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DEVELOPMENT OF MACEDONIAN MONOSYLLABIC AND DISYLLABIC TESTS FOR SPEECH AUDIOMETRY

Original scientific paper

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ABSTRACT

The aim of the study was to develop Macedonian monosyllabic and disyllabic tests for speech audiometry, to record the speech materials, and to conduct clinical validation of the tests. The following criteria were applied: word familiarity, phonetic balance, and homogeneity of audibility. Clinical validation was conducted on a sample of 30 normal hearing subjects, aged 18 to 30 years. We developed four open-set tests for speech threshold and suprathreshold testing in quiet. The tests contain two word lists with 50 monosyllabic words and two word lists with 36 disyllabic words. Each word was introduced by a carrier phrase. Psychometric function slope from 20% to 80% correct recognition for all words was 5%/dB. The difference between the presentation levels at which the subjects repeated all the words was ≤ 4 dB. Developed phonetically balanced word lists have relatively steep psychometric function slope and they are homogeneous in terms of the audibility.

Keywords: *development, Macedonian word lists, speech audiometry*

INTRODUCTION

Speech audiometry is a method of evaluating how well a patient can hear and understand specific types of speech stimuli (Kramer & Brown, 2019). Speech materials are presented by monitored live voice or recorded speech materials are used (Lawson & Peterson, 2011). The words could be presented in an *open-set* format, which means that the patient must respond without any prior knowledge of what the possible alternatives might be, or a *closed-set* format, which means that the patient is provided with a choice of several possible response alternatives (Gelfand, 2016). It is common practice to utilize a carrier phrase such as "Say the word…" prior to presentation of the word, although this is not always performed (DeRuiter & Ramachandran, 2017). The speech stimuli are presented in quiet or with addition of background noise (McArdle & Hnath-Chisolm, 2015). Many types of speech materials can be used to perform speech audiometry. The choice of materials depends on the type of the testing: threshold or suprathreshold testing. The speech detection threshold (SDT) is established by presenting familiar words, connected speech, spondaic words, or even repeated nonsense syllables (Stach, 2010). Spondaic words or *spondees* are also used for determining speech recognition threshold (SRT).

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Spondees are two syllable words that have equal stress on each syllable. Examples are words such as *baseball, sidewalk, hot dog* and *ice cream* (DeRuiter & Ramachandran, 2017). The most common way to describe suprathreshold hearing ability is with word recognition measures. Word recognition score (WRS) is determined by presenting monosyllable words at suprathreshold level (Stach, 2010). Sentences are also used for suprathreshold speech recognition testing (Bess & Humes, 2008).

In development of speech audiometry tests, the authors applied various criteria, such as: phonemic balance, balance of the number of syllables, use of disyllabic words in languages where there are no spondaic words, use of disyllabic words for suprathreshold testing instead of monosyllable words, introducing the words with and without carrier phrase, selection of the words depending on the density of lexical neighbourhood and other rules depending on the specifics of the language in which the test was developed. However, some criteria were considered essential in selecting test items for measuring speech recognition including word familiarity, phonetic balance, and homogeneity of audibility. The same criteria are applied in development of tests for adults and children (Diefendorf, 2015).

It is generally accepted that *word familiarity* increases test scores (Lawson & Peterson, 2011). Word familiarity ensures that we measure auditory threshold, not vocabulary knowledge (Ramkissoon, 2001). The authors could ask linguist for help to select familiar words, but, it can be done in another way, for example, with rating the word familiarity and selection of words that are more familiar. Word familiarity must be considered especially when testing children. There is a well-established effect of word frequency, with a significant bias favoring the recognition of words with a higher frequency of occurrence compared with lower-frequency words (Gelfand, 2016).

Phonetic balance means that the phonetic composition of the word lists is equivalent and representative of everyday speech in that language (Bess & Humes, 2008). The relative frequencies of the phonemes in the test list are as close as possible to the distribution of speech sounds used in that language. A phonetic balance of monosyllabic word materials is based on analysis of large number of words used in newspaper articles, words used in certain conversations or the most common words in the language (Gelfand, 2016).

Homogeneity of audibility refers to the presentation level at which the speech stimuli are heard. If the words are homogenous with respect to audibility, they all are just recognizable at about the same speech intensity level (Stach, 2010). If the word lists are not homogeneous in respect to audibility, homogeneity could be achieved by digital adjusting of the recorded speech materials (Gelfand, 2016).

The aim of the study was to develop Macedonian monosyllabic and disyllabic test for speech audiometry, to record the speech materials, and to conduct clinical validation in order to determine whether the word lists are homogeneous in terms of audibility.

METHODS

In this prospective study we developed four tests for speech threshold and suprathreshold testing in quiet. The tests are in an open-set format. They contain two word lists with 50 Macedonian monosyllabic words and two word lists with 36 disyllabic words and are suitable for testing children and adults. The following criteria were applied during the test development: word familiarity, phonetic balance, and homogeneity of audibility. In the early stages of the research we performed acoustic analysis of Macedonian vowels and consonants in the computer program Praat and analysis of coarticulation in nonsense syllables and real words. These results are not presented in this paper.

The words were selected from the *Orthographic dictionary of the Macedonian standard language* (Koneski, 1999) and *Digital dictionary of the Macedonian language.* The final word lists were approved by two linguists. We calculated the frequency of occurrence of Macedonian phonemes in order to develop phonetically balanced word lists. For this purpose we used a corpus of 178 sentences containing the most frequent words in Macedonian language. The sentences were previously selected from about 2.5 million electronic articles from the Macedonian internet portals in study for development of Macedonian text-to-speech system (Peshanski, 2018).

Developed word lists were recorded in Macedonian Radio Television. Each word was presented with the carrier phrase: Say the word…" recorded at the same intensity level as the words. There are eight recordings because all words in the four word lists were pronounced by a male and a female speaker. A Sennheiser e840 microphone (Sennheiser electronic, Germany) was used during the recording, placed at a distance of 5-10 cm from the mouth. Digital recording of the speech used a sampling frequency of 44,100 samples per second.

Homogeneity of audibility was determined during clinical validation of word lists conducted on a sample of 30 normal hearing subjects, 15 males and 15 females, aged 18 to 30 years (mean age of 24.3±3.6 years), examined at the Department of Otorhinolaryngology, Division of Audiology, City General Hospital "8th September" Skopje. Pure tone audiometry and speech audiometry were performed with MADSEN Astera^2 audiometer (GN Otometrics, Denmark) and Sennheiser HDA 300 (Sennheiser electronic, Germany) circumaural earphones in sound proof booth. Hearing threshold was obtained with modified Hughson-Westlake technique for frequencies from 125 to 8000 Hz. Speech detection threshold, speech recognition threshold, and word recognition score were determined in all participants. For this purpose we used recorded speech materials pronounced by a female speaker.

The study was approved by the Ethics committee of City General Hospital "8th September" Skopje. The Protocol number of Ethical approval is: 24/89-1/2019.

RESULTS

We calculated the frequency of occurrence of Macedonian phonemes in order to develop phonetically balanced word lists. The vowel /a/ (a) has the highest frequency of occurrence in Macedonian language, and the consonant /s/ (ʤ) has the lowest frequency. Macedonian phonemes are given along with their transcription into International Phonetic Alphabet (IPA) symbols in parentheses. Phonemes in the tests have a similar frequency of occurrence as phonemes in the sentence corpus. Frequency of occurrence of Macedonian vowels in sentence corpus and four word lists is displayed in Table 1.

Table 1. Frequency of occurrence of Macedonian vowels in sentence corpus and four word lists

Vowels	Corpus	Test 1	Test 2	Test 3	Test 4
MKD (IPA)	No (%)	No (%)	No (%)	No (%)	No (%)
а (a)	1498 (12.9)	17 (10.1)	17 (9.9)	23 (13.5)	24 (13.5)
о (o)	1165 (10)	11 (6.5)	11 (6.4)	18 (10.5)	16 (9)
е (e)	1078 (9.3)	10 (5.9)	10 (5.8)	18 (10.5)	16 (9)
и (i)	1057 (9.1)	9 (5.3)	9 (5.2)	9 (5.3)	10 (5.6)
у (u)	287 (2.5)	3 (1.8)	3 (1.7)	4 (2.3)	6 (3.4)

The phonemes are displayed in order, starting with the most frequent sound and parallel to the phonemes in sentence corpus. The sentences contain 2439 words and 11629 phonemes, 5085 (43.7%) vowels and 6544 (56.3%) consonants. Frequency of occurrence of Macedonian consonants in sentence corpus and word lists is displayed in Table 2.

Table 2. Frequency of occurrence of Macedonian consonants in sentence corpus and four word lists

Consonants	Corpus	Test 1	Test 2	Test 3	Test 4
MKD (IPA)	No (%)	No (%)	No (%)	No (%)	No (%)
т (t)	816 (7)	13 (7.7)	14 (8.1)	13 (7.6)	12 (6.7)
н (n)	799 (6.9)	12 (7.1)	11 (6.4)	8 (4.7)	9 (5.1)
р (r)	588 (5.1)	10 (5.9)	11 (6.4)	8 (4.7)	9 (5.1)
с (s)	512 (4.4)	10 (5.9)	11 (6.4)	8 (4.7)	9 (5.1)
в (v)	475 (4.1)	9 (5.3)	10 (5.8)	8 (4.7)	8 (4.5)
д (d)	467 (4)	8 (4.7)	10 (5.8)	7 (4.1)	8 (4.5)
к (k)	419 (3.6)	8 (4.7)	9 (5.2)	7 (4.1)	8 (4.5)
л (l)	365 (3.1)	7 (4.1)	8 (4.7)	5 (2.9)	6 (3.4)
м (m)	321 (2.8)	4 (2.4)	5 (2.9)	5 (2.9)	6 (3.4)
п (p)	302 (2.6)	4 (2.4)	4 (2.3)	3 (1.8)	4 (2.2)
г (g)	211 (1.8)	4 (2.4)	4 (2.3)	3 (1.8)	3 (1.7)
б (b)	193 (1.7)	4 (2.4)	4 (2.3)	3 (1.8)	3 (1.7)
ј (j)	187 (1.6)	4 (2.4)	4 (2.3)	3 (1.8)	3 (1.7)
з (z)	171 (1.5)	4 (2.4)	3 (1.7)	2 (1.2)	2 (1.1)
ш (ʃ)	144 (1.2)	3 (1.8)	2 (1.2)	2 (1.2)	2 (1.1)
ч (ʧ)	111 (1)	3 (1.8)	2 (1.2)	2 (1.2)	2 (1.1)
ц (ʦ)	104 (.9)	2 (1.2)	1 (.6)	2 (1.2)	2 (1.1)
ж (ʒ)	64 (.6)	2 (1.2)	1 (.6)	2 (1.2)	2 (1.1)
ф (f)	60 (.5)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
ќ (c)	53 (.5)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
х (h)	52 (.4)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
њ (ɲ)	36 (.3)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
џ (ʤ)	31 (.3)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
ѓ (ɟ)	28 (.2)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
љ (ʎ)	21 (.2)	1 (.6)	1 (.6)	1 (.6)	1 (.6)
ѕ (ʣ)	14 (.1)	1 (.6)	1 (.6)	1 (.6)	1 (.6)

The consonant /т/ (t) has the highest frequency from all consonants. Test 1 contains 169 phonemes, 50 vowels (29.6%) and 119 consonants (70.4%). Test 2 contains 172 phonemes, 50 vowels (29.1%) and 122 consonants (70.9%). Test 3 contains 171 phonemes, 72 vowels (42.1%) and 99 consonants (57.9%). Test 4 contains 178 phonemes, 72 vowels (40.4%) and 126 consonants (59.6%). Test 3 and Test 4 are consisted of disyllabic words and each word contains two vowels as a nucleus of the syllables.

Syllable structure in monosyllabic tests and the number of words with that structure is displayed in Table 3. The syllables contain different combinations of consonants (C) and vowels (V). The CVC syllable structure was the most frequent.

Table 3. Syllable structure in monosyllabic tests

Syllable structure	Test 1	Test 2	Total
	No (%)	No (%)	No (%)
CVC	27 (27)	28 (10.1)	55 (55)
CCVC	12 (12)	14 (6.5)	26 (26)
CVCC	8 (8)	8 (8)	16 (16)
CCV	2 (2)	/ (0)	2 (2)
CV	1 (1)	/ (0)	1 (1)
Total	50 (50)	50 (50)	100 (100)

Syllable structure in disyllabic tests and number of words with that structure is displayed in Table 4. The CVCCV syllable structure was the most frequent, followed by CVCV, CVCVC, and CCVCV syllable structure. Other syllable structures were represented in a smaller percentage.

Table 4. Syllable structure in disyllabic tests

Syllable structure	Test 3	Test 4	Total
	No (%)	No (%)	No (%)
CVCCV	10 (13.9)	10 (13.9)	20 (27.8)
CVCV	11 (15.3)	8 (11.1)	19 (26.4)
CVCVC	5 (6.9)	9 (12.5)	14 (19.4)
CCVCV	5 (6.9)	3 (4.2)	8 (11.1)
CVCCVC	2 (2.8)	2 (2.8)	4 (5.6)
VCCVC	1 (1.4)	/ (0)	1 (1.4)
VCVC	1 (1.4)	/ (0)	1 (1.4)
CVCCCV	1 (1.4)	/ (0)	1 (1.4)
CVCCCVC	/ (0)	1 (1.4)	1 (1.4)
CCVCVC	/ (0)	1 (1.4)	1 (1.4)
CCVCCV	/ (0)	1 (1.4)	1 (1.4)
Total	36 (50)	36 (50)	72 (100)

Frequency of the word classes in four word lists is displayed in Table 5. The most frequent words in all tests were the nouns, followed by the adjectives, and the verbs. Other word classes were represented in a smaller percentage.

Table 5. Frequency of the word classes in four word lists

Word classes	Test 1	Test 2	Test 3	Test 4	Total
	No (%)	No (%)	No (%)	No (%)	No (%)
Nouns	38 (22.1)	37 (21.5)	27 (15.7)	27 (15.7)	129 (75)
Adjectives	7 (4.1)	13 (7.6)	2 (1.2)	4 (2.3)	26 (15.1)
Verbs	/ (0)	/ (0)	6 (3.5)	4 (2.3)	10 (5.8)
Numerals	2 (1.2)	/ (0)	/ (0)	/ (0)	2 (1.2)
Adverbs	/ (0)	/ (0)	1 (.6)	1(.6)	2 (1.2)
Pronouns	1 (.6)	/ (0)	/ (0)	/ (0)	1 (.6)
Prepositions	1 (.6)	/ (0)	/ (0)	/ (0)	1 (.6)
Particles	1 (.6)	/ (0)	/ (0)	/ (0)	1 (.6)
Total	50 (29.1)	50 (29.1)	36 (20.9)	36 (20.9)	172 (100)

All participants included in clinical validation of the tests had pure tone average (PTA) and SDT ≤ 10 dB HL. SRT was 16 dB HL. WRS was determined at starting level of 10 dB SL (re: SRT). Only the right ear was tested at three presentation levels in 2 dB increments. A total of 1500 words were repeated from the Test 1 and Test 2, and 1080 words from the Test 3 and Test 4. Percentage of repeated words at different presentation levels is displayed in Figure 1. Most of the words in all tests were repeated at the level of 26 dB. The difference between the presentation levels at which the subjects repeated all the words was ≤ 4 dB.

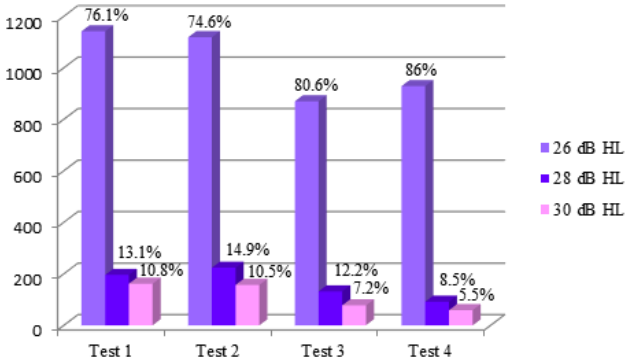

Figure 1. Percentage of repeated words at different presentation levels

Mean psychometric function for all monosyllabic and disyllabic words repeated from 30 normal hearing subjects is displayed in Figure 2.

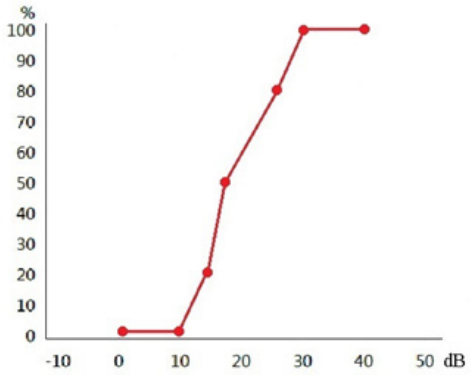

Figure 2. Mean psychometric function for monosyllabic and disyllabic words

We obtained 100% word recognition at the level 30 dB HL in all subjects. Psychometric function slope from 20% to 80% correct recognition was calculated manually and the value was 5%/dB. The slope of a word recognition function expresses the relation between the change in correct recognition performance (Δy) and the change in the presentation level of the speech signal (Δx) that is expressed as Δy/Δx. The performance 80% is obtained at 26 dB HL, and the performance 20% is obtained at 14 dB HL. According to the form Δy/Δx, 60%/12 dB = 5%/dB.

DISCUSSION

We developed Macedonian monosyllabic and disyllabic tests for speech audiometry by applying the following criteria: word familiarity, phonetic balance, and homogeneity of audibility. Two linguists confirmed that the words in the tests are familiar for children and adults. The word familiarity could be ensured at different ways. Garadat, Abdulbaqi & Haj-Tas (2017) presented an initial list of speech stimuli to a sampled population in a form of survey to rate their familiarity with these words. Stimuli that were selected to be included in the final lists had a high familiarity index.

Development of the tests was preceded by an acoustic analysis of Macedonian vowels and consonants, as well as, analysis of coarticulation in nonsense syllables and real words. Two sets of acoustic measurements were made in analysis of vowels: fundamental frequency (Fo) and formant frequencies from F1 to F5. Spectral characteristics of the consonants were analyzed by determining the spectral moments: center of gravity, spectral standard deviation, skewness and kurtosis. Formant frequencies and Fo in children were higher than formant frequencies and Fo in men and women. The consonants as isolated phonemes had concentration of acoustic energy in lower frequencies in comparison to consonants in vowel context. F2 transition is an acoustic cue for the place of articulation in speech perception (Ristovska et al., 2018; Ristovska et al., 2019; Jachova, Ristovska & Spasov, 2021).

The frequency of occurrence of Macedonian phonemes was calculated from the corpus of sentences containing the most frequent words in order to develop phonetic balanced word lists. There was no Macedonian word frequency dictionary. Frequency of occurrence of the phonemes could be calculated from word frequency dictionary or by selecting several articles. Sagon & Uchanski (2006) calculated the frequency of the phonemes and the most frequent syllable structure with analysis of about 3000 words from three articles in weekly newspaper.

Our monosyllabic tests (Appendix A) contain 50 words presented in quiet background. The most frequent syllable structure is CVC. The initial use of monosyllabic words for speech recognition testing is attributed to Egan who worked in the Psychoacoustics Laboratory at Harvard University in 1948. His original pool of 1000 words was divided into 20 lists of 50 words, which collectively are known as the *PAL PB-50* word lists. Each list was considered to be phonetically balanced. Ira Hirsh and the colleagues from the Central Institute for the Deaf, in 1952 selected 120 very common words of the initial *PAL PB-50* along with 80 other words to compose new phonetically balanced four 50-word lists known as *CID W-22.* They used the carrier phrase "You will say…" (McArdle & Hnath-Chisolm, 2015). We avoided this phrase because the acoustic analysis of coarticulation showed that this phrase (In Macedonian: „Ќе кажеш...") is not suitable. There is a long duration of the noise of the fricative /ш/ (ʃ) as a last phoneme in the phrase (Ristovska et al., 2019). The pause between the phrase and the word from the test is very short, about 300-450 ms, and some influence of the final phoneme of the phrase on the phoneme in the initial position of the word is possible. We took into account possible effects of coarticulatory factors during test development. We used the carrier phrase: "Say the word…" (In Macedonian: „Кажи го зборот..."). Lehiste and Peterson in 1959 developed lists of CNCs (consonant-syllable nucleus [vowel]-consonant) that were phonemically balanced versus phonetically balanced. Phonetically balanced lists did not take into account the position of the sound in a word and how that acoustic realization of the sound would be affected by coariculatory factors. Lehiste and Peterson argued that phonemic balancing could be accomplished by allowing for the frequency of occurrence of each initial consonant, vowel nucleus, and final consonant to be similar across CNC word lists. Their lists were condensed into four lists of 50 words known today as the Northwestern University Auditory Test Number 6 (*NU No. 6)* (McArdle & Hnath-Chisolm, 2015). The *Maryland CNC Test* also used phonemic balanced word lists developed by Lehiste and Peterson. Each word lists contains CNC monosyllabic words (Mendel, Mustain & Magro, 2014).

The words in our tests are familiar to adults and children as well. The *CNC test* was originally developed for assessment of the word recognition of adults, and many children with a language age of 5 to 6 years will find many of the words to be unfamiliar (Wolfe, 2020). The measurement of speech recognition with the pediatric population must consider the selection of test materials within a child's receptive vocabulary competency.

Haskins in 1949 developed *Phonetically Balanced Kindergarten (PBK) Test* composed of monosyllabic words selected from the spoken vocabulary of kindergartens. The test could be administered if the receptive vocabulary age of the child approaches at least that of a normal hearing 6 years old child or older (Diefendorf, 2015). *PBK* have remained one of the most important outcome measures for assessing speech recognition in children with hearing impairment using cochlear implants. However, a number of studies have reported poor performance on PBK word list by children using cochlear implants (Kant & Banik, 2017).

Developed tests are in an open-set format and the children can only hear the words without picture identification. To avoid the possibility the words to be unfamiliar to children, Ross and Lerman in 1970 developed the *Word Intelligibility by Picture Identification (WIPI) Test*. The *WIPI* test is a closed-set test and includes picture plates with six illustrations per plate. The use of *WIPI* materials is appropriate for those children with receptive vocabulary ages of 4 years and greater. For younger children, Eliot and Katz developed the *Northwestern University-Children's Perception of Speech (NU-CHIPS)*. The words are documented to be in the vocabulary of children with normal hearing as young as age 3 years (Diefendorf, 2015).

First tests for speech audiometry were developed in English. Every language has the specifics and the authors must take them into account during the test development. Durankaya et al. (2014) developed a Turkish speech recognition test, considering phonemic balance, homogeneity, and familiarity criteria. The most frequently used Turkish monosyllabic words were selected from the corpus and three word lists were developed, each composed of 50 words. Rathna Kumar et al. (2016) developed speech identification test in Marathi for assessing adults by considering word frequency, familiarity, words in common use, and phonemic balancing. They developed four word lists, each containing of 25 words.

We used disyllabic phonetically balanced words for development of disyllabic tests (Appendix B). Usually, spondaic words are used for determining SRT. Spondaic words are disyllabic words that have equal stress on each syllable. There are no spondaic words in Macedonian. In Macedonian disyllabic words, the first syllable is stressed. There are words from foreign origin such as: *laptop, smartphone, facebook, you tube, hot spot, hot dog* etc. Some of them have translation in Macedonian. Recorded 42-word spondee tests were originally developed at the Harvard Psychoacoustics Laboratory by Hudgins, Hawkins, Karlin, and Stevens in 1947. They tried to use phonetically dissimilar words from a familiar vocabulary that were as homogeneous as possible with respect to their audibility. Subsequently, Hirsh and colleagues from the Central Institute for the Deaf improved the original spondaic materials by reducing the list to the 36 most familiar spondees and by recording the words in a way that made them homogeneous with respect to their audibility. Each test word in their *CID W-1 Test* and *CID W-2 Test* was preceded by the carrier phrase "Say the word …" which was recorded at a level 10 dB higher than the test word itself (Gelfand, 2016). We also used the carrier phrase "Say the word …" in our disyllabic tests, but it was recorded at the same intensity level as the words. Many authors developed speech recognition test according to specifics of the language. Trimmis et al. (2006) developed phonemically balanced word lists for suprathreshold word recognition testing. The test material consisted of 4 lists, each containing 50 open-set disyllabic words. Monosyllabic words were not included because few exist in the Modern Greek language. Harris et al. (2007) developed speech audiometry materials for word recognition and SRT testing in quiet for native speakers of Russian. SRT materials were developed by selecting 25 disyllabic words. The recordings were digitally adjusted to match the mean PTA of the native listeners.

Homogeneity of audibility was examined during the clinical validation of the tests. Recorded speech material was installed in OTOsuite software of the audiometer MADSEN Astera^2. We obtained word recognition score 100% at maximum 30 dB HL in all subjects. Psychometric function slope from 20% to 80% correct recognition for all words was 5%/dB, which is relatively steep slope and the word lists are homogeneous with respect to audibility. Wilson & Carter (2001) examined the relation between the slope of a mean word recognition function and the homogeneity or variability (with respect to recognition) of the individual stimulus items that compose the test materials. They concluded that the more homogeneous performance is on the individual test items with respect to both location and slope, the steeper the slope of the mean psychometric function. Harris et al. (2004) developed Polish disyllabic test for SRT testing. The mean slopes from 20 to 80% were 10.1%/dB for male speaker and 9.8%/dB for female speaker. Ji et al. (2011) developed Chinese Mandarin monosyllable test material with homogenous items. The mean slope of eight equivalent lists was 5.0±.29%/dB.

After the confirmation that the tests are homogeneous in terms of the audibility, the next step in the clinical validation of the tests was analysis of correlation between pure tone thresholds and speech thresholds in patients with hearing loss. We found high correlation between hearing thresholds and speech thresholds: SDT and SRT (Ristovska & Jachova, 2021; Ristovska et al., 2021).

CONCLUSION

Developed phonetically balanced word lists have relatively steep psychometric function slope and they are homogeneous in terms of the audibility. The word lists are suitable for speech threshold and suprathreshold testing for children and adults with hearing loss who are native speakers of Macedonian. Using these tests, speech audiometry can be performed with recorded speech materials as a preferred method for presentation of speech stimuli as opposed to presentation with monitored live voice.

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APPENDIX A

Ristovska and Jachova Monosyllabic Tests

Test 1		Test 2	
Macedonian	English	Macedonian	English
парк	park	лист	leaf
цвет	flower	знак	sign
град	city	ден	day
стан	apartment	воз	train
збор	word	март	march
шал	scarf	сад	bowl
лав	lion	час	hour
дожд	rain	југ	south
рид	hill	мед	honey
чај	tea	туѓ	foreign
пат	road	нов	new
бик	bull	кат	floor
жед	thirst	свет	world
кит	whale	ѕвон	bell
јас	I	сам	alone
два	two	фин	fine
чист	clean	раст	growth
не	no	тап	blunt
влез	entrance	брат	brother
камп	camp	даб	oak
фен	hair dryer	кељ	wild cabbage
наш	our	ќош	corner
ноќ	night	под	floor
број	number	кран	crane
век	century	хит	hit
мост	bridge	клас	class
син	son	вид	type
план	plan	рис	lynx
танц	dance	џип	jeep
рез	cut	јак	strong
хор	choir	вест	news
ѕид	wall	плин	gas
три	three	брег	coast
нов	new	жолт	yellow
клуч	key	маст	ointment
снег	snow	бенд	band
коњ	horse	наш	our
ваш	your	драг	dear
кељ	wild cabbage	тен	complexion
тост	toast	волк	wolf
рој	swarm	цел	whole
џин	giant	вир	puddle
глас	voice	дом	home
ѓон	sole	коњ	horse
тим	team	зрел	mature
врат	neck	твој	your
без	without	слон	elephant
сув	dry	крив	bent
млад	young	чај	tea
густ	thick	друг	other

APPENDIX B

Ristovska and Jachova Disyllabic Tests

Test 3		**Test 4**	
Macedonian	English	Macedonian	English
дете	child	книга	book
топка	ball	време	time
сонце	sun	мисли	think
зебра	zebra	денес	today
трева	grass	песок	sand
мајка	mother	точка	dot
песна	song	шета	walk
ѕвоно	bell	пингвин	penguin
топло	warm	клупа	bench
куќа	house	десно	right
татко	father	ноти	notes
чита	read	љубов	love
јаде	eat	цвеќар	florist
играч	player	зајак	rabbit
љубов	love	тостер	toaster
вода	water	шепот	whisper
сусам	sesame	хуман	humane
носи	wear	џудо	judo
шума	forest	слика	picture
лови	hunt	ѕвезда	star
домат	tomato	табла	board
млеко	milk	јајце	egg
храна	food	сиво	gray
цреша	cherry	тигар	tiger
тенис	tennis	води	lead
ќеврек	bagel	тажно	sad
дедо	grandfather	доктор	doctor
јагне	lamb	фарма	farm
жолти	yellow	тесто	dough
вози	drive	руда	ore
жеден	thirsty	чувар	guard
готви	cook	меѓа	borderline
оџак	chimney	желба	wish
сестра	sister	роден	born
филтер	filter	молња	lightning
бања	bath	сака	love