

Auditory Processing Disorder (APD) – Be vigilant and aware

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Abstract

Auditory Processing Disorder (APD) are defects of the auditory sense, which result from abnormalities in the functioning of the auditory path at the level of the central nervous system from the center of the Cochlea to the auditory cortex. This is a problem that 2-3% of children, aged 7-14 suffer from in Poland.

The aim of this paper is to establish a spectrum of the most common symptoms as well as to determine the most common age range of the children that have been diagnosed.

A retrospective analysis was conducted, based on the medical documentation of patients diagnosed and treated in the audiological clinic. The examined group consisted of 215 children ages 6 to 18. The inclusion criteria were as follows: normal peripheral hearing and an IQ indicator of at least 85. Data was analyzed with the use of STATISTICA 9.1 program.

The highest number of children were admitted with problems connected to writing (78,15%), reading (69,77%), and concentrating (60,93%). The most common symptoms among patients who have been diagnosed with APD were as follows: late speech development (96%), speech defects (91,4%), problems with learning a language (91,67%). The most numerous group represented were patients aged 10 to 12 (40,93%). The accuracy of the initial diagnosis was the highest in the 6 to 7 age group (96,15%).

The results of this paper speak for the necessity of increasing APD awareness among people close to a child as the problems that emerge are common and a lot of the diagnoses late.

Introduction and aim

Auditory Processing Disorder (in short - APD) consists of problems in the interpretation of auditory information at the level of the central nervous system with a correct reception of said information by the peripheral structures. It is estimated, that this problem concerns 2-3%, and according to some authors even 5% of Polish children ages 7-12 [1,2].

According to the data of the American Speech-Language-Hearing Association (ASHA) people with APD suffer from difficulties in understanding speech amongst noise, localizing and directing sound, differentiating sounds that are similar to each other as well as temporal sound processing. The first symptoms among children may manifest by speech development abnormalities and difficulties in articulating sounds.

In a school environment, children suffering from APD, despite having normal intelligence levels, have a lot of problems due to improper processing of sound impulses. This manifests itself in difficulties in learning how to read, write and problems with concentration that result from the inability to correctly understand the teacher's directions, to follow his statements and poor auditory memory. These children struggle with low self-esteem, have bigger problems with managing stress as well as emotional and social problems [3,4]. That is why proper diagnostics of those disorders is so important. The introduction of tests for these disorders was preceded by complete electrophysiological test as well as imaging tests of the auditory pathway. It was concluded,

that the described symptoms are a result of central damage in the case of patients whose peripheral hearing was normal. Furthermore, imaging showed damages in the area of the cortex responsible for understanding speech. Even though one abnormal result from among the tests described in the methodology is enough to recognize APD, both its sensitivity and specificity is low. It increases considerably in the case of 3 abnormal tests. Given this assumption, the sensitivity of the test used by the authors is around 70%, whereas the specificity is at the level of 80%.

The aim of this paper is to establish a spectrum of the most common symptoms as well as to determine the most common age range of the children that have been diagnosed with auditory processing disorder. Based on the information which age group was predominant among patients with suspected APD and the information what the accuracy of the suspicions was the aim is to determine whether the awareness of this problem among primary school children is sufficient.

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The aim of this paper is to establish a spectrum of the most common symptoms as well as to determine the most common age range of the children that have been diagnosed with auditory processing disorder.

Materials and methods

The data of 215 children were analyzed, including 61 girls and 154 boys aged 6 to 18. These patients were diagnosed in view of APD in the Audiological Clinic at the John Paul II Upper Silesian Child Health Centre in Katowice. The conditions of inclusion into the study included positive peripheral hearing tests (impedance and tonal and also acoustic otoemission – OTE) and the results of an IQ test (WISC-R) of above 85. Exclusion criteria were as follows: correct results of the peripheral hearing test, WISC-R below 85 and incomplete patient data. Four age groups were distinguished according to the levels of school education (which result from a child's age). The first group was children aged 6 and 7 attending preschool of first grade of primary school. The second group consisted of 8 and 9 year olds that attend the second and third grade, i.e. elementary education. The third group consisted of children from 10 to 12 years old which are grades 4 to 6, and finally the last group were children aged 13 and above, attending middle and high schools.

The confirmation of the initial diagnosis was established if the results of at least three of the following tests were not correct:

1. Duration Pattern Test (DPT) or Speech Perception Test (SPT), during which the patient hears three sounds with different length or frequency and the aim is for him to recognize and arrange the tones in order;
2. Compressed Speech Test (CST), during which the patient recognizes monosyllabic words subjected to temporal compression;
3. Filtered Speech Test which consists of repeating 20 words heard in sequence, which were first distorted by a filter;
4. Sound in Noise Test (SIN) which requires the patient to repeat words heard amongst noise at the frequency of 3dB.
5. Gap Detection Test (GDT), during which noises and gaps are presented alternatively and the patient has to recognize them using a button;

6. Dichotic Digit Test (DDT) which consists of repeating two different pairs of numbers that are simultaneously given into each ear;

7. Integration test, which is a part of DDT, during which the patient repeats numbers he hears, that are directed to both ears. This test measures the transfer of information between the hemispheres. The integration process translates into the ability to combine different information presented simultaneously into both ears;

8. Competing Words Test, during which the patient hears different words in each ear simultaneously and has to repeat the word from the left and right ear. This is a test that evaluates the ability to split attention.

All tests were executed in identical conditions. The child was sat down in a specially muted room that was isolated from any external noise and was given headphones through which the technician's instructions and successive stages of the tests were given. Several tests were carried out during one day with rest periods of a few days in order to prevent the child from losing interest and reluctance to participate.

A database was established, which contained information such as: gender; age during the time of the tests; problems reported during the consultation with an audiologist, which may be connected to APD – mainly problems with reading, writing, focusing and speech impediments. The demographic and clinical data was processed using the STATISTICA 9.1 program. The test that was used was connected to qualitative variables – CHI2 with the Yates correction. During the log-linear analysis a statistically relevant effect of two-dimensional interaction was identified.

Results

From the 215 patients that were directed to the audiological clinic with suspected disorders of central auditory processing, 78,14% had their initial diagnosis confirmed. Table 1 contains the age scope of the examined children. The accuracy of APD suspicions among respective age groups is presented in table 2. The largest group among the directed children was 10-12 years old (40,93%). The smallest group consisted of children aged 6 to 7 (12,09%). It is worth mentioning that the accuracy of the diagnosis was largest in this group and was 96,15%. Another noteworthy fact is that the group of patients that were directed late (meaning above the ages of 12), meaning children that are in middle school, was significant. This group consisted of 16% of all patients.

Based on the CHI2 with the Yates correction in unifactorial analysis for the accuracy of the diagnosis a significant difference in the distributions was stated

Also noteworthy, is the fact that boys were directed to examination of central auditory processing more often than girls, adding to the fact that the boys to girls ratio within the younger age groups was 2:1. That discrepancy gets even larger with age as the ratio reaches the level of 3:1 in the 10-12 years old age group (Table 3). Among patients with confirmed APD, this ratio is similar, reaching almost 3:1 at the peak – 10-12 year olds (Table 4).

Table 1. Distribution of age of the examined children.

Age group	Number of children	Percentage distribution
6 -7 years old	26	12,09%
8 – 9 years old	66	30,70%
10 – 12 years old	88	40,93%
> 12 years old	35	16,28%
Total	215	100%

Table 2. Representation of the number of examined children and the number of confirmed APD diagnoses among the established age groups.

Age Group	Number of examined children	Number of confirmed APD diagnoses	Distribution of confirmed diagnoses	CHI ² test with the Yates correction
6-7 years old	26	25	96,15%	p=0,003
8-9 years old	66	58	87,88%	
10-12 years old	88	60	68,18%	
>12 years old	35	25	71,43%	

Table 3. Distribution of gender among the established age groups among children suspected of having APD.

Age groups	Girls	Boys	Total	Percentage of girls	Percentage of boys
6-7 years old	8	18	26	30,77%	69,23%
8-9 years old	21	45	66	31,82%	68,18%
10-12 years old	23	65	88	26,14%	73,86%
>12 years old	9	26	35	25,71%	74,29%
Total	61	154	215	28,37%	71,63%

Table 4. Distribution of gender among the established age groups among children with confirmed APD.

Age group	Number of girls with APD	Number of boys with APD	Percentage of girls with APD	Percentage of boys with APD
6-7 years old	8	17	32,00%	68,00%
8-9 years old	17	41	29,31%	70,69%
10-12 years old	17	43	28,33%	71,67%
>12 years old	7	18	28,00%	72,00%
Total	49	119	29,17%	70,83%

Table 5. Results of tests for partial and marginal associations in the multifactorial log-linear analysis for two-dimensional interactions in the log-linear analysis of three factors.

Interaction	Partial Association	Peripheral association
Medical specialty – Age group	NS (p=0,99)	NS (p=0,98)
Medical specialty – Confirmation of the diagnosis	NS (p=0,11)	NS (p=0,09)
Age group – Confirmation of the diagnosis	p=0,009	p=0,005

The results of tests for partial and marginal associations in the multifactorial log-linear analysis for two-dimensional interactions are presented in table 5. A relevant interaction between the age group and the APD diagnosis was established (Table 5).

Problems reported by parents of children directed to an audiologist according to a descending frequency of reporting are gathered in table 6. The largest number of parents as well as children reported problems with writing. Other often reported issues consisted of difficulties concentrating, speech impediments and not having obtained age appropriate reading skills.

The most common issue among patients diagnosed with APD is a delayed development of speech during childhood, problems at school (mainly in learning languages and math), speech impediments and delayed (Table 7).

Discussion

APD concerns a large population of children, since 3 out of a hundred children in Poland, ages 7 to 13, suffer from this disorder. In his paper published in 2015 De Bonis paid special attention to the importance of diagnosing the disorders of functions such as memory, concentration and problems with the utilization of language in the overall recognition of the issue [5]. Other problems most commonly listed in literature involve problems with hearing in noise and in spaces that have echoes, difficulties with following verbal instructions,

Table 6. Problems reported by patients (and their parents) directed with suspicion of APD.

Problem	Number of children	Percentage
Writing difficulties	168	78,15%
Concentration disorders	131	60,93%
Speech impediments	67	31,16%
Reading difficulties	150	30,23%
Remembering	58	26,98%
Understanding verbal instructions	41	19,07%
Late reactions	28	13,02%
Emotional disorders	28	13,02%
Expressing oneself	28	13,02%
Dyslexia	26	12,09%
Delayed speech development	25	11,63%
The Polish language	24	11,16%
Psychomotor hyperactivity	21	9,77%
Mathematics	12	5,58%
Foreign languages	11	5,12%

misinterpreting short words, frequent asking to repeat statements and distracted focus [6]. Other areas that are being focused on are the capacity of the working memory and auditory lateralization [7]. This corresponds with the results of a study conducted by the authors, which show that the main problems for children with diagnosed APD are: a delayed development of speech (96%), problems with the Polish language (91,67%), speech impediments (91,04%). Also common (seen with around ¼ of the examined patients), were slow work tempo, problems with math, remembering, expressing oneself, foreign languages, reading, understanding verbal instructions, writing and concentration.

These kind of symptoms certainly have a negative effect on a child that functions in a school environment. This leads to school results worse than they would be based on the global intellectual evaluation of the child. It also leads to low self-esteem and emotional disorders of various intensities.

The Polish Otolaryngological Society recommends that the currently

Table 7. Problems with normal functioning among children with a confirmed APD diagnosis.

Problem	Number of children	Number of confirmed diagnoses	Percentage of confirmed diagnoses
Delayed speech development	25	24	96,00%
The Polish language	24	22	91,67%
Other speech disorder	67	61	91,04%
Slow tempo of working	28	24	85,71%
Problems with math	12	10	83,33%
Problems with remembering	58	48	82,76%
Problems with expressing oneself	28	23	82,14%
Problems with foreign languages	11	9	81,82%
Reading problems	150	122	81,33%
Problems with understanding verbal instructions	41	33	80,49%
Writing problems	168	127	75,60%
Concentration disorders	131	99	75,57%
Emotional disorders	28	20	71,43%
Psychomotor hyperactivity	21	15	71,43%
Dyslexia	26	16	61,54%

used evaluations of central auditory processing for children are to be carried out from age 7 onwards (2015 year). The reasons for that are complex, with the main focus being on the development process of the auditory pathways, but also problems with getting younger patients to cooperate on a satisfactory level. There is a lack of set norms for children under the age of 7. Age is a compromise of sorts, that takes into account the fact that on the one side the maturity of the auditory pathway enables it to function close to the level of adults around the age of 12, and on the other side at the age of 7 the overall maturity is advanced enough in order to establish a good level of cooperation with the child [8]. It is also the beginning of education at school. The fact that children from that age group are rarely directed (up to date) to an audiologist may be linked to the fact that clear defects of auditory perception such as problems with reading, writing, expressing oneself and concentration in a class conditions are much more visible in a school environment. That is the time that these defects are being recognized by parents and educators.

The results of our analysis indicate, that the accuracy of the diagnosis was most accurate (96,15%) in the 6 to 7 age group. The majority of this group however, was children that were 7; the analysis includes only three children that were about to (within the following months) turn 7 that had a high intellectual potential. They The youngest 7 year old and children about to turn 7 were directed to the audiological clinic for APD diagnostics the least (12,09% of all directed patients).

In research conducted in Poland, children were subjected to the Dichotic Digit Test (DDT) [9]. A non-correct result was recorded in 11,4% of cases at children aged 7 and in 11,3% of children aged 12. The authors of this research suggest, that screening tests of the central auditory processing should be conducted among school children. Proceeding in this direction will help find those who suffer from above described problems amongst small children and, in consequence, enable taking steps towards correcting them at an early stage. Following that logic even further, the optimal situation would be if those tests were conducted at a pre-school age.

There is an increase of interest in disorders of the central auditory processing, including the issue of the possible methods of early detection of said disorders [10]. Attempts are taken to examine children under the age of seven with objective methods. This kind of objective examination could be very helpful and important in the case of diagnosing children for which tests for APD are not age appropriate. A research that uncovered the differences in the transiently-evoked

otoacoustic emissions (TEOAEs) in children suffering from APD compared to ones that are healthy. The research showed that counter-lateral otoemission suppression is more common with children with APD compared to the control group [11]. Perhaps further research and a standardization of objective tests will enable diagnosing children in the pre-school age.

Finding those disorders is all the more important, as patients suffering from APD can be helped. First of all, the school acoustic environment can be improved. According to ASHA standards, the background noise of the environment in which child is studying should not exceed 30 dB, reverberation can last up to 30 sec and the signal to noise ratio should be lower than 15 dB. This can be achieved by, for example, using noise reducing curtains, however it is a difficult issue and at the moment rarely attained [12]. There are also the so called Frequency Modulation (FM) systems that support hearing in noisy places [13]. Auditory training is also important. Mc Arthur in his research (2009) concluded that instructing and simple speech training can have a positive impact in terms of auditory processing in children [14]. It seems that specially programmed video games, which allow for active training, have considerable potential. They allow for gradation of the difficulty level, to adjust and to increase it based on the child's capabilities [15]. The methods which are currently quite frequently used, that involve passive listening to specially crafted musical programs are somewhat controversial. These methods are not recommended until convincing scientific research is published. Nowadays, schools implement special methods for education of children with this problem i.e., individual teaching on school grounds in terms of specific subjects and / or teaching in smaller groups. Various aiding devices are also being used, which enables children suffering from APD to work more efficiently.

If it cannot be done at an earlier age, children that should be focused on are those, which have significant problems in the first grade of primary school despite having adequate intellectual potential and support from their parents.

Conclusions

The findings of the research conclude, that the knowledge among educators, parents and primary care physicians concerning disorders of the central auditory processing is insufficient, which is why school children are often directed for APD testing late. Symptoms such as delayed speech development; speech impediments; significant

problems with acquiring new skills in first grade despite adequate intellectual potential and support from the parents; difficulties in learning languages, math and concentrating should be considered as red flags as they may indicate the child suffers from APD. It is necessary to raise awareness and vigilance in terms of these issues among people close to the child physicians, especially pediatricians and pediatric neurologists. The benefits of early diagnosis and, in consequence taking appropriate actions cannot be overstated.

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