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The Effects of Epilepsy on Language Development and Cognition in Children

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Introduction

A child's language development and acquisition of language skills are reliant on the cognitive attributes of their brain (Owens, 2008). Any disturbance in the brain's activity, regardless of the region or severity, may impact any or all of the language structures. Such a disturbance could be the result of a single seizure or multiple seizures. Epilepsy is a neurological disorder that is characterized by seizures, and is also known as a seizure disorder (Guierrini, 2010). This causes a massive disruption of electrical communication between neurons in the brain. This leads to a surge of excessive neuronal firing that usually affects a person's behavior, memory, and feelings (Monjauze, Broadbent, Boyd, Neville & Baldeweg, 2011). As a result of a disruption in the brain, it can be speculated that this would have an affect on language, as language is processed and constructed in the brain. Specifically, the development of a child's language and cognition can be impacted, as the brain's wiring is in a constant state of change and continuously building connections in the young brain. Therefore, the following evidence appears to indicate that there is an effect of epilepsy and its treatment on language development and cognition in children.

Language Development

Infants are exposed to language as early as birth and it remains to be a part of their existence throughout the lifespan. They begin to understand, acquire, and express their own language at a very young age. It may appear that first words mark the beginning of an infant's language development; however, first words are an example of a developmental stage that has expanded from pre-linguistic behaviors (Owens, 2008).

These pre-linguistic behaviors that develop long before first vocalizations and first words demonstrate how language development begins immediately (Owens, 2008).

Language will continue to grow and develop throughout a person's life. Language is a complex system; it is a powerful tool made up of symbols and is used to express and understand thoughts (Owens, 2008). This dynamic system is made up of three different components: Form, content, and use. Form includes morphology, syntax, and phonology. Content includes semantics or the meaning of words. Use includes pragmatics or how we use language in functional and appropriate manners (Owens, 2008). These components all contribute to a person being highly communicative. It is possible for there to be problems with any of the components of language or all of them (Kaderavek, 2011).

Language is rooted in early cognitive development (Kaderavek, 2011). According to the article by Monjauze, Tuller, Hommet, Barthez, and Khomsi (2005) it may be argued that there is a critical period during childhood when active language development occurs within a limited time frame. This is also known as a sensitive period, when circuits are being established and solidifying their connections among language structures. This age is believed to end around age 6 or 7 years old (Monjauze et al., 2005). However, this critical period is subject to debate. Various researchers have suggested different time frames whereas some researchers have not implied a definitive time frame regarding this sensitive or critical period. This period is important to consider when discussing language development, as a rapid expansion of skills at a given time may be key to a child's overall language growth. Regardless of a time frame, it is suggested that the developing brain matures in its language regions throughout childhood (Owens, 2008). Additionally, early language performance can be a predictor for later language development and overall language skills– poor early language can foretell poor later language skills and vice versa (Monjauze et. al., 2005).

The link between cognitive development and language continue to be studied. Current researchers studying neural maturation argued that not only does brain development aid language performance, but also a child's learning facilitates changes in the brain regions allotted to a specific task (Kaderavek, 2011). Language and cognition are bidirectional: a child changes throughout the period that he or she is learning language, as the brain undergoes changes during learning (Kaderavek, 2011). Language development is highly correlated with brain maturation and specialization. Although there are areas in the brain where language is significantly weighted, the left hemisphere, the brain functions globally and not as isolated or independent units.

When discussing typical language in the left hemisphere, Yuan et al., (2005) accentuate the importance of the left hemisphere as the major contributor of language specialization. The left hemisphere is known as the "language center" of the brain, due to its sizeable amount of prominence in the areas utilized during acquiring, understanding, and expressing language (Yuan et al., 2005). Specifically, Broca's and Wernicke's areas are in the left hemisphere and take the most active role during language activities (Yuan et. al., 2005). Owens (2008) reports "66-98% of humans are left-hemisphere dominant for language. Left hemisphere is specialized for language in all modalities, and at perceiving rapidly changing sequential information" (p. 153). This is consistent among children and continues into adulthood (Yuan et al., 2005).

Cognition

It is impossible to have a discussion about language without referring to cognition. "Language development is parallel to cognitive development" (Owens, p. 30). The cognitive hypothesis suggests that language development is derived from early cognitive development, prior to the emergence of the first word (Owens, 2008). It should be noted, however, that there are children with normal cognitive abilities that do not attain language, and some argue that cognition does not always influence language (Owens, 2008).

Evidence of the correlation between language and cognition is strong, particularly in the first two years (Owens, 2008). A child's brain undergoes change as the child learns (Owens, 2008). Cognition involves memory, thought, learning problem solving, organization, and storage (Owens, 2008). All of those components are equally involved in language development. At approximately ages three or four, there appears to be a "crossover period" where language is equivalently able to influence thought (Owens, p. 98). This crossover period involves language influencing the learning of new cognitive processes, as well as learned cognitive processes influencing language; children begin to use language to demonstrate the use of their knowledge (Owens, 2008). This crossover proposes the link between contribution of language to cognition, as well as cognition to language. The acquisition of a new skill in either cognition or language is echoed in the other (Owens, 2008). Furthermore, language production underlies mental processes (Owens, 2008).

Epilepsy

Epilepsy is defined as, “a disorder of the brain characterized by an enduring predisposition to generate epileptic seizures and by the neurobiologic, cognitive, psychological, and social consequences of this condition requires occurrence of at least 1 episodic seizure” (Guierrini, p. 500). There are four broad categories that epilepsy can be divided into that most children fall under (Guierrini, 2010). These categories include: benign epilepsy (20-30%), absence epilepsy (30%), juvenile myoclonic epilepsy/symptomatic focal epilepsy (20%) and idiopathic generalized epilepsy (13-17%) (Guierrini, 2010).

According to Dewi and Zelleke (2010) epilepsy is found to be one of the most widespread major neurological disorders in children. Guierrini (2006) reported that 10.5 million children worldwide are estimated to have active epilepsy. The incidence of children diagnosed with epilepsy in the first year of life is 150 per 100,000 worldwide, and 45-50 children per 100,000 worldwide are diagnosed after the age of 9 years old (Guierrini, 2010). It is diagnosed typically with the use of an electroencephalogram (EEG), which records the electrical activity of the brain and measures brain waves, and seeks to identify any atypical functioning. Atypical electrical activity or “spike waves” that are apparent on an EEG can be demonstrated through the person’s state of consciousness, perception, and feelings. These spike waves and excessive electrical activity can be in any isolated location or multiple parts of the brain. If there were epileptic activity in any or all of the language centers, it would suggest that this could cause some type of disturbance, and thus, have an impact on language. As stated above, there are a significant number of children diagnosed with epilepsy in the first year of life, which correlates to the beginning of early language development (Guierrini, 2010).

The Link: Epilepsy and Language

Epilepsy and language are linked together as they both are generated in the brain. A connection exists between children with epilepsy also having language impairment (Widjaja et al., 2013). Neuropsychological impairment including cognition and language is a significant comborbidity of epilepsy, and affects up to 82% of children with epilepsy (Widjaja et al., 2013). Therefore, the majority of children with epilepsy have some type of neuropsychological impairment. There are reasons for language impairment to occur, as research is showing that language pathways are rerouting themselves in subjects with epilepsy (Yuan et al., 2005) and cortical reorganization is also found in subjects with epilepsy (Datta et al., 2013). Although creating new pathways for language has been found to occur (Yuan et al., 2005), the compensation may not propose accurate and total replacement of proficient language performance.

Language Lateralization

Language is dominant in the left hemisphere, also known as left sided lateralization, in 90% of the total population (Carlson, 2010). Functional magnetic resonance imaging (fMRI) is used to produce images illustrating neural activity in brain regions (Brookshire, 2007). The enhanced areas shown up on an fMRI represent increased metabolic brain activity (Brookshire, 2007). In typical children and adults, fMRIs confirm left hemisphere dominance or lateralization during language activities. Yuan et al. (2005) researched if there was the same lateralization during language in patients with epilepsy, as there are in patients without epilepsy. They also contemplated the cause of reorganization in the brain structures: if there was atypical lateralization, was it due to the epilepsy or due to the impairment in the left hemisphere? The study by the researchers included 18 pediatric patients between the ages of 8 and 18 years old, diagnosed with epilepsy (15 with partial epilepsy, 2 with idiopathic generalized epilepsy, and 1 with benign rolandic epilepsy). The control group included 18 age and gender matched, healthy patients. During a verb-generated task, it was found that there were different levels of concentration in the language centers as evidenced by the fMRI. "Brain activation in the Broca's and Wernicke's areas is stronger and more concentrated in healthy children than that in children with epilepsy" (Yuan et al., p.597). The fMRIs of all 18 children with epilepsy showed atypical hemispheric language dominance. The dominance was not in the left hemisphere, as it is in typical adults and children, rather it was either predominately in the right hemisphere, or abnormally bilateral. It should be noted that although the language center is said to be in the left hemisphere, it is a hemispheric dominance, and does not work in isolation from the other areas of the brain or the other hemisphere. With that being said, the bilateral dominance is atypical without the dominance in the left, as it is in healthy controls (Yuan et al., 2005).

Yuan et al. (2005) confirmed that there was atypical lateralization, yet the researchers still inquired what the reason for this was. They believed a possible explanation would be that the epilepsy causes damage in the brain, and perhaps this damage triggers the brain to either activate the already acquired language areas that are still of use in the left hemisphere, or it constructs new areas to compensate for the lack of functional areas in the left hemisphere (Yuan et al., 2005). “The question remains whether the atypical language lateralization in epilepsy patients is due to the prolonged effect of seizures on the brain, or whether preceding brain pathologies cause both the atypical lateralization and the epilepsy” (Yuan et al., p.599). The redistribution of pathways to activate language may be due to the brain compensating for injury to the left hemisphere that is caused by the seizures or seizure activity. Because of this, the brain may make adaptations through developing new language connections owing to the brain’s plasticity. These pathways continue to be written, and therefore result in an entirely new pathway that either is right hemispheric dominant or bilateral (Yuan et al., 2005).

Further, the study discovered lateralization patterns based on age. The researchers discovered that the specialization of language areas increases in the left as age increases (Yuan et al., 2005). When epilepsy occurs in the patient who has yet to develop language due to experiencing seizures starting at a very young age, the epilepsy may impair or inhibit the left hemisphere specialization from increasing, specifically, in the Broca’s and Wernicke’s areas (Yuan et al., 2005).

Monjauze et al. (2011) conducted a study in which they defined a specific and common type of epilepsy as, “benign epilepsy of childhood with centrotemporal spikes (BECTS) is an idiopathic, localization-related seizure disorder characterized by frequent focal interictal discharges affecting the perisylvian regions, without significant brain lesion or neurologic history” (p. 79). The focus of the seizure activity and electrical discharges take place in the perisylvian region, which is the area surrounding the sylvian fissure in the left hemisphere (Brookshire, 2007). The researchers wanted to investigate language deficits in BECTS due to recent findings proposing that seizure activity affected the cerebral organization for language (Monjauze et al., 2011). The researchers wondered if these findings were temporary or if the disturbance of language development was permanent in subjects currently in remission from BECTS. The study included 13 subjects with BECTS between the ages of 15 and 23.8 years old, and the subjects were in full remission of seizure activity between 1.3 and 8 years (Monjauze et al., 2011). The control group included 13 aged matched, healthy subjects. The study used electrophysiologic recordings while neuropsychological assessments were administered to reveal timing and lateralization of linguistic processes (Monjauze et al., 2011). The following language tests were given to all subjects: Receptive One-Word Picture Vocabulary Test, Clinical Evaluation of Language Functions–3, Test for Reception of Grammar, Comprehensive Test of Phonological Processing, and WORD for literacy skills (Monjauze et al., 2011). The researchers found right or atypical lateralization in 54% of the BECTS group, specifically the right frontal cortex (Monjauze et al., 2011). Interestingly, when the researchers had this group engage in expressive language tasks, results suggested that atypical anterior language organization is associated with decreased performance (Monjauze et al., 2011). Reorganization of language pathways and right-sided lateralization had a negative effect on language performance (Monjauze et al., 2011).

Significant language deficits were found in 46% of the BECTS group (Monjauze et al., 2011). "Results suggest that the developmental trajectory of linguistic maturation and cerebral organization is vulnerable to the effects of prolonged epileptiform activity associated with BECTS, resulting in language difficulties that extend into adulthood" (Monjauze et al., p.82). The longer the effects of the seizure activity, the more impact they may have on the brain's development and organization of language structures. The results indicated that BECTS is associated with language disorders, with the most impacts on expressive grammar and literacy skills. These outcomes lead researchers to believe there would be expected findings of selective language disorders, which persist in adolescence and into adulthood (Monjauze et al., 2011).

Everts et al. (2010) looked at language lateralization with the use of an fMRI in children with epilepsy as they performed verbal memory tasks, specifically Words Pair Learning, Word Pairs Recall. Researchers found that 30% of those with focal epilepsy had atypical language dominance, either bilateral or right hemisphere dominant, in at least two of the three verbal memory performance tasks. In contrast, all of the controls in this study (participants without epilepsy) demonstrated typical left-sided language in at least two of the three regions of interest in verbal memory performance (Everts et al., 2010). The research also demonstrated that there was no difference in language lateralization between patients with left-sided or right-sided epilepsy, as well as no differences in gender (Everts et al., 2010). This suggests that there was increased lateralization in the subjects regardless of the location of seizure activity in the subject's brains and points out that the atypical lateralization is not a result of focal location of epilepsy.

Cortical Reorganization

Datta et al. (2013) pointed out that the impact of epilepsy on cerebral plasticity is a topic of ongoing debate. The researchers stated that natural and typical language development can be affected in children with epilepsy and there is evidence shown that traditional left hemispheric specialization for language may be obviously hampered (Datta et al., 2013). This was shown in studies in patients with symptomatic and cryptogenic left temporal lobe epilepsies (Datta et al., 2013). The researchers were looking to identify the brain's plasticity and ability to reorganize and compensate for deficits resulting from seizure activity in the brain.

Neuropsychological studies agreed that children with BECTS maintain typical global intellectual capacity; however, neuropsychological deficits may be present (Datta et al., 2013) and are dependent on the location of the epileptic discharges in the brain. In addition to deficits in nonverbal functions, there have been deficits related to language including: delayed reading, numeracy and spelling; impaired reading, delayed language development with mixed phonologic and lexicosyntactic problems; deficits in verbal fluency, verbal explanation and expansion, semantic knowledge, and lexical comprehension (Datta et al., 2013). Oromotor deficits were also found in children with

BECTS (Datta et al., 2013). These findings suggest that although the children may have intact global capacity, there are still deficits across aspects of language components.

The subjects in the study by Datta et al. (2013) had significantly lower language laterality indices (LI) compared to the healthy control group. The lowest LI scores for the sentence generation fMRI task were in found in the anterior language network. In contrast, the posterior language network area did not show significantly lower LI scores compared to controls (Datta et al., 2013). One of the most lateralizing fMRI language tasks was sentence generation (Datta et al., 2013). This task included semantic and syntactic language aspects and was mainly the network of productive language that was activated (Datta et al., 2013). “To conclude, our study findings indicate that BECTS patients reorganize their language in more bilateral or right-hemispheric language networks, especially for the anterior language areas, without significantly impacting their cognitive, especially language performances” (Datta et al., p. 493).

Verbal Memory Performance

Everts et al. (2010) focused on the scores of various neuropsychological tests done on children with epilepsy. The subjects included 40 patients, 10 female and 22 male, who were diagnosed with refractory, symptomatic, and focal epilepsy. Ages of the patients spanned 7 to 18 years. All 40 patients with epilepsy were given assessments to test performance measurements against typically developing peers. The neuropsychological tests in the patients with epilepsy were within the average range (Everts et al., 2010). Despite this, significantly more patients showed below-average verbal memory performance than expected against the controls, which were made up of 18 subjects without epilepsy. Verbal memory performance was derived from scores on tests including Word Pairs Learning, and Word Pairs Recall (Everts et al., 2010). The scores rated below average on verbal memory performance did not show differences relating to focal location of epilepsy or gender (Everts et al., 2010). Focal location of epilepsy and gender demonstrated no difference in scores among patients. However, patients who had seizures in multiple areas of the brain displayed decreased language performance when compared to patients with frontal or temporal seizures (Everts et al., 2010). This would suggest that the location of the epilepsy was not a predictor of poor performance on verbal memory, rather global seizure activity resulted in diminished performance. Also, the age of the child at assessment was correlated with language performance and visuospatial memory. As the age of the subjects increased in the epilepsy group, the performance on language and visuospatial memory tasks were decreased (Everts et al., 2010). This correlation could reflect that with increased age, the longer duration of epilepsy or younger age at onset is linked to decreased performance (Everts et al., 2010).

Age of Onset of Epilepsy

It is probable that age of onset would be a factor on language development because the time when seizures initially begin may influence the developmental stage the child is currently in and the stages to come. The development of language is hierarchical, and therefore, it would appear that the earlier the epileptic activity on the brain, the greater the impact. It is possible that there would be a vast impact due to the delayed development of all other skills required to build off of the necessary foundational language skills. Also, it can be speculated that the earlier epilepsy develops, the earlier and more severe outcome of impairment in the language areas.

Caplan et al. (2009) conducted a study to determine if younger children are more vulnerable to the affects of ongoing seizures than those of older children, based on the assumption that the brains of the younger children have more active language developmental processes. Caplan et al. (2009) hypothesized that younger children are more likely to have more linguistic impairments than children at an intermediate age, which in turn, would have more deficits than adolescent children. The study included 284 children, 104 with cryptogenic complex partial epilepsy, 78 with absence epilepsy and 102 aged matched controls without epilepsy. There were 59 children in the young group, ages 6.3-8.1; 87 children in the intermediate group, ages 9.1-11.7; and 36 children in the adolescent group, ages 13.0-15.2 (Caplan et al., 2009). The young group was administered the Test of Language Development-Primary, the intermediate group was administered the Test of Language Development-2, and the adolescents were given the Test of Adult Language (Caplan et al., 2009). The results indicated that significantly more young, intermediate, and adolescent subjects had language scores 1 standard deviation (SD) below average compared to the aged-matched control groups (Caplan et al., 2009). Additionally, results showed that across the age groups, significantly more adolescent epilepsy subjects had language scores 1 SD below the mean than both the young and intermediate epilepsy subjects (Caplan et al., 2009). Those results contrast the predictions made by Caplan et al. (2009), as they found an increase in the rate of language impairment and wider range of linguistic deficits in the adolescent epilepsy subjects. The young epilepsy group had 25% with language impairment, the intermediate epilepsy group had 33.3% with language impairment, and the adolescent epilepsy group had more than 50% with language impairment (Caplan et al., 2009). The findings established that the longer the duration of epilepsy, implying the younger the age of onset, there were greater affects on linguistic deficits (Caplan et al., 2009). “These findings imply an age-related rise in vulnerabilities to linguistic deficits as well as differential effects of seizure variables during the long protracted course of language development” (Caplan et al., p. 2404). Caplan et al. (2009) stated that although syntactic and semantic skills are intact by age 5, a fact used to support their hypothesis, those skills continue to develop and experience rapid acceleration in later years. The maturation of skills is due to growth in complex thought, flexibility, and integration of knowledge (Caplan et al., 2009). The findings also suggest that the brain has an increased vulnerability of linguistic dysfunction to the ongoing effects of seizures (Caplan et al., 2009). When children have seizures at an early age, they are more likely to continue having seizures (Caplan et al., 2009). The increased length of seizure activity over time can place a further hindrance on the redevelopment of previously acquired skills and the development of new skills.

Berroya et al. (2003) stated that the researcher’s findings demonstrated that the children who had the shorter duration of epilepsy had the better reading and spelling performances on various. These findings suggested that not only the duration of epileptic activity had a factor likely to influence language development, but also the epileptic dysfunction itself, meaning any amount of seizure activity regardless of duration, affects language development (Berroya et al., 2003). The study reported led researchers to believe and expect to find selective linguistic disorders in children with epilepsy, which will persist in adolescence and adulthood (Berroya et al., 2003).

The age of onset of epilepsy could also have an affect on cognition in children. "Half of the cases of childhood onset epilepsy occur in the preschool years at an age when serious encephalopathic conditions associated with a globally poor prognosis initially manifest" (Berg, Caplan, Baca, & Vickery, p.661). Children with epilepsy, even those without apparent structural brain lesions or impairment have been found to have poorer cognitive performance than children without epilepsy (Berg et al. 2013). Additionally, Kernan et al. (2012) indicated that the age of onset of epilepsy has been shown to not only have a link but can predict later cognitive ability, with those diagnosed with epilepsy at a younger age associated with poorer cognitive outcomes.

Cormack et al. (2007) discovered there was some evidence that early onset of epilepsy is associated with increased risk of impaired cognition compared to adult onset. "Data also suggest that neural development during the 1st year of life lays down the foundation for the subsequent development of higher order cognitive skills, in line with the notion of sensitive periods in brain development. If such processes are derailed, a normal developmental trajectory may become increasingly elusive" (Cormack et al., p.204).

Abnormal White Matter

Epilepsy can affect the direct regions of the brain associated with language and cognitive development. Additionally, epilepsy can affect the white matter (WM) in the overall brain (Widjaja et al., 2013). Widjaja et al. (2013) discussed white matter in the brain as being considered to be critical for the link between cortical processing networks required for cognition (Widjaja et al., 2013). In this study, the children with epilepsy were found to have widespread abnormal WM in their brain, regardless of both site of localization of epilepsy and age of onset (Widjaja et al., 2013).

Widjaja et al. (2013) also discussed how both the left and right hemispheres contribute to language processing early in life. With increasing age, there is a greater emphasis and contribution of the left hemisphere (Widjaja et al., 2013). It was suggested that abnormal white matter may disturb the networks for language processing during childhood, which can alter the timing or degree of the involvement of the right hemispheric structures for language (Widjaja et al., 2013). This change may be responsible for the different language processes and lateralization found in children with epilepsy.

The severity of abnormal WM was related to age at seizure onset, with greatest abnormality found in earlier age of onset (Widjaja et al., 2013). Additionally, research demonstrated that lower fractional anisotropy in the posterior corpus callosum was significantly correlated to earlier age at seizure onset (Widjaja et al., 2013). The study also indicated that their animal studies have demonstrated repeated electroconvulsive-induced seizures in the young rat, which resulted in reduced brain growth (Widjaja et al., 2013). This effect was found to be dependent on the developmental stage at age of onset, and more severe when seizures began at younger ages (Widjaja et al., 2013). The data suggest that the immature brain may be increasingly vulnerable to changes related to recurrent seizures. The relation between abnormal WM and duration of epilepsy was weaker (Widjaja et al., 2013). There was no significant difference between seizure localization but significant differences in WM abnormality between the epilepsy group and controls (Widjaja et al., 2013).

"White matter tracts are thought to play a critical role in linking the different components of the cortical processing networks necessary for cognition. Hence, injury may lead to "connectivity" between these cortical regions and therefore neuropsychological impairment" (Widjaja et al., p. 1065). The tests utilized to measure performance include the Boston Naming Test, Expressive Vocabulary Test-2, and the Peabody Picture Vocabulary Test -2 (Widjaja et al., 2013). The results of this study showed that all subjects in the epilepsy group scored significantly worse on tests in terms of language, executive functioning, and neuropsychological processes (Widjaja et al., 2013).

Widespread abnormal WM was found in both cerebral hemispheres in the subjects with localization related epilepsy against healthy controls (Widjaja et al., 2013). The literature also suggested that WM may be defenseless to seizure-related changes in the pediatric brain, and due to the amount of vulnerability, neurological impairments could result (Widjaja et al., 2013). To conclude, the study found widespread abnormal WM in the children with epilepsy (nonlesional localization-related), which was correlated with impaired neuropsychological function (Widjaja et al., 2013). The researchers stated that their findings determined impaired WM integrity might be related to the direct effect of seizures (Widjaja et al., 2013). Such impairment in WM integrity “may reflect disruption in the connectivity for cortical processing networks, which is necessary for the development of cognition (Widjaja et al., p. 1070).

Language Deterioration

An important component to discuss is the element of regression of previously acquired skills. It could be speculated that a disruption such as a seizure could not only delay or deter typical development, it could potentially cause deterioration of already learned language. Berroya et al. (2003) sought to determine if children with benign rolandic epilepsy encountered speech and language deterioration. Their study was a case report of a 5-year-old boy with benign rolandic epilepsy, who had previously been considered to be developing typically in terms of neurodevelopment, language, and behavior, prior to onset of seizures (Berroya et al., 2003). The researchers reported that two months following onset, he developed difficulty understanding and responding to language, despite the fact that his seizures were considered to be under control (Berroya et al., 2003). Ten months post onset, the child’s speech again deteriorated in association with return of seizures (Berroya et al., 2003).

The child’s language function showed marked fluctuation, with some days of typical communication and other days involving word finding difficulties and poor comprehension of language (Berroya et al., 2003). The study demonstrated that not only is it imperative to consider where the child is in their development of language and how it will impact them moving forward, it is important to judge if all the skills they have obtained up until that point will continue to stay unharmed. It is not only an issue of stopping or delaying development, there is a possibility of regression in language development.

Effects of Treatment-Antiepileptic Drugs

Guierrini (2010) discussed the use of anti-epileptic drugs (AEDs) and the effects of treatment (Guierrini, 2010). Many children who have epilepsy are treated with the use of AEDs (Guierrini, 2010). AEDs have various side effects that go far beyond causing fatigue. They can interfere with brain pathways involved in both learning and memory (Guierrini, 2010). The majority of children who have epilepsy also have accompanying cognitive impairment; cognitive impairment that co-occurs is in part attributed to AEDs (Guierrini, 2010). Furthermore, Guierrini (2010) stated that the prolonged use and effects of drugs that can decrease cognitive processing might not be compensated for at a later age. This suggests that utilizing AEDs over time will not only negatively affect the brain's networks and wiring, the ability to make up for such deficits could be impacted as well.

Dewi and Zelleke (2010) stated, "adverse effects of AEDs are of particular concern in young children who are acquiring new skills and may result in long lasting developmental impact" (p.240). This supports the idea that language development is acquired through stages and a misstep at a single stage could derail progress and impact overall development. As suggested earlier, this has been identified to be of particular concern for children with epilepsy; however, Dewi and Zelleke (2010) confirm that the treating epilepsy with the use of AEDs can additionally hinder overall development.

Selassie, Viggedal, Olsson, and Jennische (2010) questioned the effects of AEDs on speech, language, and cognition in children. An association between an increase in AED and lower IQ was not found; however, some speech, language, and neuropsychological functions were affected (Selassie et al., 2008). However, children who were on more than one type of AED "were slower in rapid picture naming and had poorer scores in auditory analogy and narrative memory, reflecting difficulty with language processing" (Selassie et al., p. 437).

Future Directions

The research reviewed has discussed the effects of specific types of epilepsy on cognition and language. The research has focused on outcomes related to the specific type of epilepsy against children without epilepsy. These findings are important as they answer the question regarding if there is an effect of epilepsy at all on language and cognition in children. The literature reviewed have not discussed or focused on studies where the outcomes measured one type of epilepsy against another type in terms of their respective diagnoses and its affects on language development or cognition. Such studies could be beneficial to understand if certain types of epilepsy have a greater affect on language development and cognition than others. Comparing results based on specificity of type of epilepsy could provide beneficial information as to expectations and predictions in measures of language development and cognition based on diagnosis. Additionally, it could be beneficial to determine the specific areas of language that is most affected by epilepsy. The studies reviewed have discussed language as a broad category and a focus on various aspects of language could be helpful.

The research reviewed also does not provide information regarding the percentage of children with epilepsy who take AEDs. It could also be beneficial to compare the affects of AEDs against children with epilepsy who do not currently or have not taken them. The research above discussed the affects the AEDs can have; however, measuring results of the comparison between language and cognitive performance between those who take AEDs and those who do not could provide information regarding treatment effects and predictions of outcomes.

Conclusion

The literatures reviewed have provided evidence regarding the correlation of the effects of epilepsy on language development and cognition in children. The support for such claims is associated with seizure age of onset, cortical reorganization, language lateralization, abnormal white matter, and language deterioration. It is important to understand that there is a link between children with epilepsy and its negative impact on language development and cognition, and how this effect can take place in multiple capacities. Additionally, it is imperative to understand the effects of the treatment for epilepsy can accompany language and cognitive impairment. This provides helpful predictors for children with epilepsy and their expected outcomes due to the fact that many children are treated with AEDs. Seizures and any type of epilepsy diagnosed can cause such disturbance in the brain that can have lasting effects on language development and cognition in children.

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