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RESEARCH ARTICLE

Development and evaluation of the Persian version of the multiple auditory processing assessment

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Abstract

Background and Aim: Auditory processing disorders may have detrimental consequences on a child's life, if undiagnosed and untreated. The multiple auditory processing assessment (MAPA), as a valid model, has been introduced for central auditory processing assessment and diagnosis in school children. The purpose of this study was to design and evaluate the Persian version of MAPA for auditory processing assessment in 9-12 year-old school children.

Methods: The present study was conducted in two phases. First, the Persian version of the MAPA, consisting of five subtests, namely the monaural selective auditory attention, the triplet dichotic digits test, competing sentences, quadruple pitch pattern test and Tap test was developed and compiled into a CD. Second, to assess the Persian version of MAPA, a study was conducted on 300 children of both genders, aged 9-12, who were selected from seven normal primary schools. The children's normal peripheral hearing was ensured through screening, and then central auditory system was assessed through the Persian version of MAPA.

Results: The results showed that the mean scores obtained in each of the five subtests increased with age ($p<0.0001$), and no significant differences was observed between the gender in the mean scores obtained in any of the five subtests ($p>0.05$). The results confirmed high reliability of each of the tests as well as the mean score of all the five subtests (ICC=0.91).

Conclusion: The Persian version of the MAPA has a high validity and test-retest reliability for the assessment of auditory processing in 9-12 year-old Persian-speaking children.

Keywords: Auditory processing disorder; school children; multiple auditory processing assessment

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Introduction

Central auditory processing disorder (CAPD) is an information processing deficiency that is specific to the auditory modality [1]. According to the 1996 consensus statement by the American Speech-Language-Hearing Association (ASHA), the central auditory processing system is responsible for six behavioral processes. These six processes are sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal aspects of audition, auditory performance decrements with competing acoustic signals, and auditory performance decrements with degraded acoustic signals [2].

A rough prevalence estimate for auditory

processing disorders (APD) in childhood is 7% [3]. According to Musiek and Chermak, the prevalence of this disorder is about 2% to 3% in children; they have also mentioned that if the tests are accurate enough the prevalence can be higher. [4] The prevalence of APD in learning disability has been found to be 30-50% [5]. Children with APD may have difficulty recognizing subtle differences between sounds in words or may have difficulty with interpretation of longer strands of auditory information, such as verbal directions. Moreover, children with APD often have significantly increased difficulty in the presence of background noise [6].

Currently, there are two pre-packaged test batteries available to assess and diagnose APD in children. These test batteries are: the screening test for auditory processing disorder (SCAN) and the multiple auditory processing assessment (MAPA) [7,8,9]. The purpose of these test batteries is to allow for early diagnosis and detection of APD in children in order to augment early intervention [9].

In an attempt to provide a reliable behavioral test battery, Domitz and Schow, administered a battery of APD tests to school-aged children. They named their test battery the multiple auditory processing assessment (MAPA) [9]. The MAPA protocol consists of five subtests within three domains of auditory processing, including monaural (low redundancy; monaural separation closure-MSC), temporal (auditory pattern temporal ordering-APTO) and binaural (dichotic speech; binaural integration/binaural separation-BIBS). The tests include the monaural selective auditory attention test (mSAAT), the Tap test, the pitch pattern test (PPT), the dichotic digits test (DDT) and the competing sentences test (CST) [9].

In mSAAT, it requires the subject to listen for a word selected from the monosyllabic word list that is embedded in competing background noise of high-interest speech (e.g. a story). In the Tap test, three series of taps are presented to the listener. After each series the listener must indicate the number of taps heard. The MAPA pitch pattern test, introduces high and low pitches binaurally in a four-tone series, and the subject identifies the pattern by verbalizing, (e.g. high-high-low-high). The MAPA dichotic digits employed number triplets presented dichotically, the subject repeats items from the right ear first, then from the left. In the MAPA competing sentences test, two sentences are presented dichotically, and the subject repeats both sentences. MAPA as a new CAPD battery test compared to SCAN have high sensitivity for CAPD [9,10].

The diagnosis and treatment of auditory processing disorders (APD), especially in children, is at the forefront of research in audiology [11,12,13]. In Iran, no studies have been done on the prevalence of CAPD in school children. Considering high prevalence and effects of some skills including communication and academic and social skill, identifying children at the risk for auditory processing disorders should be a priority, as it enables early intervention, treatment and rehabilitation and reduces their learning difficulties in educational centers [14,15]. Therefore, in this study, we tend to create the Persian version of MAPA which has been introduced as a new test battery for central auditory processing assessment, and to evaluate the Persian version of MAPA for 9-12 year-old school children.

Methods

The present study was carried out in two phases; phase one involved the compilation of a set of tests, and phase two was to assess their reliability. In phase one, five subtests including the mSAAT, the three pair dichotic digits test (DDT), the competing sentences test (CST), the Tap test [9] and the quadruple PPT were recorded on a compacted disk (CD) along with instructions for use and exercises. We used the Persian version of the mSAAT which have been developed and evaluated by Aarabi et al. in Iran University of Medical Sciences [16]. We also developed the three pair DDT and the quadruple PPT based on the new version of the MAPA (Beta III). In developing the three pair DDT, monosyllabic digits 1 to 9 were verbalized by a male talker and the voice

was recorded via analog-to-digital method and software Cubase 5. The CST was derived from the original Persian model of the tests and was adjusted by the researcher for zero signal to noise ratio (SNR) in accordance with the MAPA model. Instructions on how to perform each test were also recorded in the studio by a male talker voice and compiled into a CD along with the five subtests and some exercises and were labelled as the "Persian MAPA model".

In phase two, the researchers were settled in the schools and positioned themselves in a quiet area with no auditory or visual distractions and then randomly selected one classroom and examined all of its students. Prior to the assessments, the students' parents signed the consent form. The dominance of the students' right or left handedness was determined using the Edinburg handedness inventory (EHI). After establishing the students' verbal consent through a short interview and preparing them for completing the tests, a Welch Allyn otoscope was used to assess the tympanic membrane and external auditory canal. A tympanoscopy was then performed on both ears using a Rexton Hand Tymp (Denmark) and an audiometric screening was then performed using the SA78B sound echo device for assessing peripheral hearing. The study began with 324 children aged 9-12 from seven different schools in Arak, but 24 did not meet the inclusion criteria and were thus excluded. The study inclusion criteria for the students consisted of having received normal results on the pure tone audiometry (PTA) for screening peripheral hearing at an intensity level of 20 dB and at frequencies of 500 to 4000 Hz, type A tympanogram (0.3<Ytm<1.6 cc and -50<TPP<+50dapa) in both ears [17], fluent speech without stuttering, willingness to take part in the experiment and not being too tired to complete the tests.

Central auditory assessments were then performed with mSAAT, followed by the DDT, the CST, the Tap and PPT. Instructions to complete the test were explained to each participant in advance and exercises were given to ensure the students' full understanding of the proper completion of the test. The students were free to withdraw from the study at any point in time. The study limitations included difficulty obtaining the consent of Markazi Province, Ministry of Education as well as the school heads and teachers, and ensuring the cooperation of the children in completing the tests. The students with abnormal results on the peripheral hearing test or with inadequate attention and care during the assessments were replaced by other students.

The central auditory assessment tests were carried out on a lap top using A4Tech HS-800 supra aural headsets (U.K). At the beginning of each session, the lap top and headset sound quality was controlled by the sound level meter to ensure a comfortable hearing. Students' responses were recorded simultaneously in the MAPA answer registration form. The Persian version of this form was designed by the researcher in accordance with the original form and includes the respondent's personal details and audiometry, tympanoscopy and central auditory processing test details.

The data obtained in each age group were described using the central tendency and dispersion indices (the mean and standard deviation). The Kolmogorov-Smirnov test was first used to ensure the normal distribution of the data. The independent t-test was then performed to compare the scores obtained by gender and the ANOVA to compare them by age group. The reliability of the MAPA was assessed using the Pearson correlation coefficient, the intra class correlation (ICC) and the standard error of measure (SEM). The data obtained were analyzed using SPSS 22.

Results

A total of 300 normally hearing students with a mean age of 10.48 (±1.11) years were examined in this study. The participants were divided into three age groups. Of these groups, 76 (25.3%) students were 9, 76 (25.3%) students were 10, 74 (24.7%) student were 11 and 74 (24.7%) students were 12 years old. 150 (50%) students were female and 150 (50%) were male, and 289 (96.3%) were right-handed while 11 (3.7%) were left-handed.

Table 1. The mean (standard deviation) and minimum normal scores in the five subtests of the Persian version of the MAPA by age group in percentage (n=300)

Age	Mean (standard deviation)							
	mSAAT (right)	mSAAT (left)	Tap test	PPT	DDT (right)	DDT (left)	CST (right)	CST (left)
9 (n=76)	82.5 (13.1)	82.8 (10.8)	81.1 (11.4)	58.6 (13.5)	81.6 (12.4)	72.8 (11.4)	47.8 (10.1)	39.8 (8.5)
10 (n=76)	85.2 (12.3)	85.8 (11.1)	82.4 (11.3)	59.4 (13.7)	84.2 (11)	76.2 (10.5)	49.7 (10.8)	43.9 (9.6)
11 (n=74)	91.9 (8.4)	91.6 (8.5)	84.0 (10.6)	62.7 (13.6)	89.3 (10.1)	84.8 (9.7)	54.4 (10.6)	48.8 (8.7)
12 (n=74)	93.3 (8.9)	92.9 (8.6)	87.7 (8.9)	63.2 (13)	90.3 (10.1)	86.1 (9.5)	58.6 (10.3)	54.0 (9.5)

mSAAT; monaural selective auditory attention test, PPT; pitch patterns test, DDT, dichotic digits test; CST, competing sentences test

The results of the ANOVA showed statistically significant differences between the age groups in the mean scores obtained in all the five subtests. The results of the Games-Howell post hoc test revealed that the mean scores increased with age ($p<0.0001$). Table 1 presents the mean scores obtained in all the five subtests by age group.

As shown in Fig.1, the independent t-test showed no significant differences between the gender in the mean scores obtained in any of the five subtests ($p>0.05$).

The reliability of the tests was assessed using the Pearson correlation coefficient, the ICC and the SEM, and the obtained results confirmed the reliability of each single test as well as the reliability of the mean score of all the five subtests (Table 2).

Discussion

The present study was conducted to develop and evaluate the Persian version of the MAPA model. The results showed an increase in the mean scores of all the five subtests (the mSAAT, the three pair DDT, the CST, the Tap and the PPT) with age ($p<0.0001$). No significant differences were observed between the genders in the mean scores obtained ($p>0.05$). The assessment of the reliability of the tests confirmed the reliability of each single test as well as of the mean scores of all the five subtests.

Summers studied the MAPA in 8-11 year-old school children and showed an increase in the mean scores of all the tests with age in both genders [10]. Conlin studied the MAPA in 9-13 year-old children and also showed an increase in the mean scores with age [10]. In the present study, the mean scores of all the five subtests increased with age in both genders as well (Table 1). These results were expected as auditory processing improves with the development of the auditory system, the brain hemispheres and the interhemispheric pathways, which occur with the child's growth, and also as the child’s auditory attention and memory improve with age. These improvements result in better test scores with increasing age.

Domitz and Schow conducted a study on 8-9 year-old children using the previous version of the MAPA. Conlin then compared the results of his test with those obtained by Domitz and Schow and reported lower mean scores in all the tests [9]. The mean scores obtained in the present study were also lower than those obtained in the study by Domitz and Schow. Conlin attributed the lower mean scores in his study to the structural changes and the more difficult tasks assigned in the new version of the MAPA (the Beta III version). In the new version, the CST requires 100% correct repeats of the two sentences heard simultaneously, which makes the test more difficult, especially for younger age groups. The mean score obtained in this test by 9 year-old children was reported as 41% (with a standard deviation of

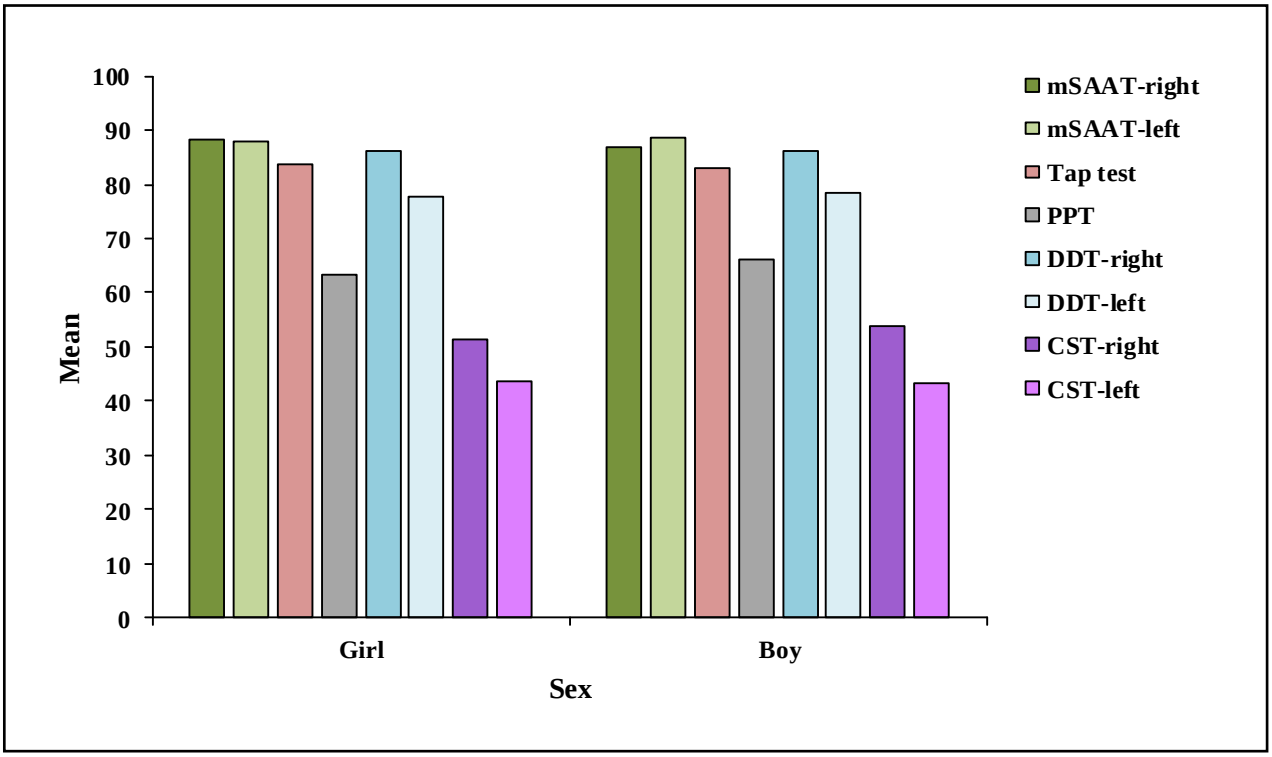

Fig. 1. Mean scores obtained in the five subtests by gender (n=300).

14%) [10], which is consistent with the results of the present study with respect to this age group.

The DDT results obtained in the present study were similar to those obtained by Conlin. The three pair DDT model requires a greater memory engagement, which makes the test more difficult and results in lower scores [10]. The quadruple PPT is also more difficult and results in lower mean scores [10]. The results obtained in the present study for the PPT were similar to those obtained by Conlin.

Nevertheless, the results obtained in the present study for the mSAAT were inconsistent with those obtained by Conlin. The different results may be attributed to the differences in the language structure and content of the two studies and the cultural differences amongst the participants [10]. The differences in study methods may also be at play. A comparison of the obtained mean scores with the normal scores shows the necessity of conducting further studies on the Persian version of the MAPA in different age groups.

Aarabi et al. used the Persian version of the mSAAT to examine 34 (27 normal and 7 learning disabled) school children aged 7-9 and reported the mean scores obtained by the 9 year-old children as 92%, which is very similar to the score reported in the present study. They also confirmed the reliability of the Persian version of the mSAAT with an ICC of 0.79 [16].

Rajabpur et al. carried out the two pair DDT on 7-9 year-old male school children [18], and reported higher mean scores with this test than with the three pair DDT used in the present study in the group of 9 year-old children. The different results may be attributed to the different structure of the three pair DDT which engages the memory more than the two pair version [10].

In the present study, the reliability of the Persian version of the MAPA was assessed using different statistical methods, all of which showed a good reliability for the tests. The Pearson correlation coefficient was 0.85 for the mean scores of all the five subtests, ranging

Table 2. The test-retest reliability of the tests in the Persian version of the MAPA (n=32)

	Mean (SD)					ICC			SEM	
	Test		Re-test		Pearson correlation coefficient	Single test	Mean of the tests	p	Single test	Mean of the tests
mSAAT-right	7.6	88.23	8.5	88.6	0.74	0.74	0.85	0.0001	0.5	0.3
mSAAT-left	7.8	88.27	7.5	88.2	0.78	0.78	0.88	0.0001	0.4	0.3
Tap test	9.4	83.4	10.4	79.03	0.8	0.79	0.88	0.0001	0.5	0.3
PPT	11.6	60.97	8.2	61.8	0.84	0.79	0.88	0.0001	0.5	0.3
DDT-right	9.3	86.35	9.05	87.03	0.82	0.82	0.9	0.0001	0.4	0.3
DDT-left	10.3	79.9	10.05	77.3	0.68	0.68	0.81	0.0001	0.8	0.6
CST-right	8.6	62.63	7.3	60.62	0.71	0.71	0.83	0.0001	0.5	0.4
CST-left	9.7	48.06	6.9	46.2	0.63	0.59	0.74	0.0001	0.8	0.6
Mean score of the five subtests	5.1	79.8	4.8	78.08	0.85	0.85	0.91	0.0001	0.1	0.14

ICC; interaclass correlation, SEM; standard error of measure, mSAAT; monaural selective auditory attention test, PPT; pitch patterns test, DDT; dichotic digits test, CST; competing sentences test

from 0.63 to 0.82 for each (Table 2). The ICC provides a highly sensitive measure of reliability. The reliability of all the tests was confirmed with ICCs of 0.85 and 0.88 for the mSAAT (right and left ears), 0.88 for the PPT, 0.88 for the Tap, 0.9 and 0.81 for the DDT (right and left ears) and 0.83 and 0.74 for the CST (right and left ears); ($p<0.0001$). According to the SEM, all the tests had a good reliability.

In the study by Domitz and Schow, the correlation coefficient of the mean scores was reported as 0.94 for all the tests, ranging from 0.54 to 0.99 for the single tests [9]. Schow and Domitz reported the correlation coefficients obtained for the two pair DDT and the CST as 0.54 and 0.57 which are not very favorable and require further studies. In the study conducted by Summers on 8-11 year-old school children, the test-retest reliability of the mSAAT, PPT, Tap, DDT and CST was confirmed with Pearson correlation coefficients of 0.67, 0.91, 0.77, 0.73, and 0.86, respectively. The overall reliability of the MAPA was also reported as favorable by the SEM. In a study by Shiffman conducted over two consecutive years, the reliability of the MAPA was confirmed with a Pearson correlation coefficient of 0.85 [10].

The present study was conducted on 300 subjects among 9-12 year-old school children in the third grade and above. This population was selected due to the onset of auditory processing disorders from this age. Screening for this disorder is therefore recommended to begin from this age. Furthermore, children understand how to complete auditory processing tests only from this age [9,10]. Summers [10] and Domitz and Schow also selected their participants from third-graders and above.

Conclusion

The results of the present study confirmed appropriate reliability and validity of the Persian MAPA model with five subtests. An increase in the mean scores was observed in all the subtests with increasing age. No significant differences were observed between the genders in the mean scores obtained in any of the subtests. The Persian version of the MAPA has an apparent utility as a multiple-test CAPD battery for 9-12 year-old school-age children from both genders. In addition, the non-invasiveness and low cost of this set of tests enable its clinical application. This model comes with a CD and

is well-suited for use in the classroom or in acoustic rooms. Further study will be needed on other ages in normal subjects and on children suspected of the disorder for a better validity-assessment of this set of tests.

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