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Auditory symptoms and psychological characteristics in adults with auditory processing disorders

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Abstract

Most adults with auditory processing disorder (APD) often have trouble at work. It is possible that these listening problems in adults with APD influence their mental health. Thus, we have to take the subject's personality and mental status into consideration when supporting subjects with APD. However, studies on APD in adults are comparatively rare. In this study, we aimed to evaluate the relationships between the results of auditory tests, APD symptoms, and psychological status in subjects with APD. This study included 22 adults who complained of listening problems in everyday life, and they underwent auditory processing tests and were questioned regarding their psychological characteristics.

From the results of the auditory processing tests, all subjects showed low scores on at least one test; therefore, they were suspected of having APD. Especially, the scores were low on the auditory memory test. Furthermore, subjects with APD show relatively similar psychological characteristics to each other. However, there was no significant relationship between the results of the auditory processing tests and psychological characteristics.

We have to take notice of a subject's psychological state when they perceive their listening difficulties as a large-scale problem and feel anxious as a result. For this purpose, we should take psychological characteristics into consideration at the time of the medical examination interview before audio-psychological testing.

Keywords: Auditory processing disorder; Psychological characteristics; Egogram; Developmental disorder

1. Introduction

Subjects with auditory processing disorder (APD) have normal hearing, but find it difficult to understand spoken messages that are complex or under noisy conditions. They also have poor sound localization, impaired dichotic listening, and auditory perceptual deficits (American Academy of Audiology (AAA), 2010). Prevalence estimates of APD in school-aged children are 2–5% (Chermak and Musiek, 1997), and in older adults, 23–76% (Cooper and Gates, 1991). Additionally, APD symptoms exist in young and middle-aged adults. Adults with APD tend to show difficulties in all aspects of their lives and especially at work. They show difficulties with telephone conversations, following complex directions, learning a new language, and so on. Therefore, most adults with APD often have trouble at work. It is possible that these listening problems in adults with APD influence their mental health. Thus, we have to take the subject's personality and mental status into consideration when supporting subjects with APD. However, studies on APD in adults are comparatively rare.

Each country has its own diagnosis and treatment system for APD. Regarding assessment methods, there are a number of auditory processing tests: the dichotic listening test (DLT), speech in noise test, gap detection test (GDT), and so

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on. Recently, the British Society of Audiology (BSA) recommended using both speech and non-speech stimuli in auditory tests (BSA, 2011). If auditory processing is measured solely using speech stimuli, the test results are influenced by language development.

However, it is thought that the symptoms of APD are presented in many other disorders, such as autism spectrum disorder (ASD), dyslexia, and attention deficit/hyperactivity disorders (AD/HD) (BSA, 2011). That is, reduced high-order cognitive abilities play a significant role in APD. Most APD assessments tend to lean toward auditory tasks; therefore, the actual cause of the symptoms cannot always be identified. For this purpose, we must examine a multifaceted assessment system in addition to cognitive and psychological aspects. Among them, previous studies reported the influence of cognitive abilities, attention, and memory on APD symptoms (Moore et al., 2010). However, it is not clear how these psychological aspects influence subjects' listening disabilities, and there are no previous studies on the psychological characteristics of adults with APD.

In the present study, we examined relationships between the results of auditory tests, APD symptoms, and psychological status using personality tests, and investigated the characteristics and causes of impaired auditory cognitive processing in subjects with APD.

2. Methods

2.1. Subjects

This study included 22 adults (mean age, 30.8 ± 11.0 years) who complained of listening problems in everyday life. The subjects visited outpatient clinic for patients with hearing problem, and attended this study. The informed consents were obtained from subjects prior to participation in a study.

All subjects had normal hearing at 500, 1,000, 2,000, and 4000 Hz with thresholds ≥20 dB HL in each ear. Additionally, their syllable intelligibilities were normal. They had normal hearing, but have difficulties to understand spoken messages that were complex or under noisy conditions, therefore, they were suspected of having APD.

Their educational backgrounds included high school graduates, university graduates, and postgraduates, and they did not have intellectual disabilities. In addition, the subjects had no history of neurological disorders, head trauma, or surgery. The subjects underwent auditory processing tasks and were questioned regarding their psychological characteristics.

2.2. Auditory processing tests

A number of auditory processing tests have been developed and used in each country for the diagnosis and treatment of APD. For example, the Tests for auditory processing disorders for children (SCAN-3:C; Keith, 2000), Multiple auditory processing assessment (MAPA; Domitz and Schow, 2000) and Test of auditory processing skills-Third edition (TAPS-3; Martin and Brownell, 2005) screening tests comprise several subtests and are the most commonly used tests in many countries. Furthermore, there are some questionnaires for assessing APD (Wilson et al., 2011). In Japan, there is no standardized screening test; therefore, we used a combination of auditory processing tests. In this study, we assessed subjects' auditory processing abilities using the following four tests: the Japanese Hearing in Noise Test (HINT-J), DLT, GDT, and auditory memory test (AMT).

The HINT is used to measure the ability to hear speech in the presence of noise in many countries. The Japanese version of the HINT is performed under three noise conditions: 1) noise: front (speech and noise both at the 0° azimuth); 2) noise: right (speech at the 0° azimuth and noise from the right side at the +90° azimuth); and 3) noise: left (speech at the 0° azimuth and noise from the left side at the 270° azimuth). The HINT-J consists of 20 sentences. The subjects were asked to repeat the sentences they heard. In this test, the sentences were varied adaptively using one-up and one-down rules so that the speech recognition threshold (SRT) yielding a 50% correct performance could be measured.

The DLT is an auditory psychological test commonly used to measure binaural integration and separation abilities. In this test, different stimuli are simultaneously presented to both ears and subjects are requested to report what they perceive in each trial. If verbal auditory stimuli are presented, most right-handed subjects typically show a right ear advantage (REA) indicating left-hemispheric language dominance. The stimuli used in this study were Japanese monosyllables. During the DLT, the subjects were specifically instructed regarding the direction of attention: either divided attention (listen to stimuli from both ears with the same attention) or focused attention (listen to stimuli with a focus only on the right or left ear). The 40 stimuli were presented in a random order. The next stimulus was presented only after the subject reported what they had heard in the previous instance.

The GDT assesses temporal resolution and multiple tests have been developed in each country, for example, the Gaps-in-Noise (GIN, Musiek et al., 2011) and Adaptive Test of Temporal Resolution (Lister et al., 2006). We independently developed the adaptive GDT and used it in this study. The stimuli in this test were white noise with a silent gap with gap durations ranging from 2 to 66 ms. The subjects were required to judge the presence or absence of a gap. The stimuli were varied adaptively to measure the gap detection threshold of each subject.

2.3. Auditory memory test

The AMT is a logical memory subtest and a part of the Wechsler Memory Scale-Revised. This subtest assesses narrative memory under free recall conditions. Two short stories are presented orally; the subjects are required to retell each story from memory immediately after hearing the stories. Furthermore, the subjects are asked to recall the story 30 min later. The stories were divided into 50 segments, and the segments that they recalled were calculated.

For the auditory tasks, the subjects were seated in a sound-attenuated chamber. Except for the AMT, the stimuli presented to the subjects were played on a personal computer (Windows 7); the subject heard the stimuli through headphones. The stimuli were presented at the most comfortable level. The subject responded orally to the test stimuli they heard and the answers were checked and scored.

2.4. Psychological characteristics

To assess the psychological characteristics of the subjects, we used the Tokyo University Egogram (TEG; Kuboki et al., 1993), Pervasive Developmental Disorders Autism Society Japan Rating Scale (PARS; Ito et al., 2012), and Attention Deficit Hyperactivity Disorder Ration Scale-IV (ADHD-RS-IV).

The TEG is based on transactional analysis theory that emphasizes the ego state. The ego state is explained by thoughts and feelings manifested by corresponding patterns of behavior, and consists of three cardinal ego states: Child, Parent, and Adult. Moreover, the ego state is subdivided into two functional Parent ego states (Critical and Nurturing) and Child ego states (Free and Adapted). The TEG is comprised of a total of five functional ego states: Critical Parent (CP), Nurturing Parent (NP), Adult (A), Free Child (FC), and Adapted Child (AC). On this questionnaire, there are 50 items. The subject was asked to rate each item as "yes," "no," or "intermediate," which were scored as 2, 0, or 1 points, respectively. The total number of points from items in each ego state category was summed. The outlines of ego state patterns and question item examples are summarized in Table 1. The item examples were used English translation items of previous study as reference (Nakahara et al., 2002).

The PARS is a questionnaire used to diagnose ASD; therefore, it is possible to determine a subject's ASD traits by using this scale. This questionnaire has 33 items on a scale from zero to two. The numbers of points from the items were calculated.

The ADHD-RS-IV is a questionnaire regarding the frequency of AD/HD symptoms based on Diagnostic and statistical manual of mental disorders fourth edition (DSM-IV) criteria. This questionnaire has 18 items on a scale of zero to two and consists of two subscales: inattention and hyperactivity-impulsivity. The number of points from this questionnaire was also calculated.

Table 1
Psychological characteristics of each ego state in TEG.

Ego states	Psychological characteristics	Question item example
Critical Parent (CP)	Criticizing and regulating characteristics	I'm hard on people when they are unjust or make mistakes. I'm stubborn and inflexible.
Nurturing Parent (NP)	Permitting and encouraging characteristics	I sympathize easily with others. I often take care of others.
Adult (A)	Focusing on gathering facts and considering alternatives and being objective	I take care of things efficiently. I can express things simply.
Free Child (FC)	self-orientation and optimistic characteristics	I easily join in with casual situations. I'm open and free.
Adapted Child (AC)	Focusing on restraining one's emotions and with social characteristics	I change my opinion in the face of somebody else's objection. I often have to force myself to do things.

3. Statistics

The data from the auditory processing tests were calculated for each test and compared with scores from subjects with normal hearing in a previous study (Obuchi et al., 2013). The overall tendencies of the subjects' psychological characteristics were examined. Furthermore, we analyzed the results of tests statistically using EXSTAT (Excel statistics software, Addinsoft). Pearson's product-moment correlation coefficient and one-way analysis of variance (ANOVA) were used to compare each score.

4. Results

The results of the auditory processing tests are shown in Figs. 1−4. The DLT scores showed REA, and some subjects showed low scores under left ear attention conditions. There were some subjects who showed difficulties on the HINT-J. The scores on the DLT and HINT-J were significantly correlated (right ear scores on the DLT and noise front condition on the HINT-J: $r = -0.75$, $p < 0.01$, right ear scores on the DLT and noise right condition: $r = -0.47$, $p < 0.05$, right ear scores on the DLT and noise left condition: $r = -0.59$, $p < 0.01$).

The subjects in this study tended to show significantly lower scores than normal subjects on the AMT (recall condition: $F = 75.75$, $p < 0.01$; delayed recall condition: $t = 84.06$, $p < 0.01$). Most subjects could not recall even the immediate recall condition. In contrast, there were no differences between subjects with APD and subjects with normal hearing regarding GDT scores ($F = 0.75$, *n.s.*).

Psychological characteristics from the TEG are shown in Fig. 5. According to the mean scores on the TEG, those with

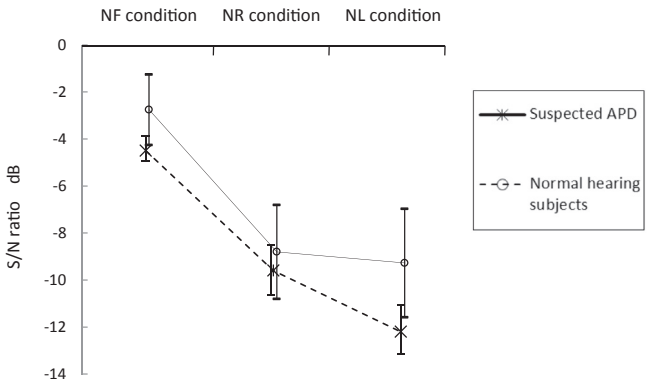

Fig. 1. Results of Hearing in Noise Test − Japanese (HINT-J).

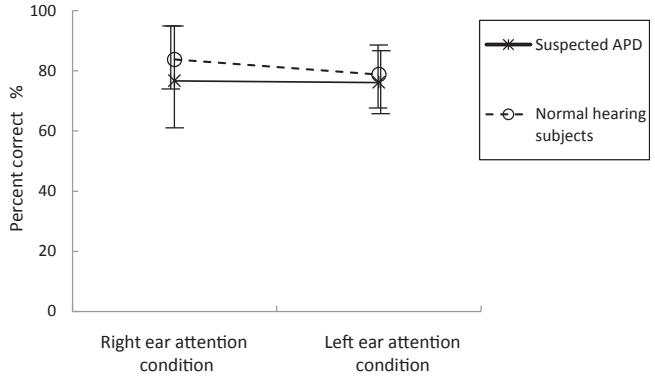

Fig. 2. Results of dichotic listening test.

an AC ego state showed significantly higher scores among subjects with APD ($F = 4.21$, $p < 0.01$); subsequently, those with the FC ego state showed higher scores than those with other ego states.

There was no significant relationship between the results of the auditory processing tests and TEG scores. However, there was relationship between TEG scores and questionnaire scores of developmental disorders. The analysis of each test indicated significant correlations between the A ego state and PARS scores, and between the FC ego state and PARS and ADHD-RS-IV scores.

5. Discussions

In this study, we aimed to evaluate the relationships between the results of auditory tests, APD symptoms, and psychological status in subjects with APD. We also assessed the characteristics and causes of impaired auditory cognitive processing. From the results of the auditory processing tests, all subjects showed low scores on at least one test; therefore, they were suspected of having APD. Especially, the scores were low on the AMT. On the AMT, the subject must focus fully on the presented stories and remember them, which require extensive cognitive ability. As a result, the degree of difficulty of the AMT was high, and many subjects forgot and could not fully recall the stories they heard. It is thought that the different degrees of difficulty of each test influence the differences between the tests. Neijenhuis et al. (2003) evaluated the auditory processing abilities of 49 adults and children using six different auditory processing disorder tests and reported dissimilar error patterns among them. Bellis (2006) explained the necessity of selecting appropriate auditory processing tests that exhibit good sensitivity and specificity for APD. Therefore, we have to understand the purpose of each

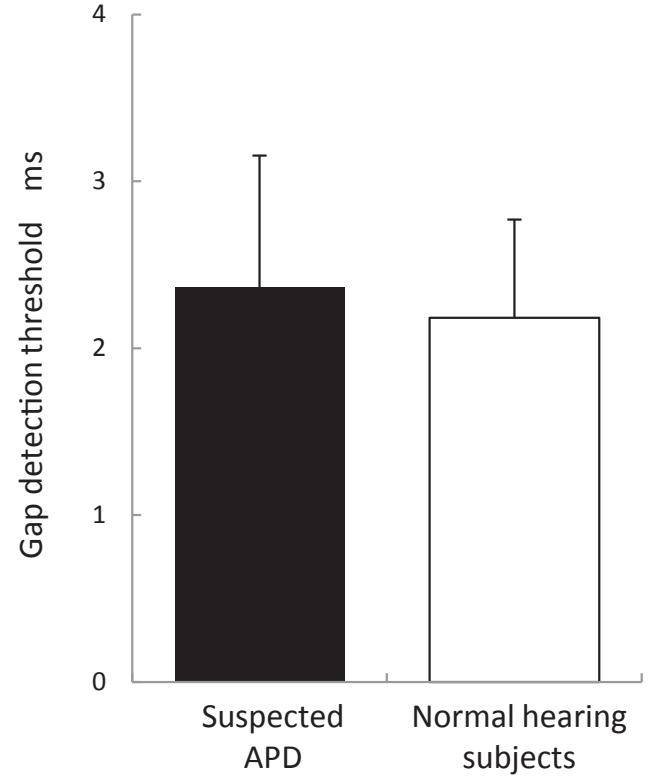

Fig. 3. Results of adaptive Gap detection thresholds.

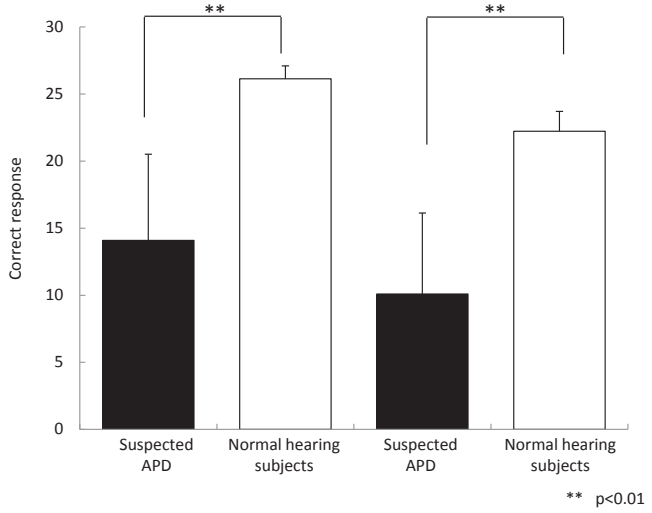

Fig. 4. Results of auditory memory test.

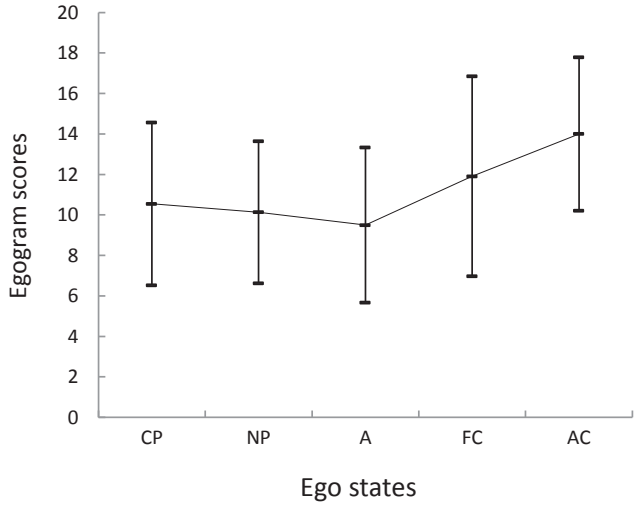

Fig. 5. Results of Tokyo University Egogram (TEG).

test and use them to assess each subject's pattern of listening disabilities.

A number of subjects showed the AC-dominant pattern as a psychological characteristic on the TEG. The AC ego state is associated with focusing on restraining one's emotions and social characteristics but does not involve self-directed thinking. The ego state influences subjective listening difficulties and increases the subject's sense of difficulty. It is thought that they tend to perceive their listening difficulties as a large-scale problem and remain anxious. As a result, they complain about their listening problems profoundly. We must acknowledge these issues and make an effort to abate them.

The scores from the A and FC ego states were correlated with the PARS and ADHD-RS-IV scores; that is, there was a relationship between psychological characteristics and developmental disorder-like traits. The A ego state is associated with the characteristics of focusing on gathering facts, considering alternatives, and being objective, and the FC ego state is associated with self-orientation and optimistic characteristics. It is possible to observe similar characteristics in subjects with developmental disorders such as ASD and AD/HD. Previous studies have reported that children with AD/HD showed sensory processing deficits, and APD and AD/HD have overlapping clinical characteristics (Ghanizadeh, 2009; Lanzetta-Valdo et al., 2017). Moreover, some studies argued that compared with controls, ASD subjects showed poorer scores on some auditory processing tests (DePape et al., 2012; Mamashli et al., 2016). Although the subjects in this study were not diagnosed with developmental disorders, it is thought that they had similar psychological characteristics.

From the above, we suggest that subjects with APD show relatively similar psychological characteristics to each other. Especially, we have to take notice of a subject's psychological state when they perceive their listening difficulties as a large-scale problem and feel anxious as a result. For this purpose, we should take psychological characteristics into consideration at the time of the medical examination interview before audio-psychological testing.

The present study's limitations should be mentioned. It is suggested that APD symptoms are caused by auditory processing, psychological characteristics and so on. However, the neurological basis of APD is not clear. It might be necessary to conduct a study to verify these findings using brain imaging techniques. Further, it is necessary to determine how to reduce the listening disabilities of subjects with APD.

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Conflict of interest

None declared.

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