Psychometric profile of children with auditory processing disorder (APD) and children with dyslexia

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Abstract

Objective: The aim was to address the controversy that exists over the extent to which auditory processing disorder (APD) is a separate diagnostic category with a distinctive psychometric profile, rather than a reflection of a more general learning disability. Methods: Children with an APD diagnosis ($N = 25$) were compared with children with dyslexia ($N = 19$) on a battery of standardized auditory processing, language, literacy and non-verbal IQ measures as well as parental report measures of communicative skill and listening behavior. A follow-up of a subset of children included a parent report screening questionnaire for Asperger syndrome (CAST). Results: There were similarly high levels of attentional, reading and language problems in both groups. One peculiarity of the APD group was a discrepancy between parental report of poor communication and listening skill disproportionate to expectations based on standardized test performance. Follow-up assessment suggested high levels of previously unrecognized autistic features within the APD group. Conclusions: Children diagnosed by audiological experts as having APD are likely to have broader neurodevelopmental disorders and would benefit from evaluation by a multidisciplinary team.
**Introduction**

Auditory processing disorder (APD) is diagnosed when a child presents with unexplained listening difficulties. The primary feature is difficulty hearing in background noise despite a normal audiogram. APD is widely diagnosed in the US and Australia [1, 2], and is beginning to receive more attention in the UK [3] and elsewhere [4].

There is, however, debate over the validity and reliability of commonly used APD assessments, definition of APD and possible mis-identification of learning problems as APD [5]. It has been suggested that APD is not a separate disorder, but rather is a reflection of an attention deficit, a learning disability or a language disorder.

It has been suggested that the diagnosis a child receives is partly dependent on the professional who assesses them. In other words, an audiologist would diagnose APD in cases where an educational psychologist or speech therapist would diagnose dyslexia or SLI [6]. In this study, we focused on whether the psychometric profile of children with an APD diagnosis differed from that of children with dyslexia. During an initial assessment, all participating children completed a detailed psychometric battery comprising standardized assessment and parent report measures. On the basis of our findings, a follow-up assessment focusing on assessment of autistic features was conducted with a subset of children from both APD and dyslexia groups.
Method

Participants

APD group
After excluding two children with low non-verbal IQ (<80) and one child for poor compliance during testing, twenty five children diagnosed with APD were recruited from audiology clinics based at four hospitals in the UK. All of these children had been diagnosed by an audiologist or auditory physician as having APD. Diagnosis at each of these centers was based on i) complaint of listening difficulties, ii) normal peripheral hearing, iii) score below recommended clinical cut-off on the SCAN-C or –A (see below: [7, 8] plus iv) failure on one or more additional non-speech tests of auditory processing (for example, Pitch Patterns or Duration Patterns Test [9] or the Random Gap Detection Test [10]). This method of APD diagnosis is typical of clinical identification of APD in the US and UK [2, 3].

Dyslexia group
19 children were recruited either from local schools or as participants from previous studies; all had a diagnosis of dyslexia by an educational psychologist. For inclusion in the study, dyslexia was defined as a reading or spelling test standard score below 85 and a performance IQ greater or equal to 80 (see Assessments, below). All participants had normal hearing as indicated by pure-tone audiometric screening test (at 20 dB HL). Parental consent for participation was obtained in accordance with University and NHS ethics requirements.

Assessments
Testing was carried out in a quiet room by a trained examiner.
Psychometric tests

i. Wechsler Abbreviated Scale of Intelligence (WASI) matrix reasoning and block design subtests [11]. Performance IQ is calculated as a composite of matrix reasoning and block design subtests.

ii. Test for Reception of Grammar, electronic version (TROG-E) [12]. The TROG-E is a test of receptive language that assesses comprehension of grammatical contrasts marked by inflections, function words and word order.

iii. Expression, Reception and Recall of Narrative Instrument (ERRNI) [13]. ERRNI assesses the ability to relate a pictured story, and recall and answer questions about it after a short interval. Children’s performance is compared to UK norms according to how much relevant story content is provided, sentence length, comprehension and recall of the story.

iv. Sentence Repetition and Repetition of Nonsense Words from NEPSY [14]. These tests, which are sensitive indicators of language impairment [15], tap short term memory.

v. Test of Word Reading Efficiency (TOWRE) [16]. The TOWRE assesses the ability to read real words and nonwords under time pressure.

vi. The OSCCI spelling test was developed within our research group as a quick and efficient test of spelling ability. Children are asked to write a list of regular and irregular words within a two minute time limit. Performance norms are based on 58 typically developing British
school children aged 6 to 15 using the regression of score on age to convert to age-adjusted standard scores.

vii. SCAN-C [8] and SCAN-A [7]. The SCAN is a US-produced standardised test of auditory processing, and is the most commonly used instrument for diagnosis of auditory processing disorder [2, 3]. Test takers repeat monaurally presented single word stimuli that have been acoustically filtered to reduce intelligibility or are presented against a background of multi-talker babble, as well as single words and sentences that are presented dichotically. Stimuli are recorded on compact disc and presented via headphones. Accuracy of responses is scored and compared to performance norms to provide standard scores. The child version, the SCAN-C is for use with children aged 5 to 11 while the SCAN-A is for those aged 11 plus.

**Parental Questionnaires**

i. Children’s Communication Checklist – 2 (CCC-2) [17]. The CCC-2 is a parent-completed questionnaire that can be used to screen for language impairment, to identify pragmatic impairments in children with communication problems and to identify children as candidates for further assessment for an autistic spectrum disorder. The CCC-2 provides norm-referenced scores in ten linguistic and pragmatic subscales as well as providing an overall index of communicative competence and a social interaction deviance score, which can be used to identify children with a communicative profile characteristic of autism.
ii. Strengths and Difficulties Questionnaire (SDQ) [18]. The SDQ is a brief screening questionnaire for behavior problems in children. The 25 items are divided into 5 subscales; emotional symptoms, conduct problems, hyperactivity/inattention, peer problems and prosocial behavior. The SDQ also provides an overall index of behavior problems.

iii. Children’s Auditory Performance Scale (CHAPS) [19]. Respondents rate a child’s ability to hear and understand in a range of conditions including noise, multiple inputs and quiet. The CHAPS provides scores for each condition as well as an overall auditory performance index. Recommended performance cut-off scores for referral for APD assessment based on normative performance data from children with suspected APD and controls are reported in the CHAPS manual.

iv. Childhood Asperger Syndrome Test (CAST) [20]

The CAST is a screening test for autistic spectrum features in children aged 4 to 11, which was completed by parents of a subset of cases 6 to 8 months after the rest of the battery. Parents respond with a yes or no to statements such as “Does s/he tend to take things literally?” or “Is her social behavior very one-sided and always on his/her own terms?” The number of ‘yes’ answers is then totaled.

Results

APD and dyslexia groups did not differ in age (means of 10.4 years, SD 2.5 and 10.1 years, SD 1.6 respectively, \( t (42) = -.48, p > 0.05 \)). There was a higher proportion of males in the dyslexia group (17/19 cases) than in the APD group (15/25 cases), Fishers \( p = 0.04 \). The two groups were not
Significantly different in performance IQ ($M = 98.7, SD = 14.8$ and $M = 102.2, SD = 11.4$, respectively for APD and dyslexia groups, $t(42) = .86, p > 0.05$).

**Comorbid conditions**

Rates of dyslexia, specific language impairment (SLI) as well as attentional and auditory processing problems were examined in the APD and dyslexia groups. Dyslexia criteria were as used for dyslexia group selection. SLI was defined as a performance IQ of 80 or better and performance on two or more out of six language tests (TROG, NEPSY sentence repetition, NEPSY non-word repetition, ERRNI storytelling, ERRNI MLU, ERRNI story comprehension) below -1 standard deviation. Around half (13 of 25, 52%) of APD children would also fit a diagnosis of either SLI, dyslexia or both. A relatively high proportion of children in the dyslexia group would also fit a diagnosis of SLI (11 of 19, 58%), not statistically significantly different proportion than in the APD group (Fishers $p = .36$).

Hyperactivity/inattention was identified using recommended cut-off scores for the parent-completed Strengths and Difficulties Questionnaire and classifications according to ‘normal’, ‘borderline’ and ‘abnormal’ cases [18]. Around 10% of the general population would be expected to score in the ‘abnormal’ range, with an additional 10% in the ‘borderline’ range. The proportion of abnormal cases was 37% and 46% for the dyslexia and APD groups, respectively. The proportion of abnormal and borderline cases combined was around 50% for both dyslexia and APD groups, not statistically significantly different from each other (Fishers $p = 1.00$).
Auditory processing problems were defined by SCAN test results. In an earlier study, we found UK children scored significantly more poorly than US norms on the SCAN-C [21]. We therefore computed standard scores from our own UK norms (99 UK school children aged 6 to 10 and 11 adults; (our 11 year-olds were treated as 10-year-olds for this purpose). – Performance was then categorised as recommended in the SCAN manual; a composite standard score better than -1 SD is ‘normal’, between -1 and -2 SD is ‘borderline’, and lower than -2 SD is ‘disordered’.

Using UK norms, 40% (10 of 25) APD group and 22% (4 of 18) of the dyslexia group scored within the borderline or disordered range, not statistically significantly different proportions (Fishers $p = .32$). One would expect around 16% of a random sample to score in this range. Note that a surprisingly low proportion of the APD group scored in the clinical range on the SCAN, given that their original diagnosis was partially based upon SCAN performance. The reasons for this are discussed in detail elsewhere [22]. Briefly, the main reasons are i) use of inappropriate US-based norms with UK children and ii) original diagnosis of APD on the basis of poor performance on at least one of four SCAN subtests rather than on the total score, a practice that inflates type 1 error and positive identification of APD.

*Group comparisons*

Group performance on standardised tests was examined via ANOVA. Results are reported in the form of composite scores for language and literacy. The ‘language composite’ score is an average of the standard scores of six language tests (TROG, NEPSY nonword and sentence repetition, ERRNI story telling, MLU and comprehension). The ‘literacy composite’ is the average of the standard scores of three literacy tests (OSCCI spelling, TOWRE word and non-word reading).
Mean composite scores are shown in Table 1. Unsurprisingly, as the group was selected on the basis of poor literacy skills, the dyslexic group did significantly more poorly on the literacy composite, although both groups’ average literacy score was below -1 standard deviation. Groups did not differ significantly on language composite or SCAN composite score.

**INSERT TABLE 1 HERE**

For parent completed questionnaires, the APD group scored more poorly on the CHAPS listening behaviors questionnaire. There was no difference in overall CCC-2 general communication composite (GCC) score. An ANOVA was carried out to compare the average score on each CCC-2 subscale between groups. Both groups scored similarly low on speech, syntax and semantics (an average subscale score is 10 with $SD \ 3$, shown in Figure 1 by a dotted line). After adjusting for multiple comparisons ($p < 0.005$), there were no significant differences between groups on any subscale. ‘Use of context’, ‘nonverbal’, ‘social’ and ‘interests’ subscales were approaching significance ($p'$s 0.02 to 0.06). The subscales on which the difference was approaching significance are associated with autistic spectrum disorders [23]. Overall, both structural language and pragmatic problems were a feature of children with suspected APD.

**INSERT FIGURE 1 HERE**

*Discrepancy between parental report and standardised tests*

During evaluation of individual test results, it was noticed that parents of APD participants tended to rate their children more poorly on the CCC-2 than their child’s performance on standardised
language tests would suggest. This tendency was examined statistically. General communication composites from the CCC-2 were converted to standard scores for comparison with the standardised language composite to have a mean of 100 and a standard deviation of 15. The magnitude of the discrepancy between parental communication checklist and standardised language test was then calculated as the language composite minus the standardised total CCC-2 score (DISCREP). There was a group difference in the magnitude of the average discrepancy score, with the APD group significantly higher (APD $M = 24.32$, $sd = 11.99$, dyslexia $M = 16.88$, $sd = 11.29$, $t(41) = -2.10$ $p < 0.05$, $r = .31$).

One possibility that may explain the discrepancy between parent report of poor communicative competence and relatively good standardised test performance is that while these children may have relatively good structural language, they have difficulties using language appropriately and effectively in more demanding communicative situations. CCC-2 subscales on which group differences were approaching significance were associated with autistic spectrum disorders, with the APD group being rated more poorly on these pragmatic subscales (though non-significant after correction for multiple comparisons).

This raised the question of some children with a diagnosis of APD having unidentified autism spectrum disorders, leading us to obtain approval from the NHS Ethics Committee to obtain additional information from the CAST, 6 to 8 months after the initial study. Valid CAST questionnaires were received from the parents of 12 dyslexia and 18 APD participants. Average CAST raw scores were significantly higher in the APD group ($11.1 \: sd = 5.5$ versus $5.2 \: sd = 2.3$, $t(28) = -3.4$, $p < 0.01$, $r = .54$). The recommended cut-off score for identification of possible clinical cases
is 15. Applying this criterion yielded 6 cases within the APD group (33%) and no cases within the dyslexia group, a marginally non-significantly different proportion (Fishers $p = .06$, two sided).

There was no correlation between DISCREP and CAST raw score ($r = .27$, ns).

**Discussion**

We were interested in whether children diagnosed with APD have a distinctive pattern of psychometric performance, and whether the pattern differed from that of children with dyslexia. Around half of the children diagnosed with APD would fit a diagnosis of dyslexia or SLI or both. Conversely, the dyslexia group scored similarly to the APD group on the SCAN test of auditory processing. A high prevalence of attention/hyperactivity problems were also a feature of both groups. While there was a trend for the APD group to do more poorly than the dyslexia group on all the behavioral measures, the only significant difference in performance between groups was on literacy measures, where the dyslexia group, who had been selected on this basis, did more poorly. Average literacy scores for the APD group were also poor. In terms of severity of attentional, reading, language and auditory processing skills, the difference between APD and dyslexia children is quantitative rather than qualitative, with APD diagnosed children tending to have more severe problems.

One thing that did distinguish these two groups was that in the APD group, there was an unusual discrepancy (DISCREP) between parental ratings of poor communicative competence or listening behaviors and standardized test performance (standardized language tests and the CCC-2, and the CHAPS and the SCAN). We considered the possibility that this might indicate that children who receive a diagnosis of APD have elevated levels of autistic features, since pragmatic difficulties are
often not detected on formal psychometric tests. The average score on a parental report screening test for ASD (the CAST) was significantly higher in the APD group than the dyslexia group. 33% of the APD group (6 children) scored above the clinical cut-off on the CAST. Asperger’s syndrome had been formally diagnosed for only one of the six APD children who scored in the clinical range on the CAST.

This result is consistent with an earlier study based on case-records, which found that 9% of referrals to a specialist APD clinic had a formal diagnosis of autism [24]. Furthermore unusual sensory sensitivity is associated with autistic disorders [25, ] and children with autism have been described as being indifferent to some sounds, such as ignoring someone calling their own name, while also being hypersensitive to sounds, such as hearing sounds that others can not or exhibiting extreme aversive reactions to innocuous sounds [26, 27].

In summary, children diagnosed with APD did not differ qualitatively from those with dyslexia in their performance on psychometric tests of IQ, auditory processing, language or literacy, though there was a tendency for children with APD to perform more poorly across all measures. In contrast to those with dyslexia, children with APD showed a discrepancy between parent report of poor communicative competence and relatively good performance on standardised language tests. We suggest that pragmatic problems associated with autistic spectrum disorder, to which standardised tests are largely insensitive, may partially explain this discrepancy. The most striking finding was that a third of children with an APD diagnosis fell within the clinical range on a screening questionnaire for Asperger syndrome, though ASD had not been formally recognised for most of these cases. It may be useful to screen children referred to APD clinics for ‘listening
difficulties’ for communication problems associated with unrecognised ASD. Effective management might then centre on remediating these children’s pragmatic difficulties. Many children with APD do have demonstrable learning problems, though it is unclear to what extent their reported listening problems are due to actual difficulties with auditory processing, language difficulties or ASD.

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References

Table 1. Mean (SD) scores by group

<table>
<thead>
<tr>
<th>Group</th>
<th>APD</th>
<th>Dyslexia</th>
<th>F statistic</th>
<th>Effect size (ω)</th>
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</thead>
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<tr>
<td>SCAN</td>
<td>91.00 (19.12)</td>
<td>97.20 (16.28)</td>
<td>1.24</td>
<td>.07</td>
</tr>
<tr>
<td>Language composite</td>
<td>94.21 (11.22)</td>
<td>93.25 (7.84)</td>
<td>0.10</td>
<td>.14</td>
</tr>
<tr>
<td>Literacy composite</td>
<td>84.50 (16.97)</td>
<td>75.33 (9.27)</td>
<td>5.24*</td>
<td>.27</td>
</tr>
<tr>
<td>CHAPS total score</td>
<td>-2.09 (0.77 )</td>
<td>-1.6 (0.67</td>
<td>3.65*</td>
<td>.24</td>
</tr>
<tr>
<td>CCC-2 GCC†</td>
<td>37.74 (15.66)</td>
<td>46.37 (23.29)</td>
<td>1.31 w</td>
<td>.16</td>
</tr>
</tbody>
</table>

* p < 0.05
†An average GCC is 82, with lower scores suggesting poorer communication skills
W Welch’s F statistic
Figure 1. Average CCC-2 subscale performance for APD and dyslexia groups

Error bars represent standard deviation. Dotted line represents normative average performance.
What is already known on this topic

Auditory processing disorder (APD) is diagnosed on the basis of listening difficulties and poor performance on tests of auditory processing despite a normal audiogram. There is debate over whether APD is a separate diagnostic entity in its own right with a distinctive psychometric profile, or whether it is a reflection of a more general learning disability.

What this study adds

Children with a diagnosis of APD have high levels of attentional, reading and language difficulties. A substantial minority may also have autistic features. These children are therefore likely to benefit from evaluation by a multidisciplinary team.