Research Article

Psychometric Function Characteristics of Time-Compressed Persian Words

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Highlights

● Mean CR (50%) of compressed monosyllabic Persian words were approximately 75%

● Two 50-word lists constructed have equivalent psychometric function characteristics

ABSTRACT

Background and Aim: The psychometric function characteristics (e.g. threshold and slope) of the time-compressed words have not been investigated in previous studies to compile psychometrically homogeneous word lists. Therefore, this study aimed to investigate psychometric function characteristics of monosyllabic time-compressed Persian words to develop psychometrically equivalent time-compressed word lists.

Methods: Two hundred most common monosyllabic words in Persian language were time-compressed at a rate of 40%-85% and presented to 21 participants with normal hearing at a fixed intensity level. The threshold and slope of the psychometric function for all words were determined using the logistic regression. The compression ratio (CR) for 5%-95% correct recognition was predicted based on the psychometric function fitted to the measured correct recognition score.

Results: Mean CR 50% of the words was in a range of 53%-78%. The mean CR 50% and slope were not significantly different between consonant-vowel-consonant and consonant-vowel-consonant-consonant words. The predicted CR for 5%-95% correct recognition varied from 61.5% to 88.4%. The final result was two 50-word lists of monosyllabic words with the same mean threshold and slope.

Conclusion: Persian time-compressed monosyllabic words have different CR 50% and slope that may interact with their intelligibility.

Keywords: Time compression; intelligibility; psychometric function; Persian monosyllabic words

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Introduction

According to the American Speech-Language Hearing Association, one of the behavioral signs of central auditory processing disorder (CAPD) is poor performance in the processing of distorted auditory stimuli [1]. Various strategies for degrading speech signals have been used including, filtering, adding noise, and altering the temporal characteristics of speech stimuli [2, 3]. A common finding about the effect of time compression on speech perception is the poor performance with increasing compression rate [3]. Recognition performance of normal-hearing people is considerably reduced at a compression rate above 50%-60% [3-6].

There is a global trend towards understanding auditory processing disorders and the effectiveness of their treatment and rehabilitation in the literature. Assessment of each ear and monitoring of auditory processing during treatment requires access to various tests. Although there are studies that have examined the effect of time compression on the standard word lists such as NU-6 and W-22 [3], we found no study that has constructed time-compressed word lists with psychometric homogeneity. This study aimed to investigate the psychometric function characteristics of Persian time-compressed monosyllabic words to develop the word lists that are psychometrically homogenous.

Methods

This is cross sectional study conducted on 21 right-handed adults (8 females and 13 males) aged 21-45 years mean age 33.2±9 years with normal hearing thresholds (<20 dB HL at 500-4000 Hz). The most common Persian monosyllabic words from Mahdavi and Rabie's study [7] including 100 recorded consonant-vowel-consonants (CVCs) and 100 consonant-vowel-consonant-consonants (CVCCs) were used in the current study. The words were time-compressed in Praat software at compression rates of 40%, 50%, 60%, 65%, 70%, 75%, 80%, and 85%. The root mean square of all words was equal to that of 1000-Hz calibration tone. A unique random word order was construed for each compression rate. The inter-word silence was three seconds. The random words were presented to the participants in descending order from 85% to 40%.

Psychometric function characteristics, including compression ratio (CR) at 50%, slope at 50%, and slope at 20%-80% were determined for each word using logistic regression. Using the inverse prediction technique, the CRs corresponding to the correct recognition from 5% to 95% were determined for each list. We considered the unit of slope as the ratio of the percentage of recognition per the percentage of compression (Pr/Pc).

The words that were poorly fitted to the logistic regression model ($R^2 < 0.5$) were excluded from the analysis. The selected words were sorted by CR 50% and then by slope 50%. The words with a CR 50% and a slope 50% within the range of mean ±1.6 of all words were selected. At this stage, 100 words (47 CVCs and 53 CVCCs) were remained. After 10 times of randomization, these words were divided into two 50-word lists.

Results

The psychometric properties of all CVCs and CVCCs are shown in Figure 1. Table 1 presents the mean values of correct word recognition. The mean CR 50%
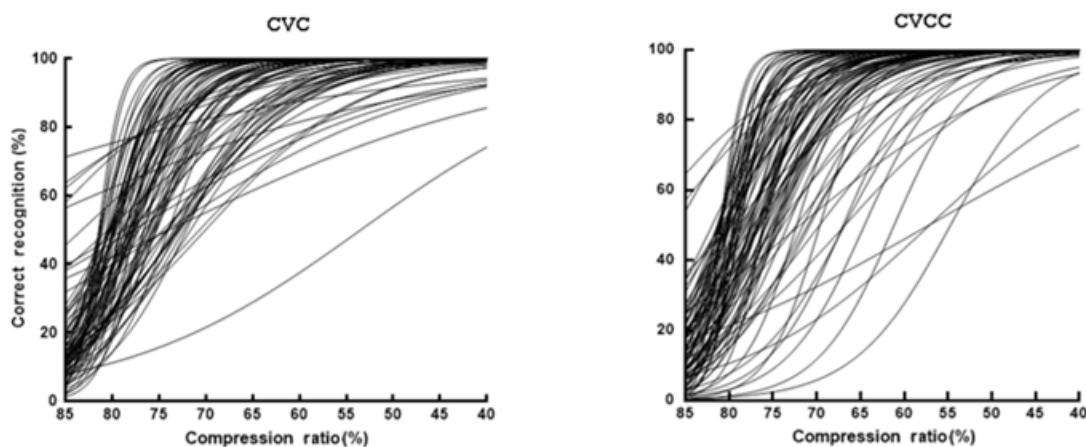
Figure 1. Individual psychometric function for all words. CVC; Consonant-vowel-consonant, CVCC; Consonant-vowel-consonant-consonant

Table 1. Characteristics of psychometric function fitted to mean correct recognition of all selected words

	Intercept		Regression slope		CR (50) (%)		Slope (50) Pr/Pc		Slope (20–80) Pr/Pc	
	CVC	CVCC	CVC	CVCC	CVC	CVCC	CVC	CVCC	CVC	CVCC
Mean	28.53	27.04	−0.38	−0.36	74.54	73.66	9.45	9.04	8.18	7.83
SD	17.90	14.70	0.20	0.20	3.10	4.60	5.80	4.70	5.00	4.00
Minimum	2.98	4.75	−0.97	−0.97	53.25	54.69	0.94	2.10	0.82	1.82
Maximum	74.39	74.39	−0.04	−0.08	78.98	79.96	24.19	24.19	20.94	20.94
Range	71.41	69.64	0.93	0.89	25.73	25.27	23.25	22.09	20.12	19.12
p	0.738		0.641		0.091		0.641		0.641	
Power	0.227		0.257		0.693		0.189		0.187	

CR; Compression ratio, Pr/Pc; Percentage of recognition per percentage of compression, CVC; Consonant-vowel-consonant, CVCC; Consonant-vowel-consonant-consonant

of CVCs was 74.5%±3.1 and for CVCCs it was 73.7%±4.6. There was no significant difference between them (p=0.091). Statistical analysis showed no significant difference between means of slope 50% and slope (20%-80%) for CVCs and CVCCs (p=0.641). The predicted mean CR in correct recognition range of 5%-95% did not show a significant difference between the lists (Table 2 and Figure. 2).

In each group of monosyllabic words, some words had a higher or lower slope than others, and the number of words were different in terms of the percentage of correct recognition at different CRs, but in overall, as the CRs decreased, the percentage of word recognition increased, indicating that the ability to recognize words more correctly improved.

Discussion

The aim of this study was to obtain time-compressed words with psychometric homogeneity in order to construct similar word lists in terms of recognition. The re-

Table 2. Comparison of the mean predicted compression ratio (%) for all words of Lists 1 and 2

Correct recognition (%)	List 1		List 2		p	Power
	Mean	SD	Mean	SD		
5	88.36	2.60	88.52	2.80	0.760	0.145
10	85.68	2.40	85.81	2.50	0.790	0.132
20	83.19	2.20	83.29	2.40	0.840	0.110
30	80.84	2.20	80.90	2.40	0.890	0.083
40	79.25	2.20	79.30	2.40	0.930	0.076
50	77.80	2.30	77.82	2.50	0.960	0.059
60	76.35	2.40	76.35	2.70	1.000	0.050
70	74.76	2.60	74.74	2.90	0.970	0.057
80	72.83	2.80	72.78	3.10	0.930	0.069
90	69.93	3.30	69.84	3.60	0.890	0.083
95	61.48	4.70	61.27	5.20	0.830	0.110
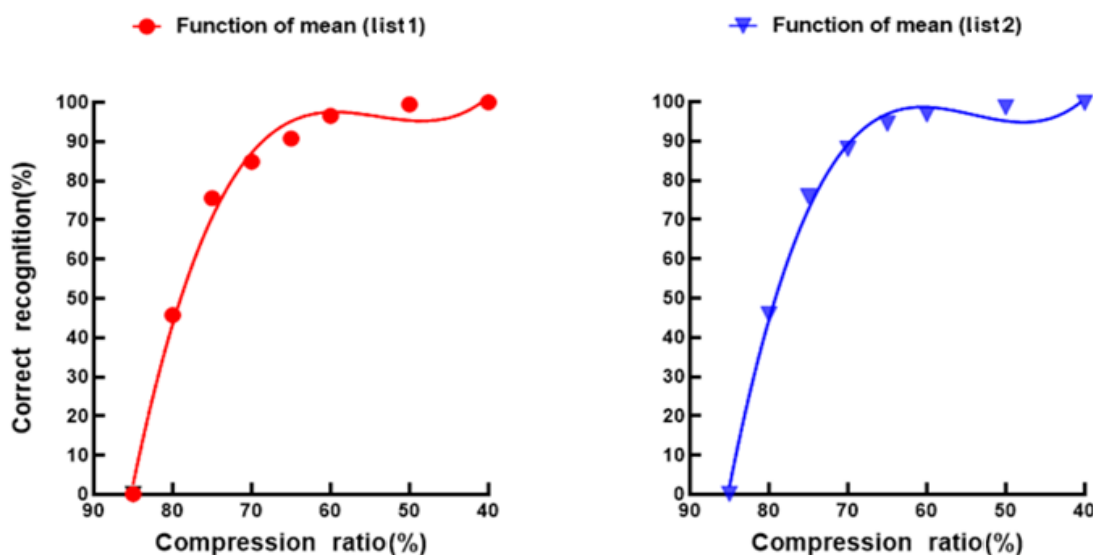
Figure 2. Psychometric function of the word lists constructed in the current study

sults showed that CVC and CVCV words had a similar CR 50% of 73%-74%. They had also a similar psychometric function slope. Two 50-word lists constructed in the current study with similar CR 50% and psychometric function slope. There was no similar study for comparing the results. Most studies have examined the effect of time compression on the recognition performance [3, 4]. Wilson et al. presented time-compressed NU-6 words to young adults at 0-60 dB HL and observed that, by increasing the CR from 45% to 75%, the recognition performance decreased. The psychometric function showed that the range of recognition performance varied from 90% for CR 45% to 25% for CR 75%. The function slope was significantly higher by increasing the CR 65% to 75% compared to the change from 45% to 65% [3]. In our study, the presentation level was fixed and the predicted CR corresponding to 5%-95% correct recognition was in a range of 88%-61% for both word lists.

Previous studies have compressed the list of known words such as Word Intelligibility by Picture Identification, NU-6, and PB-50 [4, 8, 9] and reported the results as the percentage of correct recognition. To the best of our knowledge, the current study is the first study that used the threshold and slope of psychometric function in constructing time-compressed word lists. If we assume that two lists of monosyllabic words are equivalent, their compression at a certain rate does not guarantee the same performance; in case of hearing loss, the interaction between compression and word comprehension can be more complicated. Grimes et al. presented four time-compressed NU-6 word lists at 32 dB SL to normal hearing and hearing-impaired people and found out that only

lists I and IV were equal in both groups [9], and compressing a list at two compression rates could have memory effect. It is desirable that the examiner have several unique lists to be able to compare the performance of left and right ears or monitors the rehabilitation-related changes in recognition of time-compressed words.

Conclusion

It is concluded that word list development based on the psychometric function threshold, and slope may be useful for development of 25-word lists that are equivalent in both hearing-impaired and normal-hearing clients.

Further studies are recommended with a higher number of samples and in different populations, including those with hearing loss.

Ethical Considerations

Compliance with ethical guidelines

This research approved by Ethical committee of Shahid Beheshti University of Medical Sciences with Code number IR.SBMU.RETECH.REC.1399.1114.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

MMB: Acquisition of data, statistical analysis, drafting the manuscript; MEM: Study design, statistical analysis, interpretation of the results, drafting the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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