Research Article

Development of the Persian Staggered Spondaic Word Test with Perceptual Simultaneity: Validity, Reliability, and Normative Data

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Highlights

- The P-SSW is a valid and reliable test in diagnosing auditory processing disorders
- Perceptual simultaneity is crucial for developing the staggered spondaic words test
- Normative data and qualifiers enhance the diagnostic utility of the P-SSW test

ABSTRACT

Background and Aim: The Persian Staggered Spondaic Word (P-SSW) test has been developed as a tool for identifying auditory processing disorders in Persian speakers. Utilizing the concept of perceptual simultaneity, the test was rigorously examined for psychometric reliability. Normative data were established, confirming its validity and suitability for clinical use in Persian-speaking populations.

Methods: The test was developed by optimizing the materials and using perceptual simultaneity. The test psychometric properties were also assessed and the test-retest reliability was evaluated after four weeks. This study recruited 380 participants. 24 experts evaluated the content validity. 42 individuals provided comments for the face validity verification. 213 healthy individuals were recruited to evaluate the psychometric properties.

Results: The content and face validity were confirmed. Insignificant differences were observed between the two genders. Significant differences were found in the total score and different conditions among specific age groups. Significant and positive correlations were observed between the test and retest scores ($r>0.8$).

Conclusion: Auditory processing can be assessed in Persian speakers using the P-SSW test as a valid and reliable instrument. Perceptual simultaneity might be the most appropriate technique to develop this test given the potential effects of other methods on the results.

Keywords: Development; staggered spondaic words test; perceptual simultaneity; auditory processing disorder

Introduction

The Auditory Processing Disorder (APD) is tested to confirm its presence and determine its parameters and functional effects. Comprehensive evaluations can be performed by assessing the history, completing auditory behavior questionnaires, conducting behavioral and electrophysiological tests, and performing speech and language evaluations [1, 2].The Staggered Spondaic Words test (SSW) was first used in the 1960s to identify the lesion site in the brain [3]. The test was then administered to diagnose APD [4]. The SSW constitutes the main test in the Buffalo model of auditory processing, and this model is mainly categorized based on performance in the test [1-5]. The SSW is a simple, valid, reliable test, and its specific characteristics such as its time-saving nature, and high resistance to peripheral hearing loss have turned the SSW test into one of the most popular auditory processing tests in different lesions and a variety of populations [4, 6-8].

The SSW test comprises 4 practice and 40 test items. Every test item consists of two spondaic words and provides the 1st and 2nd monosyllables for one of the ears and the 3rd and 4th monosyllables for the other, with overlapped monosyllables 2nd and 3rd. To counterbalance the ears and position of monosyllables odd-numbered items are usually presented as the Right-Ear-First (REF) and the even-numbered items as the Left-Ear-First (LEF).

Competing monosyllables have been recorded using two approaches, i.e., peak energy alignment and perceptual simultaneity. Graph visualization, listening, and sound analysis software are used in the peak energy alignment to compare the maximum energy of competing monosyllables [6, 9]. Adjustments are made to achieve the optimal time overlap between the peak energy of competing monosyllables. According to the perceptual simultaneity, after recording all four monosyllables in separate right and left channels, each competing monosyllable temporally overlaps, and pairs are played and replayed to the listeners. Listeners acknowledge when competing monosyllables reach the maximum temporal overlap [6].

Perceptional simultaneity or perceptual centering is employed in the first version of SSW i.e., Experimental list C of the SSW (EC-SSW) test to overlap competing monosyllables in the test items, enable auditory perceptual processes, and weigh and balance the dimensions of dichotic simultaneity for individual test items [6, 10, 11]. Perceptual simultaneity was reported and recommended as a reliable method to develop the SSW test [11].

Using methods other than perceptual simultaneity could affect the performance of the SSW test. Some of the versions of the SSW test in different languages and dialects were not as powerful as the EC list, and when they were remade using perceptual simultaneity, the results closely resembled the EC version. Normative data are significantly different in these versions, which cannot be solely explained by the effect of language [6, 12]. Using methods other than perceptual simultaneity can therefore alter the test and characteristics of the competing words. Utilizing the peak energy alignment method has been seen in the previous version of Persian SSW developed by Hajiabolhasan et al. [13].

The perceptual simultaneity appears to constitute the optimal overlapping method for competing monosyllabic words in the SSW test. The present research thus aimed at developing a new version of the Persian-SSW (P-SSW) test utilizing the perceptual simultaneity method and evaluating its psychometric properties.

Methods

The current cross-sectional study involved the development of the P-SSW test, which utilized perceptual simultaneity to establish the validity and reliability of the test and prospective collection of normative data in different age groups. The participants, parents, or caregivers provided written informed consent. The participants, children, and their parents were assured of their right to withdraw from the study at their discretion and without monetary compensation.

The Persian staggered spondaic words test development

Word selection

A linguistically appropriate word bank mainly comprising familiar Persian words was first prepared for the Persian-speaking population of Iran. Word bank extracted from the Bi Jen Khan Corpus for natural language processing research on the Persian language [14]. The words were selected so that each one was meaningful on its own, the combination of the first and second words formed a new meaning, and in each item, the combination of the first and fourth words also created a new meaning. This procedure is employed to prevent guessing the words. A total of 360 words extracted using 180 SSW items were distributed among experts for content validity assessments. Thirteen experts familiar with the SSW test, including 7 audiologists, 2 linguists, and 4 speech and language pathologists, received a questionnaire consisting of 180 items and evaluated the items regarding familiarity, phonological homogeneity, and appropriateness of the words for the test. The questionnaire involved

a comprehensive introduction to the SSW test and its features. The reviewed lists were then collected and the words appraised as appropriate by the experts were included in the main list. A total of 160 test words, i.e., 40 test items, and four training items were ultimately selected. Given the key role of phonemes in the Buffalo model [15], the final list was developed in a phonetically balanced manner representing the standard oral Persian.

A native Iranian male Persian speaker recorded the words in an acoustic recording studio using a Neumann Transformerless Microphone (TLM) microphone and a pop filter. The output was transmitted to Audition CC on an Apple iMac computer. The speaker narrated four training items and 160 test words back-to-back without making any overlaps. The maximum intensity was adjusted at ±3 dB in each channel.

The SSW test consisted of four training items. The 1st and 2nd training items were respectively spoken to the right and left ears. In the 3rd training item, the 1st two words were spoken to the right and the 2nd two words to the left, without overlap. In the 4th training item, the first two words were spoken to the left and the 2nd two words to the right ear. The narration speed was increased in the final two training items. The test items were added immediately after the training items. Two individual channels were created in Audition CC. The 1st and 2nd monosyllables were saved in the first channel and the 3rd and 4th in the second channel. The 3rd and 4th monosyllables were initially re-adjusted in a way that the peak of the 2nd and 3rd monosyllables reached the maximum temporal overlap.

Applying overlap through perceptual simultaneity

Eleven normal adult participants with a mean age of 28.90±1.98 years, including eight females and three males, participated in this stage. All the test items were individually played for the listeners using TDH-39 headphones at the Most Comfortable Level (MCL). The competing monosyllables were played and replayed and temporally re-adjusted until the maximum overlap was reported by participants [6, 11]. The items with the maximum overlap were ultimately collected. The minimum and maximum changes in milliseconds in comparison with the first peak energy alignment method were individually recorded for each item.

Finally, a 1000-Hz tone was added after each item to denote the beginning of the response time. Five-second silence was inserted between the tone and the next item. The test began by briefly explaining the procedure and how to respond to the item in Persian. The instructions were as follows:

“In this test, you will hear some words back-to-back. After hearing the beep sound, please repeat all the words. If you are unsure about a given word, you can make a guess”. Before the training items, the narrator said, "Let’s practice together; are you ready?”

To evaluate the face validity, test items were presented to 42 participants, including 7 experts, 11 healthy adults, 13 healthy children aged 7 (n=3), 8 (n=2), 9 (n=1), 10 (n=2), 11 (n=3) and 12 (n=2) years, 3 children with APD aged 7, 8 and 12 years and 8 adults with APD. APD in children was diagnosed using the Persian Double Dichotic Digits Test (P-DDT)[16] and the Persian phonemic synthesis test (P-PST) [17]. The Persian Randomized Dichotic Digit Test (P-RDDT) [18] was also employed to diagnose APD in adults. Qualitative feedback provided by the participants on the test's understandability and the narrator's instructions and fluency were collected. Seven audiologists also commented on the comprehensibility, recording quality of the test items, eloquence, and the narrator’s instructions. After making the final modifications, the test was prepared in WAV format for psychometric assessments.

Psychometric properties of the Persian staggered spondaic words test

The P-SSW test was psychometrically evaluated by being administered to 314 participants, including 213 healthy children aged 7 (n=34), 8 (n=39), 9 (n=33), 10 (n=35), 11 (n=35), and 12 years (n=37) and 101 adults. The assessment of the peripheral auditory system's integrity involved analyzing the subjects' air conduction hearing threshold across octave frequencies ranging from 250 to 8000 Hz and performing tympanometry with a 226-Hz probe tone. The subjects with an auditory threshold of below 15 dB HL and a type-A tympanogram were included in the study. All the subjects included in the study were right-handed individuals, spoke only Persian as their primary language, had standard IQ scores, and had no previous record of otitis media, neurodevelopmental issues, participation in music therapy, or specialized music training. The exclusion criteria comprised unwillingness to participate, fatigue, and developing otitis media or other health problems that could impair performance between the test and retest. APD in children was ruled out using the P-DDT and the P-PST. The P-RDDT was also employed to rule out APD in adults.

The P-SSW test was performed in an acoustically treated room using a two-channel audiometer (Piano, Inventis Inc., Italy) and TDH-39 headphones (Telephonics, US). The audiometer was connected to a MacBook Pro (Apple

Inc.) through a 3.5-mm auxiliary cable. The P-SSW test was presented through the audiometer at 50±5 dB SL (re: AC threshold average at 500, 1000, and 2000 Hz). The scoring system was applied as per the SSW test manual [19].
The total error in each condition of Right Non-Competing (RNC), Right Competing (RC), Left Competing (LC), and Left Non-Competing (LNC) was presented in the final column of the response sheet. The results obtained from the P-SSW test ranged from 0: correctly repeating all the items to 40: incorrectly repeating all the items.
The SSW introduced multidimensional scoring and provided measures of auditory processing functions and behaviors rather than giving a total or separate score for each ear [5, 19]. The multidimensional scoring is based on the measure of the ear and order effects and the Qualifiers. An ear effect occurs when more errors are made in one ear versus the other. An order effect occurs when more errors are made on the first spondee than on the second spondee. According to Table 1, qualifiers were recorded on the scoresheet in addition to quantitative scores.
The discriminant validity of the P-SSW test was evaluated by using its scores for different ages and genders. The normative data were obtained by administering the P-SSW test to all 314 participants and for all the conditions, reversals, order, and ear effects, the total Number of Errors (NOE), and qualifiers.
The test-retest reliability was evaluated by administering the P-SSW test twice to all the 314 participants at a 24±5-day interval, during which the participants neither attended rehabilitation sessions nor took any medicines and their health status was assumed not to change.

Data analysis

The evaluation of content validity was conducted utilizing both the Content Validity Ratio (CVR) and the Content Validity Index (CVI). The CVR was quantified using Lawshe's table. The Kolmogorov-Smirnov test was employed to determine the distribution normality of the data. The discriminant validity was evaluated using the non-parametric Kruskal-Wallis test and the Mann-Whitney U test with Bonferroni's correction. Furthermore, the Wilcoxon and Spearman tests were used to evaluate the relationships of the test with retest scores. The normative data were expressed as mean±standard deviation. The statistical analyses were conducted in SPSS-17.0 (IBM Corp., Armonk, N.Y., USA).

Results

Study population

The content validity was evaluated by 7 audiologists, 2 linguists, and 4 speech-language therapists. The test was developed based on perceptual simultaneity by 11 participants, including 8 males. Eleven healthy adults, 13 healthy children, 3 children with APD, 8 adults with APD, and 7 experts assessed the face validity. The psychometric properties of the P-SSW test were evaluated among 314 participants (153 males), including 213 healthy children aged 7 (n=34), 8 (n=39), 9 (n=33), 10 (n=35), 11 (n=35), and 12 (n=37) years and 101 adults (Table 2). The test-retest reliability was assessed by retesting all 314 subjects after approximately 4 weeks.

Psychometric assessments

Validity

Content validity

Thirteen experts selected 44 items based on the familiarity of the words, their phonological homogeneity, and the appropriateness of the entire item. The CVR and CVI were respectively obtained as 82%–97% and 94.23% using Lawshe's table.

Face validity

42 participants, including healthy children and adults, adults and children with APD, and a group of audiologists confirmed the comprehensibility of each word, each item, and the narrator's instruction. Also, the audiologists confirmed the face validity of the test and the eloquence of the narrator, the recording quality, and the comprehensibility of the narrator's instructions.

Discriminant validity

Between age group differences were evaluated in terms of RNC, RC, LC, LNC, and the total score using the Mann-Whitney U test, which rejected the null hypothesis, and suggested significant differences between at least one of the age groups with the others ($p \leq 0.001$). The Mann-Whitney U test with Bonferroni's correction revealed insignificant differences in the RNC, RC, LC, and LNC scores and the total scores between 9 and 10 years and between 12 years and the adults. In the RNC condition, no significant differences were found between ages 7 and 8 ($p=0.31$), 9 and 11 ($p=0.11$), 9 and 12 ($p=0.22$), 10 and 11 ($p=0.16$), 11 and 12 ($p=0.69$) and 10 and 12 ($p=0.32$) as well as between the age of 11 and the adults ($p=0.89$). The RC score suggested insignificant differences between ages 11 and 12 ($p=0.27$) and between the age of 11 and the adults ($p=0.11$). The LNC score showed insignificant differences between ages 7 and 8 ($p=0.28$) and ages 9 and 11 ($p=0.78$). Conversely, significant differences in RNC scores were observed when comparing ages 7 to 9, 10, 11, 12, and adults ($p<0.01$), ages 8 to 9, 10, 11, 12, and adults ($p<0.01$), age 9 to adults ($p=0.03$), and age 10 to adults ($p=0.05$). Significant differences in RC scores were observed when comparing ages 7 to 9, 10, 11, 12, and adults ($p<0.01$), ages 8 to 10 ($p=0.03$), 11, 12, and adults ($p<0.01$), age 9 to 11($p=0.02$), 12, and adults ($p=0.03$), and age 10 to 11($p=0.03$), 12 ($p<0.01$) and adults ($p<0.01$). Significant differences in LC scores were observed when comparing ages 7 to 8, 9, 10, 11, 12, and adults ($p<0.01$), ages 8 to 9($p=0.03$), 10, 11, 12, and adults ($p<0.01$), age 9 to 11, 12, and adults ($p<0.01$), and age 10 to 11 ($p=0.01$), 12, and adults ($p<0.01$), and age 11 to 12 ($p=0.01$) and adults ($p<0.01$). Significant differences in LNC scores were observed when comparing ages 7 to 9, 10, 11, 12, and adults ($p<0.01$), ages 8 to 9, 10,11, 12, and adults ($p<0.01$), age 9 to adults ($p=0.01$), age 10 to adults ($p=0.02$), and age 11 to adults($p=0.03$). The Mann-Whitney U test suggested no significant differences between the two genders in any of the P-SSW conditions and the total score in any age group ($p>0.05$).

Reliability

The non-parametric Wilcoxon test was used to evaluate the test-retest reliability in different age groups and revealed no significant differences between the test and retest in any of the RNC, RC, LC, LNC conditions, and the total score in any of the age groups ($p>0.05$). Moreover, the non-parametric Spearman test suggested significant and positive correlations between the test and retest scores in all the conditions and the total score ($r>0.8$ and $p=0.001$).

Normative data

The normative data were collected by administering the P-SSW test to all 314 healthy adults and children aged 7–12 years. The normal limits for the P-SSW scores were adjusted at 1 standard deviation above the mean as in the American English SSW test [20]. These data were obtained by determining the mean value of each condition and all qualifiers based on the number of mistakes. Table 3 presents the number of error norms for the P-SSW test in the RNC, RC, LC, and LNC conditions, the total NOE, and the order and ear effects. Table 4 also presents the number of error norms for the P-SSW test qualifiers.

Discussion

The present research was performed to develop a new version of the Persian-SSW (P-SSW) test utilizing the perceptual simultaneity method and evaluate its psychometric properties in Persian-speaking individuals.

The SSW test has yielded many re-recordings in different languages and dialects [6, 10, 12]. Perceptual simultaneity has been recommended for overlapping competing monosyllables. The same perceptual simultaneity method used in the original experimental list of the SSW recording was employed for the temporal overlap of competing monosyllables in this study. Moreover, the previous Persian version [13] did not report the normative data for the Qualifiers. By developing the P-SSW, the buffalo model's full test and questionnaire battery and also rehabilitations are now available in Persian [17, 21-25].

As reported in Wilson's study on the development of Australian SSW [6], some concerns using methods besides "perceptual simultaneity" might influence the SSW Test's performance in at least three ways: 1) Potential impact on normal performance, 2) Potential for bias, and 3) Influence on the neurologically impaired population. The potential influence on the normal population is supported by the lower error rate observed in healthy subjects during the Macquarie SSW Test (MSSW) [26] compared to the EC SSW. The MSSW elicits an average of 0.4 errors in the left competing condition with no reversals, compared to the EC SSW's 1.1 errors and 0.2 reversals on average in the same condition. Regarding potential bias, alternative methods might introduce biases into the SSW Test, such as ear dominance arising from a possible lag effect reported in investigations [6, 10, 11].

The minimum and maximum temporal change in competing monosyllables were respectively obtained as 35 and

730 ms based on perceptual simultaneity compared to the energy peak alignment method in this study. These results are consistent with earlier findings [6, 10, 11] and could easily affect the results and disrupt the diagnosis. Given the confirmed test-retest reliability and validity of the P-SSW test, its application can be supported as a valid and reliable tool in auditory processing assessments. With below 7 minutes of application time, the P-SSW test can prevent fatigue and distraction [2].

Research confirms the content validity of the test with a mean CVI of over 79% obtained by 3–10 experts. Given %54 as the minimum acceptable CVR for one-sample tests with 13 experts as per Lawshe's table the face validity of the tool was confirmed by calculating a CVI of 94.23%. These results confirm the content validity of the test. Moreover, the face validity of the P-SSW test was confirmed based on the qualitative reports and adjustments made as per the reports of the participants and experts.

The 1000-Hz tone used in this study to instigate the responses was not included in the original experimental list of the SSW test. Introducing this feature to the P-SSW test simplified the identification of the delay (i.e., X, XX) and Quick response (Q) errors.

Evaluating the test-retest reliability confirmed the stability and reproducibility of the P-SSW. The test-retest reliability of the conditions and scores obtained as 0.92 was statistically significant ($p \leq 0.01$). Tillery also confirmed the test-retest reliability of the SSW test by calculating a correlation coefficient of 0.92 ($p<0.01$) [27]. Also, Jones-Lewis [28] found the test-retest reliability for 20 volunteers who were 60 to 69 years of age and in good health without active ear disease and with mild to moderate sensorineural hearing loss at 4000 Hz and 8000 Hz. The time between the two tests was 5 weeks. Also, Zalewski [9] determined the test-retest reliability of the four SSW total scores used in NOE scoring with an adult population with hearing impairment. The results of Zalewsky's study indicated that NOE analysis has moderate to strong reliability. The correlation coefficients for the NOE scores were reported as follows: RNC: r=0.68; RC: r=0.72; LC: r=0.86, and LNC: r=0.55. The data analysis found that the total scores exceeded the 0.01 level of significance. The test-retest reliability in extended intervals between the test and retest can be affected by the progression of pathologic conditions and the maturation of the study population [9]. The present study period between the test and retest was adjusted to a maximum of 29 days. The general health, medication use, peripheral system integrity, and other disorders were monitored in the participants before the retest. The reliability finding of the P-SSW test is very crucial since it would guarantee the test serves as an effective and appropriate monitoring tool in rehabilitation programs [23, 24].

The normative data for the P-SSW test were reported in terms of mean, standard deviation, and Normal Limits (NL) in children aged 7–12 years and adults (Tables 3 and 4). The results exhibit numerous similarities to the standard information disclosed in the initial investigation, and the minimal variances can be ascribed to cultural and linguistic influences as well as the size of the sample (Table 5). This observation validates the endeavors undertaken in the current study to adhere to the original test framework. In Table 5, the main parameters of different SSW versions are represented. Normative data findings in normal adult subjects for the P-SSW, EC SSW, ASSW, MSSW, and the previous Persian SSW Recording, represent differences between the method of recordings. The findings of P-SSW and the previous version of Persian SSW show that normative data in the current study are closer to the EC SSW and other SSW tests developed with the perceptual simultaneity method. Additionally, the current study includes the largest sample size to date.

Comparing performance among the participants between males and females revealed insignificant differences in all age groups. Comparing performance among the participants by age, however, showed significant differences between the majority of age groups. The P-SSW test showed improvements with age in the performance of the participants in all the response conditions, the total number of errors, and the qualifiers. These clinically significant findings suggest the insignificant role of gender in the P-SSW test. In contrast, age was found to play a key role in diagnosing APD.

The limitations of the study consisted of failure to evaluate patients with APD and thus failure to generate cut-off points. Despite the clinical application of the obtained normative data, they should be cautiously handled. It is highly recommended that a test battery be used rather than a single test to diagnose APD.

Conclusion

The reliability and validity of the Persian Staggered Spondaic Word (P-SSW) test were confirmed for evaluating Auditory Processing Disorder (APD) in Persian-speaking children aged 7–12 years and adults. The present findings suggested the use of perceptual simultaneity for overlapping competing monosyllables. The P-SSW test is recommended for clinical practice as part of a test battery providing information about APD.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Tehran University of Medical Sciences (Code: IR.TUMS.FNM.REC.1395.608).

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Authors' contributions

EN: Study design, acquisition of data, interpretation of the results, statistical analysis, and drafting the manuscript; GM: Study design, interpretation of the results, and drafting the manuscript; SJ: Study design, statistical analysis; SSB: Study design, acquisition of data, and drafting the manuscript; MB: acquisition of data, and drafting the manuscript; MSMB: acquisition of data, JK: Study design, and drafting the manuscript.

Conflict of interest

There is no conflict of interest to disclose.

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Table 1. Qualifiers, description, and the signs of the Persian staggered spondaic words test

Qualifiers	Description	Sign
Tongue twister	Knows the answer but does not say it right. Gets tripped up in own words, repeats/anticipates sounds.	TTW
Delay	Counted as qualifier only when the answer is correct, but presented with significant delay.	X
Quick	Counted as qualifier only when the answer is correct, but presented before the beep sound.	Q
Perseveration	Repeats word from recent item or repeats the error that was given before.	P
Quiet rehearsal	rehears the words with him/herself so faintly before the beep sound.	QR
Smush	Smush: combines competing words	Sm
Extreme delay	The answer presented with extreme delay. Must show no great effort and item should be correct or error on LC item only.	XX
Smush-2	Combines a spondee word	Sm-2
Intrusive word	Gives 5th word	IW
Back-to-back	Says same word back-to-back	BTB

TTW; tongue twister, Q; quick, P; perseveration, QR; quiet rehearsal, Sm; smush, Sm-2; smush-2, IW; intrusive word, BTB; back-to-back
X: delay, XX; extreme delay

Table 2. Distribution of gender in terms of age groups participated in psychometric properties assessments

Age	Total	Male	Female
7	34	16	18
8	39	19	20
9	33	17	16
10	35	16	19
11	35	17	18
12	37	17	20
Adults	101	50	51
Total	314	153	161

Table 3. Normative data for the Persian staggered spondaic words test in different conditions and the total number of errors

Age	N	Statistics	RNC	RC	LC	LNC	TOT NOE	REV	EE		OE	
									L/H	H/L	L/H	H/L
7	34	Mean	1.38	4.08	9.38	1.67	16.55	1.05	–2.50		2.00	
		SD	0.95	2.49	2.16	1.31	3.66	1.09	3.01		5.10	
		1-NL	2	7	12	3	20	2	–6	+1	–3	+7
8	39	Mean	1.10	2.87	4.84	1.33	10.15	1.23	–1.01		0.3	
		SD	0.78	1.67	1.92	1.22	2.98	1.01	3.00		2.80	
		1-NL	2	5	7	3	13	2	–4	+2	–2	+3
9	33	Mean	0.66	2.09	3.72	0.33	6.96	0.33	–1.30		0.50	
		SD	1.08	1.94	1.89	0.64	3.24	0.64	2.10		2.10	
		1-NL	2	4	6	1	10	1	–3	+1	–2	+3
10	35	Mean	0.54	2.00	3.28	0.45	6.51	0.20	0.10		0.20	
		SD	0.85	1.90	1.72	0.78	2.99	0.40	1.90		1.40	
		1-NL	1	4	5	1	10	1	–2	+2	–1	+2
11	35	Mean	0.22	1.00	2.28	0.40	3.91	0.40	–2.30		–0.20	
		SD	0.44	1.08	1.46	0.69	2.10	0.69	2.40		1.60	
		1-NL	1	2	4	1	6	1	–5	+1	–2	+1
12	37	Mean	0.35	0.67	1.51	0.21	2.54	0.51	0.40		0.50	
		SD	0.67	0.78	1.14	0.41	1.60	0.93	1.0		1.40	
		1-NL	1	2	3	1	4	1	–1	+1	–1	+2
Adults	101	Mean	0.21	0.59	1.26	0.15	2.22	0.67	0.20		0.30	
		SD	0.41	0.56	1.16	0.36	1.32	0.77	0.30		1.10	
		1-NL	1	1	2	1	4	1	–1	+1	–1	+1

EE; ear effect, OE; order effect, RNC; right non-competing, RC; right competing, LC; left competing, LNC; left non-competing, TOT NOE; number of total errors, REV; reversals, L; low, H; high, 1-NL; one normal limit.

Table 4. Normative data for the Persian staggered spondaic words test qualifiers

Age	TTW	X	Q	P	QR	Sm	XX	Sm-2
7	2	3	2	0	0	0	0	0
8	2	1	0	0	0	0	0	0
9	1	0	0	0	0	0	0	0
10	1	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	1	0	0	0	0	0	0	0
Adult	0	0	0	0	0	0	0	0

TTW; tongue twister, Q; quick response, P; perseveration, QR; quiet rehearsal, Sm; smush, Sm-2; smush-2
X: delay, XX: extreme delay

Table 5. Normative data findings in normal adult subjects for the different recordings of staggered spondaic words test

Version of SSW	N	RNC	RC	LC	LNC	TOT NOE	REV
P-SSW1	314	0.2±0.4	0.6±0.0.6	1.2±1.1	0.1±0.4	2.2±1.3	0.7±0.8
EC SSW2	104	0.2±0.4	0.5±0.7	1.1±1.2	0.1±0.3	2.0±1.9	0.2±0.5
A SSW3	30	0.2±0.5	0.7±0.9	0.7±1.1	0.1±0.4	1.7±1.8	0.3±0.8
M-SSW4	33	0.2	0.5	0.4	0.2	1.3±1.6	0.0±0.0
Persian SSW5	58	0.57±1.02	2.67±2.84	2.11±2.42	0.86±1.36	1.63±1.20	N/A

1. Current study
2. American English Version (Developed with perceptual simultaneity method)
3. Australian SSW (Developed with perceptual simultaneity method)
4. Macquarie SSW (Developed with peak energy alignment method)
5. First version of Persian SSW (Developed with peak energy alignment method)

SSW; staggered spondaic word, N; number of participants, RNC; right non-competing, RC; right-competing, LC; left-competing, LNC; left non-competing, TOT NOE; total number of errors, REV; reversals