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Auditory processing and neuropsychological profiles of children with functional hearing loss

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ABSTRACT

Objectives: This paper compares structured history, auditory processing abilities and neuropsychological findings of children with functional hearing loss (FHL) to those with suspected auditory processing disorder without FHL (control). The main aim was to evaluate the value of a holistic assessment protocol for FHL used in a routine pediatric audiology clinic. The protocol incorporated a commercially available test battery for auditory processing disorder (APD), non-verbal intelligence (NVIQ) and tools to screen for common co-existing neurodevelopmental conditions such as attention deficit hyperactivity disorder (ADHD), language impairment (LI) and developmental coordination disorder (DCD). The outcome of such holistic assessment was expected to help in understanding the nature of FHL and to provide individualized support to mitigate their difficulties.

Methods: This retrospective study compared two groups, 40 children (M = 17, F = 23) in each group between seven and sixteen years of age, one group with a history of FHL and the other with suspected APD without FHL (control). The groups were matched against age, gender, hand use, diagnosis of APD or non-APD (31 with APD and 9 without APD in each group) and non-verbal intelligence. All the children were healthy English speaking children attending mainstream schools with no middle or inner ear abnormalities. Structured history was obtained from parents regarding different nonacademic and academic concerns. The SCAN-3:C and SCAN-3:A test batteries were used to assess auditory processing abilities; Lucid Ability test for NVIQ; Children's Communication Checklist-2 (CCC-2) for language ability; Swanson Nolan and Pelham-IV Rating Scale (SNAP-IV) for ADHD; and the manual dexterity components of the Movement Assessment Battery for Children-2 (MABC-2) as a screening tool for DCD.

Results: About 60% of children in both the groups had concerns regarding listening in noisy background. In the history, poor attention was reported in 45% of children in the FHL group compared to 82.5% in the control group ($p < 0.01$). Hyperacusis was present in 35% of children in the FHL group and in 62% of children in the control group ($p < 0.05$). Concerns about overall academic abilities were present in 59% of children in the FHL group and 75% of the controls ($p > 0.05$). Only 15% of children in the FHL group had concerns with numeracy skills in contrast to 41% of the controls ($p < 0.05$). Significantly fewer ($p < 0.01$) children in the FHL group (41%) received additional support at school than the controls (75%). Fewer children performed poorly in Filtered Words (FW) test of the SCAN-3 batteries, 30% in the FHL group and 17.5% in the control group, in contrast to Auditory Figure Ground 0 (AFG0), 85% in FHL and 80% in the control group. The number of children performing poorly in AFG0 was significantly higher compared to all the other SCAN-3 tests in FHL ($P < 0.05$), in contrast to FW and Competing Sentences (CS) only in the control group ($p < 0.05$). The control group had higher prevalence of atypical ear advantage (AEA) in left directed Competing Words (CW) (32.5%) and Time Compressed Sentences (TCS) (32.5%) compared to FW (7.5%). In contrast, FHL group had higher prevalence of AEA in AFG0 (48.7%) compared to CS (21%). High proportions of children in both the groups had LI (80% in FHL and 82.5% in the control group), with significantly lower ($p < 0.05$) levels of ADHD symptoms in the FHL group (39.5%) compared to the control group (72.5%). Impaired manual dexterity was present in 30.7% of children in FHL group and 47.5% in the controls.

Conclusions: The prevalences of APD and language impairment are high compared to ADHD symptoms in children with FHL, and holistic assessment is recommended. Despite some similarities in the auditory and neuropsychological profiles between children with FHL and those with suspected APD without FHL some differences were noted. The results suggest that children with FHL have genuine difficulties that need to be

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identified and addressed. Future research is required to identify the neural pathways which could explain the similarities and dissimilarities between the two groups.

1. Introduction

Between one and twelve percent of children are reported to present with raised hearing thresholds in pure tone audiometry inconsistent with their speech discrimination ability and absence of any recognizable abnormalities in the auditory pathway [1–3]. This could be classified as a functional neurological disorder (FND) affecting hearing and has been known by different names such as non-organic hearing loss, psychogenic deafness and pseudohypacusis. Children with such presentations have been classified into three categories depending on intention and motivation, such as malingering, factitious and conversion disorder. However, the fifth edition of the Diagnostic and Statistical Manual of Mental Disorder (DSM-V) does not require the exclusion of feigning to establish a diagnosis of FND. Neuroimaging studies of FND have shown different activity patterns in different parts of the brain [4–6]. Reduced activity in the thalamus may be responsible for reduced sensory perception, and it is not known if the elevated hearing thresholds at the initial presentations in functional hearing loss (FHL) is related to this. The correct identification of children with FHL is important to prevent iatrogenic complications. These children may end up with hearing aids with a potential danger of iatrogenic noise induced hearing loss if a wrong diagnosis of sensorineural hearing loss is made or may receive unnecessary grommet surgery with potential complications if wrongly diagnosed to have significant conductive hearing loss. This can lead to inappropriate use of resources, but the more worrying aspect of misdiagnosing FHL is that any underlying stressors, if any, associated with a functional presentation may be missed [7]. It has been suggested that functional neurological symptoms arise from complex interactions between vulnerable cognitive and emotional systems [8]. Willment and colleagues proposed number of neuropsychological assessments to evaluate FND [8]. In addition to listening difficulties at school many children with FHL have poor academic progress, learning difficulties, speech impairments and evidence of certain neurodevelopmental conditions [1,9]. However, it is not clear if all children with (FHL) routinely undergo detailed neuropsychological assessment and if carried out what the outcome of such assessments are.

Listening difficulties, poor academic progress and coexisting neurodevelopmental disorders mentioned above in children with FHL [1,9] are also features of auditory processing disorder (APD) [10–13]. Therefore, holistic transdisciplinary assessments have also been suggested for APD [14,15], and some of the assessments mentioned by Willment and colleagues [8] are also relevant for children with APD. In 1989 Hasbrouck suggested a very high prevalence of APD in FHL [16], but a percentile score of 25 was used as a cut-off criterion for identifying auditory impairment in some tests contrary to currently suggested criteria of percentile scores of ≤ 2 [17] or ≤ 10 [12] in at least two tests [17]. Additionally, the participants in Hasbrouck's study included both children and adults and there was some ambiguity about the normative data used for some of the tests. Therefore, the relation between FHL and APD is unclear and it would be important to evaluate the nature of APD using criteria currently in use, academic abilities and non-academic presentations including co-existing neurodevelopmental disorders in children with FHL and those presenting with suspected APD without FHL.

The association between APD and multiple co-existing neurodevelopmental conditions like attention-deficit hyperactivity disorder (ADHD), language impairment (LI), autistic spectrum disorder (ASD), developmental coordination disorder (DCD) and dyslexia is widely accepted [10,11,13,18–20]. In contrast speech difficulties, dyslexia and inattention has been mentioned in the literature in FHL but no details about co-existence of different neurodevelopmental conditions are mentioned [1,9,21]. Ashitani and colleagues used the ADHD rating scale IV but did not elaborate on different subtypes of ADHD and their findings suggested that inattention was present in only one third of individuals with FHL [21]. Schmidt and colleagues did not find ADHD in children with FHL, and they mentioned speech impairment without any details of the measures used [1]. The above authors report a low prevalence of speech problems in FHL [1] in comparison to those reported in children with APD [10,13]. Therefore, if the prevalence of APD is high in FHL as suggested by Hasbrouck [16], one would expect much higher prevalence of different co-existing neurodevelopmental conditions in FHL than that suggested by Schmidt and colleagues [1].

In this paper, we aim firstly to evaluate the outcome of a commonly used APD test battery in children with FHL. Secondly, we compare the clinical presentation, academic abilities, auditory performance and outcome of screening tools for some common neurodevelopmental conditions including ADHD, language impairment and developmental coordination disorder between children with FHL and suspected APD without FHL. If association between FHL and APD existed, information of any differences in the profiles of auditory processing abilities, clinical presentation and co-existing neurodevelopmental conditions between children with FHL and APD without FHL would be helpful. The information will help in providing appropriate individualized support to minimize their listening and educational difficulties, as well as guiding future research to explore how the neural pathways associated with APD differ between FHL and those without FHL. Any association between FHL and APD would also raise the question if listening difficulty associated with APD or any emotional impact of undiagnosed co-existing neurodevelopmental conditions act as stressor(s) for FHL.

2. Material and methods

Data for this retrospective study was collected as a part of a service improvement project registered with the clinical audit department of the Lancashire Teaching Hospitals NHS Foundation Trust, United Kingdom.

2.1. Participants

Data from 80 children, 35 males and 45 females, between 7 and 16 years of age (Mean = 10 years 8 months, SD = 2 years 6 months), who were assessed for APD in a tertiary pediatric audiology clinic between January 2014 and May 2018 were obtained. Forty children (M = 17, F = 23) had a diagnosis of FHL out of 416 children who were assessed for APD during this period. The children with FHL initially presented with elevated hearing thresholds, suggesting either sensorineural or mixed type of hearing loss, that were inconsistent with their ability to converse satisfactorily at normal speech levels, normal tympanograms, presence of otoacoustic emissions and intact stapedial reflexes. The protocol to confirm normal hearing thresholds in these children with FHL was similar to that suggested by Balatsouras and colleagues [22]. Pure tone audiometry was repeated using an ascending technique after reassurance that the ears were healthy and that they need to listen carefully to the tones during the hearing test so that we understand the nature of their listening difficulties to help them with their difficulties. Consistent with literature, the repeat pure tone audiogram (PTA) showed normal hearing thresholds in most cases after the reassurance [22]. Auditory brain-stem response (ABR) and auditory steady state response (ASSR) tests were carried out in children where the elevated pure tone audiogram thresholds persisted, to rule out auditory