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Evaluation of musical skills in children with a diagnosis of an auditory processing disorder

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ABSTRACT

Impaired musical skills are reported in parental questionnaires to be present in children with an auditory processing disorder (APD).
Objectives: To formally assess musical skills in children with a diagnosis of APD.
Methods: We used a validated musical test battery with extensive normative pediatric data, the Gordon's Musical Aptitude Profile and the tests of metre and melody in particular, in order to assess the musical skills of 8 children with a previously given diagnosis of APD (APD group) and 8 normal controls (control group) aged 7–15 years old. The two groups were well matched for age, sex, handedness, socio-economic factors and musical training.
Results: The APD group had significantly lower metre percentile scores than normal children (mean difference 28.9, $p = 0.003$). Melody scores tended to be lower in the APD group than in the controls, but this did not reach significance, possibly due to low power of the study.
Conclusion: This is the first study that systematically assesses musical skills in children with a formal diagnosis of APD in the absence of other developmental disorders. The APD group did significantly worse than the control group in judging metre. Musical skills assessment in children with APD may help constrain our understanding of this heterogeneous condition and possibly inform the management plan for these children.

1. Introduction

Auditory processing disorders (APD) exist as a collection of disorders in which there are deficits in the perceptual processing of auditory signals within the central auditory pathway [1,2]. Individuals with APD may have a range of deficits, including deficits in sound localization, auditory discrimination, auditory pattern recognition, temporal processing, auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals [1] as well as with sound separation and grouping [2]. In children, these deficits may manifest with primary symptoms such as uncertainty in what is heard, particularly in background noise, difficulties in understanding spoken instructions or understanding rapid or degraded speech and following spoken instructions [3], and they may also have a reduced ability for and appreciation of music [1].

Music has three fundamental component parts: pitch (broadly defined as the perceptual correlate of the fundamental frequency), timbre (the percept that allows to distinguish which instrument produces the music) and temporal structure (rhythm and metre). These elements are processed by different neural substrates of the brain [4]. It has been proposed that musical processing is modular, i.e. underpinned by an information processing system which is specific to the processing of music, and this theory is supported by the findings of dissociated impairments in music versus speech recognition abilities in some brain damaged subjects post brain damage [5]. The term "congenital amusia" refers to a developmental disorder characterised by abnormal perception of music in the presence of otherwise normal hearing and cognition [6]. This condition may be determined on a single gene basis, although a polygenic basis is still possible [7].

Children with suspected APD are anecdotally reported to have reduced musical skills. However, systematic studies of musical perception in this population are scarce. Meister et al. [8] conducted a questionnaire study to identify listening differences between an APD group and a normal control group. A musical component featured in their survey with the questions "Does your child clap to the wrong rhythm when listening to music?" and "Does your child sing or hum a wrong melody when repeating a piece of music?". The responses showed a significant difference (at the 1% level) between the two groups. These findings indicate that

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assessing musical perceptual skills may help to constrain our understanding of the nature and possible heterogeneity of APD.

The present study seeks to study musical perception by means of the Gordon's Musical Aptitude Profile and a questionnaire of musical behaviour in children with diagnosed APD. Gordon's Musical Aptitude Profile (GMAP) [9] is a validated test of musical aptitude and can provide an extensive assessment of musical potential in children and adults [10]. It is the "most commonly used test of musical ability in the USA and has the most extensive normative data on more than 12,000 children" [10].

2. Participants and methods

2.1. Subjects

This case–control study included of a group of children with a diagnosis of APD, and a control group of age matched normal children. The study was approved by the Research Ethics Committee of the Great Ormond Street Hospital/Institute of Child Health (reference number: 06/Q0508/134) and informed consent was obtained by study participants and their parents.

APD participants were recruited from consecutive cases seen from September 2006 to May 2007 at the Auditory Processing Clinic at Great Ormond Street Hospital. The inclusion and exclusion criteria for the APD group consisted of the following.

2.1.1. Inclusion criteria

All case subjects were age 7 and above, had been referred to the Department for an auditory processing assessment because of "listening" difficulties, and had been given a clinical diagnosis of an APD.

Both at the time of the APD diagnosis and in the day of the study, they had normal hearing thresholds (better than 20 dBHL in each frequency of 500, 1000, 2000, 4000 and 8000 Hz) and normal tympanometry in both ears.

Diagnosis of APD had been previously made after standard clinical test protocol (see [11,12] for test details) and other assessments and based upon the findings of

- abnormalities in at least two behavioural central auditory tests, one of which should be non-speech [12];
- exclusion of other potential confounders by means of age appropriate, validated Speech & Language and Educational Psychology assessments conducted by licensed professionals. (These assessments are part of the standard clinical test protocol at the Great Ormond Street Clinic and will not be described in this paper).

2.1.2. Exclusion criteria

The presence of a low IQ (one statistical deviation below average), a diagnosis of autism, attention deficit hyperactivity disorder, neurological disorders or a diagnosis of auditory neuropathy (based on findings of absent or abnormal ABR and/or absent or abnormal acoustic reflexes and normal otoacoustic emissions).

The control group was recruited from families of all grades of hospital staff. We endeavoured to keep the control group as closely match to the APD group as possible for sex, age, handedness (defined on the basis of the hand used to write) and socio-economic background ranked according to an "index of multiple deprivation" as calculated on the basis of a combination of indices including employment, education, housing, health and crime and calculated on the basis of the study participant's post code (see http://www.neighbourhood.statistics.gov.uk/dissemination/).
Inclusion and exclusion criteria for the controls were as follows.

2.1.3. Inclusion criteria

All subjects were age 7 and above and at a mainstream school.

They had normal hearing thresholds (as defined above) in both ears.

2.1.4. Exclusion criteria

Neurological problems, known developmental disorders or low IQ (less than 1 SD below average).

2.2. Test protocol

The test protocol consisted of:

- *Baseline Audiometry*, including tympanometry (to assess middle ear function) and pure tone audiometry (PTA) (to assess hearing thresholds) as per standard clinical procedures [13].
- *Auditory Processing Tests* were all available on a compact disc (CD) (Audiology Illustrated) which was played with a Sony CD player and routed through the speech circuitry of the GSI 61 audiometer and TDH-49 headphones at a 50 dB sensation level (as per test instructions). Outcome measures were percentage correct responses for each ear, that were classified as normal or abnormal according to departmental norms. Tests included
  dichotic digits [14]: a different pair of numbers between 1 and 10 is presented simultaneously to each ear (20 pairs in total for each ear) and the child has to repeat all 4 numbers
  frequency pattern [15]: a sequence of three tone bursts, a combination of a low- and high-frequency tone is presented to each ear, and the child has to label the sequence (20 sequences were presented to each ear).
  duration pattern [16]: a sequence of three tone bursts, a combination of a long- and short-duration tone is presented to each ear, and the child has to label the sequence (20 sequences were presented to each ear).
- The *Musical Aptitude Test* (GMAP [9]) was presented binaurally via a CD recording played via the Windows Media player of Dell Optiplex GX280 Intel Pentium® desktop computer and presented through HD-600 headphones (Sennheiser) at a comfortable sound level for the subject. We administered the reduced form of GMAP (as per the test manual's instructions), consisting of two subtests—Melody and Metre, in order to enable us to complete all the tests in one session. For both subtests, after training, 40 pairs of short musical pieces of western type music were presented to each child. The child was instructed to judge and report orally whether the two phrases within each pair sounded similar or different. Both subtests provided raw, standard and percentile correct scores per 12 month age group.
- A concise non-validated Musical Questionnaire designed to determine level of musical training background, including questions concerning musical achievements and amount of daily practise was used to determine other aspects of musical behaviour not obtained through the previous tests. This was completed by the study participant and their parent, together, before the tests were administered.

2.3. Statistical analysis

Statistical analysis was conducted with the statistical package for social sciences—SPSS. The percentile test scores for the GMAP and the test scores for the auditory processing tests of the two groups were compared with the use of the Mann–Whitney statistical test. The 95% Confidence Intervals (derived from the Independent samples *t*-test) were also obtained. Spearman's Rank correlation coefficient and tests of multiple hierarchical regression were used to analyse any relationship between the GMAP subtests and the auditory processing tests. The Mann–Whitney statistical