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A specific deficit of auditory processing in children with Rolandic Epilepsy and their relatives

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ABSTRACT

Previous research shows that children with Rolandic Epilepsy have deficits of auditory processing. We wanted to confirm the nature of this deficit and whether it aggregates in families.

We compared 40 children with Rolandic Epilepsy and 32 unaffected siblings with 99 typically developing children and 71 parents of RE children with 31 healthy adults on a battery of auditory processing tests. We also examined ear advantage in children with RE, their siblings and parents using population norms and measured non-word reading performance.

We found a specific deficit for competing words in patients, their siblings and their parents, suggesting that this particular impairment of auditory processing present in children with RE, is heritable and likely to be persistent. Importantly, scores on this subtest in patients and siblings were significantly correlated with non-word reading performance. We saw increased rates of atypical left ear advantage in patients and siblings but no evidence of this in parents.

We present these findings as evidence of familial incidence of dichotic listening and ear advantage abnormalities in relatives of children with Rolandic Epilepsy.

1. Introduction

Rolandic Epilepsy (RE) is the most common childhood epilepsy, constituting 15% of all childhood epilepsies [1]. The International Classification of Epilepsies and Epileptic Syndromes (Commission Classification and Terminology of the International League Against Epilepsy 1989), defines RE as a syndrome of brief and simple partial, hemifacial motor and somatosensory seizures, often involving oropharyngeal muscles and which may evolve into secondarily generalized tonic–clonic seizures. Onset occurs between 3 and 13 years and seizures usually remit before the age of 16 [2]. Evidence suggests that inherited factors are important in RE: early studies show that siblings are more likely to present with seizures and identical EEG abnormalities to probands [3,4] while 11% of parents reported having seizures during their childhood [3]. Later EEG studies of unaffected siblings of children with RE have shown an autosomal dominant inheritance of abnormal Centro-Temporal Spikes (CTS) [5] localizing to chromosome 11p13 [6]. Other studies show that relatives of children with RE experience similar increases in neurological and neuropsychological abnormalities such as migraine [7], and cognitive difficulties [8–10].

These cognitive difficulties include literacy and language [11], and executive functions [12–15] as well as impairments of auditory processing, understood as the bottom-up processing of sounds by the brain in the central auditory system. Studies have shown deficits of auditory processing of either temporal information [16], filtered words [17], dichotic sounds [18–20], or dichotic words [8]. Remission of auditory deficits may occur contemporaneously with remission of spikes [18,21], reflecting the pattern of other language related deficits [22], suggesting that auditory processing difficulties are associated with epileptiform activity. However, an alternative explanation is that these two phenomena co-occur due to linked genetic loci and family studies show that both patients with RE and their relatives have an elevated risk for developing co-occurring disorders such as migraine [7], Reading Disorder and Speech Sound Disorder [10]. An earlier study by our lab with a separate uncontrolled sample of RE patients and their unaffected siblings revealed a strikingly similar profile of impairments in language and attention as well as auditory processing across the two groups [8].

Auditory processing difficulties may underpin certain other higher order learning and behavioral problems in RE [23]. Children with dyslexia find dichotic listening tasks more challenging than controls [24] and demonstrate atypical left ear advantage [25]. Auditory processing

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deficits have been associated with non-word reading difficulties in children with dyslexia [26] and with RE [16].

This study aimed to define the nature of the auditory processing deficit in children with RE in a larger sample, hypothesizing deficits of auditory processing in this patient group compared with the comparison group, together with significantly greater rates of left ear advantage, indicative of shifts in language specialization. Since studies have shown siblings of children with RE are themselves more likely to present with abnormalities such as migraine [7], and cognitive difficulties [8–10], and that auditory processing difficulties may persist into adulthood [27] we also recruited siblings and parents of children with RE, examining auditory processing deficits and differences in ear advantage in family members of affected children. A final aim was to investigate associations between auditory processing and non-word reading as measured by the Graded Non-Word Reading Test (GNRT) [28] in a subgroup of the children with RE and their siblings.

2. Material and methods

2.1. Participants

Children and adolescents with RE (n = 40), their siblings (n = 32) and their parents (n = 71) were recruited between 2010 and 2014 as part of a single large genetic study of RE in the South-East of England through consultant paediatricians from 28 hospitals. Children were considered eligible if they were aged 6–18, had a history of typical orofacial seizures with an age of onset between 3 and 12 years of age; normal developmental milestones; and neurologically normal examination. Handedness for these two samples was collected using the Edinburgh Inventory of Handedness [29]. We also recruited at least one biological parent (n = 71) for each proband. Additionally, we obtained data from two control groups consisting of children (n = 99) and adults (n = 31) recruited from local schools in Oxfordshire, UK. Handedness was not recorded for these latter samples.

2.2. Measures and procedures

We assessed audiometry, auditory processing, and phonological processing from RE cases and their families as part of a full day's assessment at the Institute of Psychiatry, Psychology & Neuroscience at King's College, London. All children with RE and their siblings and parents had normal hearing as assessed by a pure-tone audiometric threshold at 20 dB HL. A subgroup of children with RE (n = 35) and siblings (n = 26) completed the GNRT.

2.2.1. Auditory processing

The SCAN-C Test for Auditory Processing Disorders in Children revised [30] measures auditory processing in children aged between 5 and 11 years. Participants aged 12 and above were assessed by using the adult version of the measure, SCAN-A Test for Auditory Processing disorders in Adolescents and Adults [31], but the tasks are identical for each version and differ only in the normative data provided in the manual. Both the child and the adult version include four subtests: Filtered Words (FW), Figure Ground (FG), Competing Words (CW), and Competing Sentences (CS) and each subtest produces a standardized scaled score adjusted for age. The FW task presents monosyllabic words that have been low-pass filtered at 1000 Hz with a roll-off of 32 dB per octave to make them sound muffled and difficult to understand. This subtest assesses the ability of the participant to understand and repeat distorted speech. The FG subtest presents monosyllabic words that are presented with an accompanying quieter multi-talker speech babble background. This subtest asks the participant to identify words in the presence of background noise. The CW subtest is a test of dichotic listening and requires participants to repeat two monosyllabic words that are played simultaneously in each ear. In the first block of trials, the participant is required to repeat the word played in the right ear first and in the second block, the word played in the left ear first. Finally, during the CS subtest, two different sentences are presented to the right and left ears within 10 ms difference. The participant is asked to focus on and repeat the stimulus presented in one ear while ignoring the other.

Additionally, the CW subtest generates two ear advantage scores—one for the Right-Ear First Task and one for the Left-Ear First Task. The information presented on cumulative prevalence for ear advantage provides a means for measuring ear advantage since control data were unavailable for this measure. The more extreme or atypical the ear advantage score, the greater the possibility of an auditory-based disorder such as a language or learning disability and in particular, a left ear advantage may indicate reversed or absent dominance for language, a particular focus of this study.

2.2.2. Phonological processing

The Graded Nonword Reading Test (GNRT) [28] is administered individually and assesses children's ability to decode novel word-like graphemes. It is particularly useful in terms of assessing phonological skills and consists of 20 non-words, which increase from 1 to 2 syllables in length. Scores were converted into z scores using the means and standard deviations for each age group provided in the manual.

2.3. Statistical analysis

To compare gender distributions across the three groups we used a chi-squared test of proportions. We used independent t tests to compare continuous auditory processing performance variables across gender. We used a multivariate one-way ANOVA with group as a factor (children with RE, siblings and comparison group) to compare the three groups on each of the subtests of the SCAN-C.

Because ear advantage data were not available for our comparison groups, we tested the hypothesis that children with RE and their siblings would show increased rates of atypical left ear advantage scores, by comparing the proportion of children in the RE group and the sibling group who had atypical ear advantage as defined by scores expected by 10% of the population, using *z* tests to evaluate differences.

We also compared the mean scores of parents of patients and siblings with a group of typical adults described above using a multivariate ANOVA. Ear advantage data were also not available for our parent group so we again used population norms as described above.

In order to investigate correlations between child auditory processing performance and GNWR scores we used Pearson's correlation coefficient to examine the relationship between these scores and those scaled scores provided by the SCAN-C.

3. Results

3.1. Children

3.1.1. Age, gender and handedness

There were significant differences in age across all three groups: patients: (mean age of 10:4 (SD: 2:5)) siblings: (mean age 12:2 (SD: 3:11)) child comparison group: (mean age 8:6 (SD: 1:5)), ($F = 30.9$; df 2168); $p < .0001$).

There were significantly more boys in the proband group (65%) compared with the siblings (37%) and comparison group (51%), ($\chi^2 = 7.4$; $p = 0.024$). We compared differences between males and females in auditory processing to determine whether gender should be included in the multivariate ANOVA model: there was no significant effect of gender on any of the auditory processing dependent variables ($p > 0.17$) but nevertheless gender was explored as a potential predictor variable.

Handedness did not differ between patients (81% were right handed) and siblings (80% were right handed) but was not measured in comparison children.