Significant differences were also found in verbal immediate memory assessed by the CMS. Numerous studies have found evidence for deficits in learning and recall of verbal information after short delays employed by standardized tests in children with epilepsy (Cohen, 1992; Rzezak, Guimarães, Fuentes, Guerreiro, & Valente, 2011; Rzezak, Guimarães, Fuentes, Guerreiro, & Valente, 2012; Schoenfeld et al., 1999). Moreover, there were significant differences between the generalized and partial epilepsy groups in receptive

vocabulary and overall FSIQ, with the generalized epilepsy group performing poorer. It has been well documented that language functioning and overall intelligence of individuals with generalized epilepsy tends to be somewhat lower than other forms of epilepsy (You et al., 2013). Thus, the neuropsychological profiles of the epilepsy groups of our study are consistent with prior literature.

Children's Autobiographical Memory Interview (cAMI): Epilepsy versus Controls

The most striking finding of the current study is of deficits in the recall of episodic, but not semantic autobiographical details in children with epilepsy. This is consistent with the studies by Gascoigne et al., (2013 & 2015) that found between-group differences in the recall of episodic autobiographical details, but not semantic details, in both group of children with temporal lobe epilepsy compared to controls, and patients with idiopathic generalized epilepsy and controls. These findings are also consistent with other populations with hippocampal dysfunction, such as children with thyroid hormone deficiency; relative to controls these patients exhibited weaknesses in episodic, but not semantic autobiographical memory details (Willoughby et al., 2013). In addition, these findings are consistent with the adult literature in demonstrating impaired episodic autobiographical memory in temporal lobe epilepsy (St-Laurent et al., 2009; Viskontas, McAndrews & Moscovitch, 2000), and impaired episodic but not semantic autobiographical memory in patients with developmental amnesia (Rosenbaum et al., 2011; Vargha-Khadem et al., 1997). In children with epilepsy, seizures may be interfering with the establishment of connections between various brain regions such as the hippocampus and associated areas that may be required to form a gestalt of an episode (Gascoigne et al., 2015).

When looking closer at the nature of these episodic autobiographical memory deficits between patients with epilepsy and controls, and consistent with previous findings (Gascoigne et a., 2013), between-group differences in the recall of autobiographical events were not present when children were prompted. Children with epilepsy only showed impairments when recalling personal events without any prompts during the Free Recall stage of the interview. This may suggest that within the epilepsy group, impairments in episodic recall were largely due to retrieval difficulties, rather than memory storage, as evidenced by free versus cued recall, respectively (Gascoigne et al., 2013).

Generalized versus Focal Epilepsy

When examining the between-group differences between generalized and focal epilepsy, there were deficits in the recall of episodic autobiographical details, with those with generalized epilepsy performing more poorly, but not in recall of semantic details of personally experienced episodes. Our findings could be explained by greater vulnerability of episodic memory disruption. It has been hypothesized that episodic memories are experienced only once, meaning that the record of the memory is unique and cannot be re-established when disrupted during seizure activity (Gascoigne et al., 2015).

In exploring these episodic memory details closer, children with generalized epilepsy recalled fewer episodic details regardless of whether they received general retrieval support. These results are also consistent with findings with adult patients with hippocampal damage that failed to find any beneficial effect of retrieval support on episodic recall (Gascoigne et al., 2015; Rosenbaum et al., 2011; St. Laurent et al., 2009; Steinvorth et al., 2005). These findings are consistent with the prior literature that suggested that generalized seizures may affect either the

storage or the retrieval of episodic details (Gascoigne et al., 2015). It is possible that generalized seizure activity disrupts the function of cortical areas within the distributed network associated with the recall of autobiographical memories, such as the hippocampus and the prefrontal cortex (Conway et al., 1999, Maguire et al., 2001; Svoboda et al., 2006). In contrast, in those with focal epilepsy, children may benefit from retrieval cues, as localized seizure activity is not as widespread. This may preserve the functioning of cortical areas needed for autobiographical memory recall and other forms of cognitive functioning. This assumption is supported by the fact that the generalized epilepsy group had significantly lower scores on standardized tests of verbal memory, verbal fluency and language. These findings may potentially have significant implications for the way autobiographical memory deficits manifest in different subtypes of epilepsies.

Participants' self-ratings on cAMI

There were no significant between-group differences between patients with epilepsy and controls in their self-ratings of their memories for personally experienced events. However, patients with epilepsy rated both their memory strength and certainty of the events recalled lower than the controls. This is consistent with findings by Gascoigne et al., (2015) who found that children with epilepsy rated their memories as being weaker. This suggests that children with epilepsy may be aware of their memory recall difficulties, as they are self-reporting lower confidence in their ability to recall specific memories related to prior life experiences.

It is also of interest to comment on the way in which children described their memories. When children with epilepsy recalled their memories, their narratives were much more unorganized and scattered in comparison to healthy age and sex-matched controls. Their

narratives were not as rich and full of perceptual details in contrast to those that did not have epilepsy. Younger children across the groups selected more recent memories such as their last Halloween, whereas older children opted to talk about memories that occurred earlier on in their childhood, such as a birthday party. The way in which memories are described and the kinds of memories children chose to speak about gives us insight into how autobiographical events are being structured in children with epilepsy and how age may influence the organization of these experiences.

Relations between epilepsy-related factors and cAMI

Consistent with our hypothesis, there was a relationship between epilepsy-related factors and autobiographical memory recall. Recall of fewer autobiographical episodic details was associated with earlier age of seizure onset. This was consistent with the findings of Gascoigne et al., (2015) who found earlier age of epilepsy diagnosis correlated to fewer episodic autobiographical memory details. Early age of onset has been shown to greatly affect cognitive skills in patients with epilepsy. These findings suggest that seizures may interfere with formation of episodic memories in early development and continuing through childhood (Gascoigne et al., 2015). There were no other relationships found between epilepsy-related factors and autobiographical memory. It may be that the effects of these variables increase with age, and long-term effects begin to emerge in adolescence (Gascoigne et al., 2013).

Relations between performance on the cAMI and verbal memory and language scores

It was hypothesized that verbal memory and language scores would be associated with episodic autobiographical events. Consistent with our hypothesis, verbal immediate memory and verbal delayed memory in the CMS was associated with every stage of the cAMI. Total free

recall, long-delayed free and cued recall, and short-delay cued recall in the CVLT-C was also related to the cAMI. A measure of verbal fluency in the category switching accuracy subtest of the D-KEFS was related to the Free Recall condition of the cAMI. Language such as word knowledge and concept formation was also associated with autobiographical recall, as a significant correlation was found between the WASI-II subtest of vocabulary and the Free Recall condition. Overall, these findings suggest that verbal memory and language is associated with autobiographical memory recall. In fact, higher verbal memory and language scores are related to better recall of personal autobiographical events. Until now, the relationship between verbal memory and language and autobiographical memory was not explicitly explored in children with epilepsy. It is possible that specific retrieval difficulties that are present in epilepsy patients may be attributed to verbal memory and language deficits that then affect autobiographical memory recall. This new knowledge emphasizes the importance of assessing autobiographical memory independent of verbal output, such as the recognition and sequencing of visual scenes. Thus, this exploratory analysis added to our understanding of the cognitive mechanisms that may play an important role in the retrieval of episodic autobiographical events.

Limitations

It is important to note that our study is not without limitations. First, our study was based on a small sample of epilepsy patients. Thus, our clinical sample was too small to undertake statistical analyses such as regression that would allow us to concurrently examine contribution of different variables on episodic autobiographical memory. For example, factors such as age of seizure onset and the presence of comorbid disorders were trending towards being significant and biased towards our generalized epilepsy group. Thus, future research should use analytic techniques that combine multiple variables, which would allow for the control for such potential

confounders, such as age of seizure onset, presence of comorbid disorders and overall age. It is important to note that overall age is a critical factor to control for, as previous research by Willoughby et al., (2012) has found that both episodic and semantic autobiographical memory recall improves with age. Although not significantly different, there was an age difference of two years between the generalized and focal epilepsy group that may have contributed to the differences seen in the neuropsychological and memory outcomes. The focal epilepsy group also seemed to be functioning higher in terms of verbal memory and language in comparison to the control group, thus it is important to interpret the results with caution and keep in mind that the findings are based on a rather small set of participants. Another important factor to control for includes the type of AEDs. The current medications that the patients in our clinical sample were on, which were valproic acid, lamotrigine, clobazam, and oxcarbazepine, have not been associated with cognitive impairment (Kim & Ko, 2016). In fact, lamotrigine and and oxcarbazepine have shown cognitive enhancing effects on attention (Kim & Ko, 2016). Nevertheless, there remains a definite need for the replication of our findings with a larger sample size. Second, in terms of recruitment, there may be a biased representation towards individuals who were seeking a cognitive evaluation (and feedback related to their performance) perhaps due to self-perceived cognitive complaints and as a result were more inclined to participate. Third, the screener language tests that were used may not be sensitive in tapping into specific language processing skills. Thus comprehensive language tests should be used in the future to explore relationships with autobiographical memory recall. Fourth, parental reports were used to comment on their child's seizure frequency and severity. This may have limited accuracy in contrast to standardized measures that neurologists use such as the Global Assessment of Severity of Epilepsy (Speechley et al., 2008) when considering seizures frequency

and intensity. Finally, the heterogeneity of the epilepsy sample is notable, as patients were diagnosed with ADHD, autism and learning disabilities; however it is difficult to rule out comorbidities when working with this neurological population. Despite these limitations, our findings have been consistent with the limited research that has been done thus far in understanding autobiographical memory in pediatric epilepsy.

Clinical implications

Our findings confirm the possibility that children with epilepsy are at a greater risk for developing episodic autobiographical memory deficits in comparison to healthy controls. Even more so, our study found that the nature of autobiographical memory deficits may be different in generalized and focal epilepsies, and may be interrelated with other forms of memory such as verbal memory. Given the existing relationship between verbal memory and language and autobiographical memory, these neuropsychological deficits may be indicative as a risk factor for impaired autobiographical memory. The implications of these findings are that clinicians should assess autobiographical memory in this neurological population as part as a standardized psychological assessment when memory complaints are referred and be aware that autobiographical memory deficits may manifest differently in various forms of epilepsy. Clinicians should also assess autobiographical memory via other means independent of verbal memory and language, such as visual memory. For example, children may sequence and draw illustrations of their autobiographical memory events that do not rely so heavily on verbal skills. Through these means, clinicians can better understand how to assess and identify autobiographical memory deficits.

Conclusion

Our study had several notable strengths that were of great significance. The sample of children with epilepsy in our study came from a community-based sample of patients. Our findings allowed for generalizability and provided further confirmation that children with epilepsy may be at-risk of episodic autobiographical memory deficits, and that these deficits may look different in various types of epilepsy. We also explicitly examined the relationship between verbal memory, language and autobiographical memory. To-date, there are no specific intervention programs or training for impaired autobiographical memory in children with epilepsy. An example of a training program that has been used extensively in children is MEmory Specificity Training (MEST) for children and adolescents with depression that have reduced specificity of autobiographical memory retrieval (Raes, Williams, Hermans, 2009). Intervention strategies such as MEST can be applied to the pediatric epilepsy population as well given the growing evidence of apparent autobiographical memory concerns. Thus, the current study highlights not only the need for early diagnosis but future research should be directed at creating intervention programs that enhance retrieval of autobiographical memories specifically in children with epilepsy.

Ultimately identifying the risks of autobiographical memory deficits is particularly important since autobiographical memory is a central element of human functioning (Conway & Pleydell-Pearce, 2000). Autobiographical memory plays a significant role in everyday adaptive functioning (Gascoigne et al., 2013), and deficits in this form of memory in these children may lead to poorer outcomes in adulthood. As a result, future research should also aim at examining the longitudinal effects of autobiographical memory deficits in this population. Overall, this study serves to increase awareness about the effects of epilepsy on autobiographical memory so

that earlier diagnosis and intervention programs may one day attenuate the memory weaknesses that this pediatric populations faces.

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Appendix A

Glossary of ILAE Terms on Seizure Types

Term	Definition
Absence, typical	A sudden onset, interruption of ongoing activities, a blank stare, possibly a brief upward deviation of the eyes. Usually the patient will be unresponsive when spoken to. Duration is a few seconds to half a minute with very rapid recovery. Although not always available, an EEG would show generalized epileptiform discharges during the event. An absence seizure is by definition a seizure of generalized onset. The word is not synonymous with a blank stare, which also can be encountered with focal onset seizures
Absence, atypical	An absence seizure with changes in tone that are more pronounced than in typical absence or the onset and/or cessation is not abrupt, often associated with slow, irregular, generalized spike-wave activity
Atonic	Sudden loss or diminution of muscle tone without apparent preceding myoclonic or tonic event lasting ~1–2 s, involving head, trunk, jaw, or limb musculature
Automatism	A more or less coordinated motor activity usually occurring when cognition is impaired and for which the subject is usually (but not always) amnesic afterward. This often resembles a voluntary movement and may consist of an inappropriate continuation of preictal motor activity
Clonic	Jerking, either symmetric or asymmetric, that is regularly repetitive and involves the same muscle groups

Term	Definition
Cognitive	Pertaining to thinking and higher cortical functions, such as language, spatial perception, memory, and praxis. The previous term for similar usage as a seizure type was psychic
Emotional seizures	Seizures presenting with an emotion or the appearance of having an emotion as an early prominent feature, such as fear, spontaneous joy or euphoria, laughing (gelastic), or crying (dacrystic)
Epileptic spasms	A sudden flexion, extension, or mixed extension–flexion of predominantly proximal and truncal muscles that is usually more sustained than a myoclonic movement but not as sustained as a tonic seizure. Limited forms may occur: Grimacing, head nodding, or subtle eye movements. Epileptic spasms frequently occur in clusters. Infantile spasms are the best known form, but spasms can occur at all ages
Eyelid myoclonia	Jerking of the eyelids at frequencies of at least 3 per second, commonly with upward eye deviation, usually lasting <10 s, often precipitated by eye closure. There may or may not be associated brief loss of awareness
Generalized tonic–clonic	Bilateral symmetric or sometimes asymmetric tonic contraction and then bilateral clonic contraction of somatic muscles, usually associated with autonomic phenomena and loss of awareness. These seizures engage networks in both hemispheres at the start of the seizure

Term	Definition
Behavior arrest	Arrest (pause) of activities, freezing, immobilization, as in behavior arrest seizure
Motor	Involves musculature in any form. The motor event could consist of an increase (positive) or decrease (negative) in muscle contraction to produce a movement
Myoclonic	Sudden, brief (<100 msec) involuntary single or multiple contraction(s) of muscles(s) or muscle groups of variable topography (axial, proximal limb, distal). Myoclonus is less regularly repetitive and less sustained than is clonus
Myoclonic–atonic	A generalized seizure type with a myoclonic jerk leading to an atonic motor component. This type was previously called myoclonic–astatic
Myoclonic–tonic–clonic	One or a few jerks of limbs bilaterally, followed by a tonic–clonic seizure. The initial jerks can be considered to be either a brief period of clonus or myoclonus. Seizures with this characteristic are common in juvenile myoclonic epilepsy
Nonmotor	Focal or generalized seizure types in which motor activity is not prominent
Sensory seizure	A perceptual experience not caused by appropriate stimuli in the external world

Term	Definition
Tonic	A sustained increase in muscle contraction lasting a few seconds to minutes
Tonic–clonic	A sequence consisting of a tonic followed by a clonic phase

Appendix B

Autobiographical Event List

Choose events that happened to you in a specific time and place more than one month ago.

For example, you could choose…

- **Your last birthday**
- **A school trip**
- **A play, circus, or concert**
- **Winning an award or a prize**
- **Your first time riding a bike, skateboarding, or rollerblading**
- **A school party or dance**
- **A boat ride**
- **A train ride**
- **A trip on a plane**
- **A wedding**
- **Halloween**
- **Moving to a new home**
- **Something that happened on vacation**
- **Your first sleepover**
- **Getting your first pet**
- **A holiday party**
- **Your performance in a play, recital, or band**
- **Your graduation**

Or, you can choose something else

(another event not on this list)!

Appendix C

Instructions for the Autobiographical Interview

I am going to ask you to tell me about two things that have happened to you; we call these things events. I will give you a list of some events that might be of help. You can choose two events from this list or you can choose a different event, one that is not on the list. The event you choose can be from any time in your life, as long as it happened at least one month ago. I will ask you to describe one event first, then the other one. Then I will ask you some questions about the events. To help me remember what you said, I will be audiotaping your description of the event and your answers to the questions.

The event has to be one where you were personally there and you took part in what happened. Do not pick events that you have heard about from your parents, family, or friends. They must have happened to you. Also, the event should be from a specific time and place. For example, describing a 3-week vacation would not be enough; that is too general. However, something that happened on one day during your vacation would be great. I would like you to give me as much detail on what happened as you can. It is like telling me a story, for example in a book or a TV show. Stories have a beginning, a middle, and an end.

I am not interested in which events you choose, but I am interested in how you tell the event to me. Pick any event that you like from the list *[point to list]*. I want to remind you that I will be asking you to give some details for these events later. So, pick events that you feel comfortable describing to me in detail.

Do you have any questions?

Appendix D

Participant Rating Scales

How much did your feelings (mood/emotional state) change from before to after this event happened?

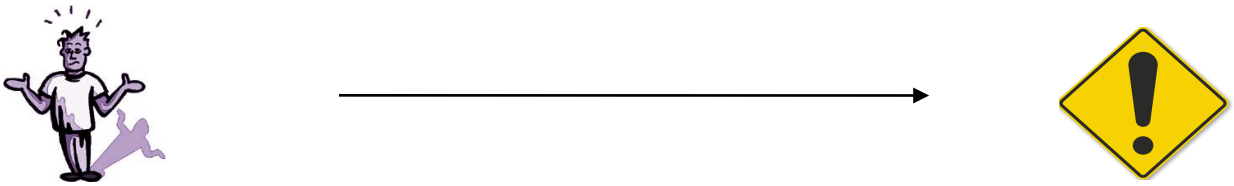
1 **2** **3** **4** **5** **6** **7**

No change in how I felt — Some change — Tremendous emotional Change

How important is the event to you NOW?

1 **2** **3** **4** **5** **6** **7**

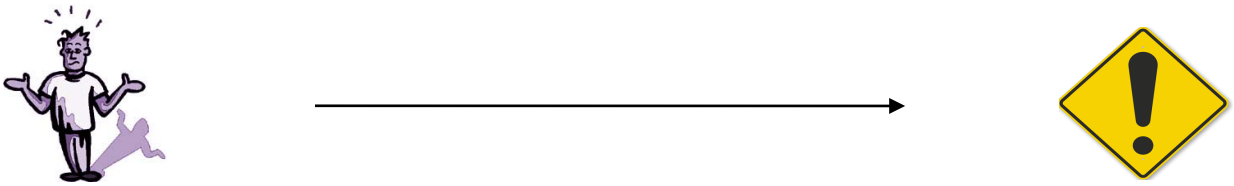
No importance — Some importance — Of great importance



How important was this event to you THEN?

1 **2** **3** **4** **5** **6** **7**

No importance — Some importance — Of great importance



How clearly can you see this event when you imagine it again?

1	2	3	4	5	6	7
Vague memory			Clear			Extremely clear

How many times do you think of this event?

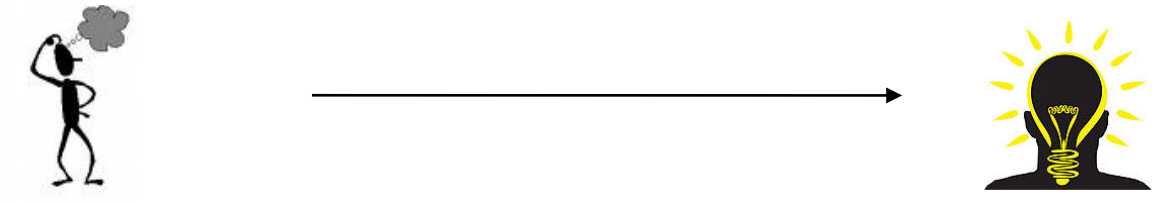
1	2	3	4	5	6	7
Rarely			Sometimes			Very often

How sure are you of what you remembered just now?

1	2	3	4	5	6	7
Not too sure, not confident about details			Somewhat confident			Very confident about recollection

How strong is your memory of the event?

1	**2**	**3**	**4**	**5**	**6**	**7**
Not very strong			Fairly strong			Very strong



Appendix E

Sample Scored Autobiographical Memory Protocol

I remember last Halloween, **(Time-Internal)** I was like you know Bumblebee **(Event-Internal),** the transformer? **(Semantic)** And my brother was Batman **(Event-Internal)** and my mom and my dad bought this Halloween costume **(Event-Internal)**, it's like a big T. Rex, **(Event-Internal),** and it was very funny **(Emotion-Internal).** And my mom was Claire **(Event-Internal)** and she has like the flair **(Perceptual-Internal)**, and then she'll throw it across the street **(Perceptual-Internal)** and daddy goes take off and tries to get it **(Perceptual-Internal).**

Appendix F

Description of Scoring Categories

Category	Description	Example
Internal (Episodic)	Details related to an event that occurred within one day.	
Event	Happenings, people involved the actions and reactions of others, the weather, buying objects or food	- 'I fell asleep' - '3 friends' -'she was smiling' - 'my mom drove' - 'it was sunny' - 'I bought a burger'
Time	Year, season, month, date, day of week, time of day	-'1 year ago' - '2010' - 'it was summer' - '2 months ago' - 'it was May' - 'it was the day before my birthday' - 'afternoon'
Place	Country, province, city, street, building, room, part of room	- 'my house' - 'I was in the kitchen' - 'I was in the 3rd row'
Perceptual	Sounds, smell, tastes, physical sensations, visual details, body position, duration of event	- 'it was loud' - 'it smelled like wood chips' - 'the apple was sweet' - 'I had a headache' - 'she was short' - 'I was standing' - 'I was there for 3 hours'
Thought/ emotion	Feelings, thoughts, opinions related to event, expectations	- 'I was so excited' - 'I didn't know what to do' - 'the worst part about the trip was…' - 'I expected a lot of people to come'
External (Semantic)	General knowledge or facts, personal knowledge or facts ongoing events, extended states of being ('Paris is the capital of France,' 'Scott also lives in Toronto')	
Other	Event, time, place, perceptual, or thought/ emotion details that pertain to other events not identified as the main event in the recollection and factual information. Unsolicited repetition of details Metacognitive statements, editorializing inferences	- 'standing, yeah I was standing' - 'I'm not sure if I'm remembering this right - 'it was a fairly good day' - 'I must have been wearing my coat because it was winter'