Research Article

Clinical Application of the Persian Version of Buffalo Model Questionnaire by examining Its correlation with the Buffalo Model Test Battery

Farnoush Jarollahi[1], Shoreh Jalaie[2], Mohsen Ahadi[1], Zohreh Ahmadi[3], Saeedeh Khamisabadi[1*]

1. Department of Audiology, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran
2. School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran
3. Rehabilitation Science, School of Health Science, University of Ottawa

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Highlights

- P-BMQ is a useful tool for screening of auditory processing evaluation in children
- In this study we investigated the correlation of P-BMQ and central test battery
- The Prevalence of CAPD in SLD based on the Buffalo test battery was obtained

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*** Corresponding Author:**
Department of Audiology, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
khamisabadisaeede@gmail.com

ABSTRACT

Background and Aim: The Buffalo Model Questionnaire (BMQ) has been proposed for the screening, helping to diagnose and also monitoring the effect of rehabilitation on the improvement of Central Auditory Processing Disorder ((C)APD). In this regard, the applicability and accuracy of Persian-BMQ (P-BMQ) are evaluated by examining the correlation between the results of this questionnaire and the Buffalo model test battery.

Methods: Overall, 254 children, normal and with Specific Learning Disorder (SLD) aged between 7–12 years old participated in this cross-sectional study. The questionnaire was completed by the parents of children who were subjected to the Buffalo model test battery evaluations.

Results: In the normal group, the highest correlation (0.648) was shown between the Decoding (D) component of the P-BMQ with the Row Staggered Spondaic Word (RSSW) variable. In the SLD group, the highest correlation (0.318) was shown between the Variance-tolerance fading memory (V) component of the P-BMQ and the qualitative Persian version of the Phonemic Sentence Test (P-PST) variable. The highest correlation was considered to be between the D component of the P-BMQ with the Right Competitive word, started in the Left ear (RC-LEF) variable in the SSW test (0.498), and qualitative P-PST variable (0.471); and 0.360 between the V component of the P-BMQ and Persian version of the Speech in Noise with S/N=4 in the Left ear (P-SIN4L) of variable in the P-SIN test.

Conclusion: P-BMQ is a useful screening tool complementing the Persian Buffalo model test battery for evaluating auditory processing evaluation in children.

Keywords: Central auditory processing disorder; specific learning disorder; Buffalo model questionnaire

Introduction

(Central) Auditory Processing Disorder ((C)APD) can be considered one important cause of educational problems [1]. Children who have (C)APD could have one or all of these problems: speech perception in noise difficulty; difficulty in processing fast speech, poor listening skills; weakness in following the sequence of directions; requests to repeat the subjects; delayed response to verbal stimuli; weakness in the implementation of phonetic and language skills; difficulties in pronunciation, reading and learning; and, rapid fatigue against long-term mental activities [1]. The prevalence of (C)APD in the population of normal children in the USA is 5% [2], and in Iran is 4.6% [3], and in specific learning disabled children is about 30–50% in the USA [4] and about 75% in Iran [5]. Due to the high prevalence of (C)APD and its significant consequences on auditory skills, early diagnosis, and treatment of (C)APD are very important; and requires proper knowledge of parents and educators about the child's performance. Considering the complexity of the auditory system, the diagnosis of (C)APD would be a challenging process requiring a comprehensive assessment consisting of a set of physiological and behavioral tests performed during several sessions [6]. Therefore, (C)APD features are classified into broader classes to allow a better understanding of a person's (central) auditory processing problems, identify the consequent communication and educational problems, and determine what is needed to improve such disorders [6]. (C)APD classifications can also facilitate the explanation of the mentioned problems to a child's parents and teachers and the development of an appropriate treatment plan [6]. Audiologists need to be able to assess the integrity of the entire auditory system to provide services to people with communication, language, and specific learning disorders. It is also essential to use accurate and comprehensive tools, such as questionnaires, to help diagnose Auditory Processing Disorder (APD).

One of the most common methods of diagnosis and remediation of (C)APD is based on the Buffalo model which is a remediation protocol consisting of a test battery and a questionnaire. The Buffalo Model Questionnaire (BMQ) is one of the available specialized questionnaires in this field and has gained greater attention compared to other (C)APD questionnaires due to its high sensitivity (95%) and specificity (85%) [7]. This questionnaire was first introduced by Katz in 1996 after the American Speech-Language-Hearing Association (ASHA) announced the need for screening children at risk for (C)APD. In the following years, the questionnaire was expanded based on experiences in the diagnosis and treatment of people with (C)APD. In this questionnaire, the behavioral characteristics frequently observed in people with APD were recorded. Therefore, rather than a mere product of the Buffalo model, the BMQ is the result of knowledge and experience gained during research to obtain an effective screening tool for (C)APD [8]. The BMQ is a 48-item questionnaire with nine General questions (G) and 39 questions for the assessment of Decoding (D), Integration (I), Organization (O), Memory (M), Various tolerance fading memory (V), Central auditory processing (C) and performance in the presence of Noise (N). The questionnaire's information is related to the three age groups of <6 years old, 6–18 years old, and >18 years old [8]. The practical information obtained from this questionnaire can be used before (C)APD assessment for screening; after (C)APD assessment to confirm the findings of diagnostic tests; before, during and after implementation to confirm the progress of (C)APD remediation [9].

The developed checklists and questionnaires should be APD-specific, and the evaluated functions should not be influenced by non-auditory factors (e.g. language or memory) to avoid the over-referral of children with non-auditory problems for APD assessment [10]. The advantage of the BMQ over other (C)APD questionnaires is that it only involves auditory information [8]. BMQ is the cheapest (C)APD assessment tool, requires the shortest screening time, and is accessible to all individuals dealing with children including parents, educators, psychologists, speech therapists, occupational therapists and speech-language pathologists.

Now, the Persian version of BMQ (P-BMQ) as a clinical tool is available [11] and in an attempt to recommend the P-BMQ as a complement to the Persian version of the Buffalo model diagnostic test battery (i.e. Persian Staggered Spondaic Word (P-SSW)) [12, 13], Persian Phonemic Synthesis Test (P-PST) [13, 14], and Persian Speech in Noise (P-SIN) [15] in (C)APD evaluation, its applicability and accuracy should be evaluated. This is done by determining the correlation between the results of this questionnaire and the test battery of the Buffalo model [16, 17], and it can lead to the timely identification and remediation of children suspected of (C)APD. So, in this article, the importance of using this questionnaire in its clinical application has been investigated.

Methods

This cross-sectional study was conducted on school-age normal (control group) and Specific Learning Disorder (SLD) (target group) children in the city of Tehran. The differences and similarities in P-BMQ scores were compared between these two groups.

In the control group, 60 normal children (30 female) aged 7–12 years with mean(SD) 9.11(1.63), were chosen using a randomized sampling method, from public elementary schools in districts 1 to 6 of Tehran from each class.

In the target group, 149 specific learning disabled children, 83 females (55.7%) aged 7–12 years with mean(SD) 8.47(1.41) were randomly selected by visiting the health centers and special schools for SLD children from 1 to 18 districts in Tehran city. The type of specific learning disorder was determined by studying the child`s medical file. In these medical files, the diagnosis of SLD and its type was clear, and most children had reading and writing disorders, but it was not clear based on what criteria the psychologist made this diagnosis.

After the parents completed the consent form, both groups were referred to the audiology clinic, School of rehabilitation sciences, Iran University of Medical Sciences (IUMS).

The inclusion criteria for the control group were normal peripheral hearing, no ear infections, no speech and language disorders, non of functional and neurological disorders, being right-handed, and being monolingual. The inclusion criteria for the target group included all the criteria for the control group that were mentioned except for specific learning disability. The exclusion criteria for both groups were parents' lack of motivation to complete the questionnaire.

At the audiology clinic, the external auditory canal and tympanic membrane were examined using otoscopy, and both ears were assessed using a handheld tympanometer (Tymp, Rexton, Denmark) and an audiometer (SA78B, Pejvak Ava, Iran). An intensity level of 20 dB at 500–4000 Hz was set as normal in pure tone audiometry and type A tympanometry (–50<TPP (dapa)<+50, 0.3<Ytm (mmho)<1.6). Then, (C)APD assessment test battery (P-SSW, P-PST, P-SIN) was performed on the subjects in an audiometry acoustic room, with a laptop and a headphone (TDH39 model). Simultaneously, the parents were then asked to fill out the BMQ and researchers would answer all questions of parents if there were any ambiguities.

Forty items were used in the P-SSW test. Each item included four monosyllable words. The first and second words consist of a spondee word. The third and fourth words consist of the second spondee word. Also, the first monosyllable word and the fourth monosyllable word develop another meaningful spondee word. The second and third words are presented in a competing manner. The first and fourth word is presented in a non-competing manner. SSW test indicators include Right Noncompetitive word started in the Right ear)RNC-REF(, Right Competitive word started in the Right ear)RC-REF(, Left Competitive word started in the Right ear)LC-REF(, Left Noncompetitive word started in the Left ear)LNC-LEF(, Left Competitive word started in the Left ear)LC-LEF(, Right Competitive word started in the Left ear)RC-LEF(, Right Noncompetitive word started in the Left ear (RNC-LEF(, Row SSW)RSSW(, Corrected SSW)CSSW(.[18].

In the P-PST, two lists of 25 monosyllabic words were presented phoneme by phoneme to both ears and, the listener must put these phonemes together and say the desired word. P-PST indicators include a quantitative score and a qualitative score. In the quantitative evaluation, 4 points are given to each word and the score is expressed as a percentage. The quality score is checked according to qualifier indicators X, XX, Q, QR, NF, Rv, P, and 1st [14]. In the SIN test, 25 monosyllabic words in the presence of interfering noise signal were presented to both ears and the auditory word recognition was calculated by percentage. SIN test indicators include SIN8R: speech in noise with S/N=8 in the right ear, SIN4R: speech in noise with S/N=4 in the right ear, SIN0R: speech in noise with S/N=0 in the right ear, SIN8L: speech in noise with S/N=8 in the left ear, SIN4L: speech in noise with S/N=4 in the left ear, SIN0L: speech in noise with S/N=0 in the left ear, SINR: total speech in noise in the right ear, SINL: total speech in noise in the left ear [15]. All the tests were evaluated at a person's comfortable listening level (50–60 dB SPL).

SPSS version 17 was used for statistical analysis. The Kolmogorov-Smirnov test was used to determine the normality of the data. In descriptive statistics, in order to calculate the percentage of normal and abnormal results in the central battery test, mean and SD were calculated. In statistical analysis, the relationship between P-BMQ and central auditory processing test batteries was tested using Pearson correlation coefficients. A p-value less than 0.05 and 0.01 were considered statistically significant.

Table 1. Percentage of abnormal scores in specific learning disabled children based on gold standard test battery for central auditory processing disorder

Test battery	%			
	P-SSW	P-PST	P-SIN	P-SSW, P-PST, P-SIN
Abnormal	10.5	5.3	4.8	19.1
Normal	89.5	94.7	95.2	80.9

P-SSW; Persian version of staggered spondaic word, P-PST; Persian version of phonemic sentence test, P-SIN; Persian version of speech in noise

Results

Evaluation of data of 149 specific learning disabled children with Buffalo model test battery showed abnormal scores in P-PST, P-SIN, and P-SSW tests (5.3%, 4.8%, and 10.5%, respectively) in the SLD participants; Moreover, 19.1% of them had abnormal scores in all three tests (Table 1).

After assessment with Buffalo model diagnostic test battery for APD (P-SSW, P-PST, P-SIN), the children with SLD were categorized as those with (C)APD and those without (C)APD. The latter group included children with SLD who did not have abnormal scores in SSW, PST, and SIN tests. The correlations between P-SSW, P-PST, P-SIN tests, and the P- BMQ (concurrent validity) were evaluated in both study groups in general. A significant positive direct relationship was observed between the P-BMQ components and the sum of RSSW and P-SIN in left ear scores. In this direct relationship, the highest correlation (0.479) was between all components and the ∑CAP scores of the P-BMQ and the RSSW score. Moreover, significant negative inverse relationships were observed between the P-BMQ components and the sum of qualitative and quantitative P-PST, the highest correlation in this case (–0.471) was between the score of component D of the P-BMQ and the quantitative P-PST variable and the lowest significant correlation (–0.187) was between the component G of the P-BMQ and the quantitative P-PST (Appendix 1).

Overall correlations between the P-BMQ components and the Buffalo model test battery scores in normal children and SLD groups, i.e., SLD not suspected of (C)APD and SLD with (C)APD (concurrent validity), showed the highest correlation (0.617) between the total score of

Table 2. Cutoff point of Persian version of Buffalo model questionnaire

Item	Subtest	Mean*(SD)	Cutoff	Sensitivity (%)	Specificity (%)
1	D	0.10(0.30)	0	77.0	90.0
2	N	0.10(0.30)	0	75.0	90.0
3	M	0.05(0.20)	1.5	85.0	95.0
4	V	0.01(0.12)	1.5	79.0	69.0
5	I	0.08(0.27)	0	65.5	92.0
6	O	0.03(0.18)	1.5	41.0	97.0
7	C	0.03(0.18)	1.5	48.0	100.0
8	G	0.16(0.45)	1.5	79.7	87.0
9	∑CAP	0.40(0.82)	3.5	96.6	67.0
10	Total	0.48(0.96)	4.5	95.3	83.0

D; decoding, N; noise, M; memory, V; various tolerance fading memory, I; integration, O; organization, C; central auditor processing, G; general questions, CAP; central auditory processing

* The mean of incorrect response of BMQ

∑CAP component of the BMQ and the RSSW variable in the normal group. In the SLD group, the highest correlation (–0.338) was seen between component D of the P-BMQ and the quantitative PST score (Appendix 2).

The correlation between the P-BMQ and the Buffalo model tests battery was examined to evaluate the concurrent validity of the questionnaire with each test, the results of Pearson correlation analysis showed a moderate positive direct relationship between the P-BMQ components and the sum of the RSSW scores. In this direct relationship, the highest correlation (0.498) was between the component D score of the P-BMQ and component RC-LEF of the RSSW variable and the lowest significant correlation (0.152) was between the component G of the P-BMQ and the RC-REF and LC-REF (Appendix 3).

According to the correlation of the P-BMQ and PST components, the results of Pearson correlation analysis showed a less significant relationship between the components of the P-BMQ and the quantitative and qualitative scores of P-PST scores. We used all evaluations and scoring based on the formulation reported by the test manufacturer and both quantitative and qualitative scores [14]. In this relationship, the highest correlation (–0.459) was between the ∑CAP score of the P-BMQ and the qualitative PST component of the P-PST. The lowest significant correlation (0.145) was between component N of the P-BMQ and qualifier component XX of the P-PST. In other words, the moderate relationship between the components of the two variables under study varied between 0.145 and 0.459 (Appendix 4).

The results of Pearson correlation analysis showed moderate relationships between the components of the P-BMQ and the sum of P-SIN scores. The highest correlation (–0.360) was between the N score of the P-BMQ and the signal-to-noise equal to 4 in the left ear (component SIN4L) of the P-SIN variable and the lowest significant correlation (0.145) was between component V of the P-BMQ and the equal signal-to-noise ratio of the right ear)component SIN0R(of the P-SIN variable (Appendix 5).

The results of the questionnaire including mean values, standard deviation and cutoff values from 60 normal children aged 7 to 12 years and 149 children with specific learning disabilities have been inserted in Table 2.

Discussion

In this study, 209 children were studied, and 39.6% showed abnormal results in the Buffalo model battery test. A direct and positive correlation was observed between P-BMQ and SSW and PST. A negative and inverse relationship was observed between P-BMQ and PST. In the normal group, the highest correlation between the ∑CAP component of P-BMQ and RSSW results was observed. In the SLD group, the highest correlation was observed between the D component of P-BMQ and P-PST. In the SSW survey, the correlation range was between 0.152 and 0.498.

In the P-PST analysis, the correlation range was from 0.145 to 0.459. In the study of P-SIN, the correlation range was from 0.145 to 0.360. Based on the correlation results, a higher correlation was observed between P-SSW and P-BMQ and between P-PST and P-BMQ than between P-SIN and P-BMQ.

Likewise, Pavlick et al. examined the relationship between the BMQ, as a (C)APD screening tool, and the results of a battery of diagnostic tests for (C)APD [7]. Since the SSW and P-PST are multidimensional, most of the functions identified in the BMQ are also covered by diagnostic evaluation tests [7]. There was a weak correlation between the BMQ components and the sum of SIN scores. Consistently, the results of the Pavlick et al. study in 2010 showed that the SSW and the P-PST are significantly related to the BMQ, whereas the SIN test was not [7]. To explain these results, the author referred to the fact that the BMQ questions cover more hearing behaviors related to SSW and PST than SIN and it is why the SIN is not highly correlated to BMQ [7]. Since most SLD children had deficits in reading and writing, then perhaps another reason for the higher correlation between P-BMQ and SSW can be considered.

The correlation values in this study are not significant compared to Pavlick et al.'s study. In this research, due to time and cost limitations, it was not possible to examine a sufficient number of samples that only have (C)APD, and SLD children comorbid with (C)APD were investigated. P-BMQ cannot be used alone to evaluate (C)APD, but due to the existence of a relatively good correlation, it can be used as a complementary tool along with the Buffalo model battery test.

The routine application of a screening tool can contribute to more comprehensive assessments using (C)APD evaluation tests [7]. Programs for (C)APD diagnosis in school-age children must 1) emphasize behaviors that are essential in the processing of complex auditory stimuli, such as temporal processing or auditory discrimination; 2) have sensitivity and specificity standards; 3) clearly show the pass or refer criteria; 4) have test-retest reliability and good validity [7]. According to the results, the P-BMQ has the four items mentioned above. It has a clear sensitivity, specificity, and cut-off (Table 2). Validity, and reliability values have been published in our older paper [11]. The P-BMQ has good psychometric properties and can be used as a parent-educator-assessor scale for screening 7–12-year-old children [11]. The questionnaire has acceptable sensitivity and specificity (more than 80%) when used between normal and abnormal groups.

Therefore, the BMQ can be used as a screening tool for 7–12 school-aged children, and as a complement to the Buffalo model diagnostic test battery in diagnosis and remediation for (C)APD children.

Conclusion

The Persian version of Buffalo Model Questionnaire has acceptable sensitivity and specificity values, appropriate psychometric characteristics, the presence of cutoff point data, and good validity and reliability. So, it is a safe clinical option and useful screening tool as a complement to the Persian version of the Buffalo model test battery for evaluating and remediating auditory processing disorder in 7–12 year-old children.

Ethical Considerations

Compliance with ethical guidelines

This paper is confirmed by Ethic Code No. IR.IUMS.REC.1394.9211301206.

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Authors' contributions

FJ: Study design, revised and supervision the manuscript; SJ: Statistical analysis; MA: Critical revision of the manuscript; ZA: Drafting the manuscript; SK: Study design, drafting the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

Appendix 1. Correlation of the Persian version of Buffalo model questionnaire components with the Buffalo model test battery

BMQ components	P-SSW		P-PST		P-SIN test	
	RSSW	CSSW	Qualitative PST	Quantitative PST	Left ear	Right ear
D	0.471**	0.471**	–0.427**	–0.471**	0.251**	0.158*
N	0.254**	0.254**	–0.288**	–0.303**	0.187**	0.080
M	0.393**	0.393**	–0.354**	–0.375**	0.232**	0.067
V	0.337**	0.337**	–0.305**	–0.297**	0.246**	0.088
I	0.259**	0.259**	–0.254**	–0.237**	0.262**	0.198**
O	0.107	0.107	–0.092	–0.075	0.000	-0.129
C	0.386**	0.386**	–0.415**	–0.400**	0.294**	0.119
G	0.212**	0.212**	–0.212**	–0.187**	0.183**	0.007
∑CAP	0.479**	0.479**	–0.459**	–0.470**	0.318**	0.139*
TOTAL	0.463**	0.463**	–0.445**	–0.445**	0.316**	0.120

BMQ; Buffalo model questionnaire, P-SSW; Persian version of Staggered Spondaic Word, P-PST; Persian version of phonemic sentence test, P-SIN; Persian version of Speech in Noise, RSSW; row SSW, CSSW; Corrected-SSW, D; decoding, N; noise, M; memory, V; various tolerance fading memory, I; integration, O; organization, C; central auditory processing, G; general questions, CAP; central auditor processing

** Significance at 0.01 level, * Significance at 0.05 level

Appendix 2. Correlations between the Persian Buffalo model questionnaire components and the Buffalo model test battery in normal and specific learning disorder with, central auditory processing disorder children

Groups	P-BMQ components	P-SSW		P-PST		P-SIN test	
		RSSW	CSSW	Qualitative PST	Qualitative PST	Left ear	Right ear
Normal	D	0.648**	0.648**	–0.398**	–0.352**	–0.030	0.073
	N	0.246	0.246	–0.286*	–0.457**	–0.030	0.398**
	M	0.246	0.246	–0.236	–0.278*	0.162	0.188
	V	0.191	0.191	–0.125	–0.189	0.066	0.263*
	I	0.279*	0.279*	–0.156	–0.067	0.153	0.175
	O	0.064	0.064	–0.066	–0.138	–0.128	–0.043
	C	0.361**	0.361**	–0.365**	–0.225	–0.128	–0.001
	G	0.135	0.135	0.002	–0.074	0.165	0.263*
	∑CAP	0.617**	0.617**	–0.444**	–0.472**	–0.032	0.326*
	TOTAL	0.562**	0.562**	–0.411**	–0.424**	0.069	0.401**
SLD with (C)APD	D	0.249	0.249	–0.251	–0.299*	–0.003	–0.014
	N	–0.185	–0.185	0.057	0.092	0.129	–0.137
	M	0.013	0.013	–0.021	–0.054	–0.066	0.039
	V	0.210	0.210	–0.290*	–0.318*	0.029	0.125
	I	–0.086	–0.086	0.035	0.057	–0.084	0.261
	O	–0.035	–0.035	–0.028	–0.011	–0.057	–0.098
	C	0.150	0.150	–0.275	–0.216	0.026	–0.055
	G	–0.282	–0.282	0.133	0.203	–0.053	–0.279
	∑CAP	0.093	0.093	–0.222	–0.219	0.007	0.046
	TOTAL	–0.019	–0.019	–0.147	–0.119	–0.013	–0.058

P-BMQ; Persian-Buffalo model questionnaire, P-SSW; Persian version of staggered spondaic word, P-PST; Persian version of phonemic sentence test, P-SIN; Persian version of speech in noise, RSSW; row SSW, CSSW; corrected-SSW, D; decoding, N; noise, M; memory, V; various tolerance fading memory, I; integration, O; organization, C; central auditor processing, G; general questions, CAP; central auditor processing, SLD; specific learning disorder, CAP; central auditor processing

** Significance at 0.01 level, * Significance at 0.05 level

Appendix 3. Correlation between the Persian version of Buffalo model questionnaire and the P-Persian staggered spondaic word test

P-SSW / P-BMQ component	RNC-REF	RC-REF	LC-REF	LNC-REF	LNC-LEF	LC-LEF	RC-LEF	RNC-LEF	RSSW
D	0.388**	0.446**	0.315**	0.288**	0.330**	0.357**	0.498**	0.483**	0.471**
N	0.127	0.196**	0.191**	0.204**	0.170*	0.248**	0.273**	0.215**	0.254**
M	0.301**	0.382**	0.289**	0.230**	0.292**	0.389**	0.310**	0.324**	0.393**
V	0.248**	0.268**	0.262**	0.237**	0.267**	0.338**	0.271**	0.272**	0.337**
I	0.136*	0.165*	0.245**	0.207**	0.213**	0.265**	0.228**	0.183**	0.259**
O	0.120	0.147	0.066	-0.021	0.112	0.095	0.136*	0.033	0.107
C	0.262**	0.342**	0.261**	0.263**	0.241**	0.408**	0.353**	0.333**	0.386**
G	0.169*	0.152*	0.152*	0.188**	0.162*	0.200**	0.199**	0.153*	0.212**
∑CAP	0.345**	0.419**	0.353**	0.311**	0.346**	0.453**	0.449**	0.413**	0.479**
TOTAL	0.333**	0.399**	0.341**	0.314**	0.334**	0.437**	0.435**	0.392**	0.463**

P-SSW; Persian Staggered Spondaic Word, P-BMQ; Persian- Buffalo model questionnaire, RNC-REF; right noncompetitive word, started in right ear, RC-REF; right competitive word, started in right ear, LC-REF; left competitive word, started in right ear, LNC-REF; left noncompetitive word, started in right ear, LNC-LEF; left noncompetitive word, started in left ear, LC-LEF; let competitive word, started in left ear, RC-LEF; right competitive word, started in left ear, RNC-LEF; right noncompetitive word, started in left ear, RSSW; row SSW, D; decoding, N; noise, M; memory, V; various tolerance fading memory, I; integration, O; organization, C; central auditor processing, G; general questions, CAP; central auditor processing

** Significance at the 0.01 level, * Significance at the 0.05 level

Appendix 4. Correlation of the Persian versions of Buffalo model questionnaire and phonemic sentence test

PST / BMQ	X	XX	Q	QR	Qualitative .PST	Quantitative. PST
D	0.107	0.201**	0.009	–0.028	–0.427**	–0.471**
N	0.056	0.145*	0.176*	0.068	–0.288**	–0.303**
M	0.036	0.052	0.097	0.070	–0.354**	–0.375**
V	–0.024	–0.035	0.161*	0.022	–0.305**	–0.297**
I	–0.031	0.098	0.119	0.239**	–0.254**	–0.237**
O	–0.152*	0.003	0.215**	0.166*	–0.092	–0.075
C	0.001	0.088	0.178*	0.042	–0.415**	–0.400**
G	–0.048	0.049	0.210**	0.024	–0.212**	–0.187**
∑CAP	–0.008	0.123	0.179**	0.101	–0.459**	–0.470**
TOTAL	–0.012	0.119	0.206**	0.095	–0.445**	–0.445**

PST; Phonemic Sentence Test, BMQ; Buffalo model questionnaire, X, XX, Q, QR; Qualifiers, D; decoding, N; noise, M; memory, V; various tolerance fading memory, I; integration, O; organization, C; central auditor processing, G; general questions, CAP; central auditor processing

** Significance at the 0.01 level, * Significance at the 0.05 level

Appendix 5. Correlation of the Persian version of Buffalo model questionnaire and Persian version of speech in noise

Component	SIN8R	SIN4R	SIN0R	SINR	SIN8L	SIN4L	SIN0L	SINL
D	–0.027	–0.222**	–0.119	0.158*	–0.086	–0.166*	–0.232**	0.251**
N	0.064	–0.174*	–0.131	0.080	0.063	–0.360**	–0.128	0.187**
M	0.019	–0.116	–0.157*	0.067	–0.062	–0.207**	–0.243**	0.232**
V	0.062	–0.152*	–0.158*	0.088	–0.086	–0.241**	–0.211**	0.246**
I	–0.116	–0.209**	–0.126	0.198**	–0.172*	–0.203**	–0.099	0.262**
O	0.178*	–0.110	0.014	–0.129	0.111	0.000	–0.203**	0.000
C	0.083	–0.294**	–0.231**	0.119	–0.009	–0.290**	–0.296**	0.294**
G	0.055	–0.087	–0.081	0.007	–0.040	–0.206**	–0.084	0.183**
∑CAP	0.043	–0.264**	–0.200**	0.139*	–0.053	–0.322**	–0.288**	0.318**
TOTAL	0.056	–0.253**	–0.184**	0.120	–0.055	–0.322**	–0.277**	0.316**

SIN8R; Speech in noise with S/N=8 in right ear, SIN4R; Speech in noise with S/N=4 in right ear; SIN0R; speech in noise with S/N=0 in right ear, SINR; total speech in noise in right ear, SIN8L; speech in noise with S/N=8 in left ear, SIN4L; speech in noise with S/N=4 in left ear, SIN0L; speech in noise with S/N=0 in left ear, SINL; total speech in noise in left ear, D; decoding, N; noise, M; memory, V; various tolerance fading memory, I; integration, O; organization, C; central auditor processing, G; general questions, CAP; central auditor processing

** Significance at the 0.01 level, * Significance at the 0.05 level

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