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# A Modern Greek Word Recognition Score Test Designed for School Aged Children

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OBJECTIVE: Several word recognition tests in Greek have been developed over the years. However, none of these tests was especially designed for children.

MATERIALS AND METHOD: In this study, a test for measuring suprathreshold word recognition score in Modern Greek speaking children has been developed. The test is designed in an open-set format and consists of two lists of 50 bisyllabic words in each list. Two syllable words were chosen as stimuli because of the limited number of monosyllabic words in Modern Greek. The lists are phonemically balanced with a vocabulary level of 6 through 12 years of age.

RESULTS AND CONSLUSION: Results of the lists in Modern Greek speaking children with normal-hearing and different types of hearing loss revealed that the test appears to be a useful additional tool for the audiological evaluation of children.

Speech recognition measurement is an important element in assessing, how hearing loss affects an individual's life and communication interactions. There are two fundamental speech diagnostic tools used in a routine comprehensive audiological evaluation, speech recognition threshold (SRT) testing, and word recognition score (WRS) testing. The purpose of SRT testing is to find the lowest level of hearing for speech, where 50% of the speech material can be correctly recognized. The purpose of WRS testing is to determine the approximate suprathreshold level at which an individual can correctly understand and repeat a list of words [1]. It yields a score which is the percentage of a list of words that are correctly identified at suprathreshold levels.

The primary focus of speech recognition tests for children is almost the same as for adults. The measurement of a child's WRS helps the audiologist in several ways: it assesses the degree of the speech recognition difficulty; it aids in diagnosis of the site of the disorder in the auditory system; it assists in the determination of the need for and proper selection of sensory devices (e.g., hearing aids, hearing assistive devices, cochlear implants); it provides useful information for proper placement within a training curriculum; it helps the clinician to determine performance longitudinally.

Although speech audiometry materials for adults are presently available in Modern Greek, there is still a deficit in paediatric materials. Many of the words in adult word lists are unfamiliar to children. No speech test material for children less than 12 years of age exists in Greece to the time of this writing. Thus, an urgent requirement exists towards the development of paediatric speech materials.

Considering the foregoing limitations in Modern Greek speech materials for paediatric evaluation, the goal of this study was to develop a test for suprathreshold word recognition testing designed for elementary school aged children. The specific aims of this study were to determine the word familiarity of list items, to construct phonemically balanced word lists for suprathreshold word recognition testing, and to perform a preliminary investigation of list equivalence.

## MATERIALS AND METHODS

### Development of Materials

Type of Materials

Since the beginning of speech audiometry, tests of WRS testing have been constructed with a wide variety of speech materials including nonsense syllables, words (mono-, bi-, multisyllabic) and sentences. However, intelligibility curves for different materials revealed that the higher the redundancy of the stimulus, the fewer the acoustic cues needed to recognize it. Performance intensity (PI) curves are found to be steeper for speech stimuli with high linguistic redundancy than stimuli with low linguistic redundancy.

Nonsense syllables are the least and sentences the most redundant type of item. An advantage of nonsense syllables is that contextual clues are absent and as a result their recognition is not dependent upon the vocabulary of the listener. It must be noted that speech test of hearing should evaluate peripheral hearing function and not central processes such as linguistic or mental abilities. On the other hand, they are first too abstract and second they do not represent the appropriate phonemic sequence in the language. Thus, they are difficult for many patients and especially for children to discriminate [2]. Also, the listener does not need to identify meaningless material. Words have higher face validity than nonsense syllables since we communicate with words in daily conversation [3]. It was mainly of these reasons that the use of monosyllabic word lists has been widely accepted.

However, there are a limited number of monosyllabic words in Modern Greek language and most of them are not content words. Thus, the type of material to be used would be bisyllabic words with the least amount of phonemes in order to control redundancy.

Word selection and familiarity

The most important factor appears to be the child's receptive vocabulary. Construction of speech audiometry tests for children is more difficult, since they are still developing their language skills, and thus selection of test materials become rather more limited than with adult patients [4]. More emphasis is placed on the test words being

simple and easy since the familiarity of a given word increases the intelligibility of that word. Research has shown that highly familiar word lists, compared to less familiar word lists, provide a more accurate measure of an individual's comprehension [5]. It is important to have speech materials which accurately resemble the language of the individual being tested in order to obtain precise measures. However, no database on the word familiarity or frequency of word occurrence of Greek words exists to the time of this writing.

Primary education in Greece is intended for pupils aged 6 to 12 years. Initially, 1000 bisyllabic words were drawn from the first and second grade textbooks of the Modern Greek language subject taught in primary school ordinary curriculum. The inadequate number of words in first grade textbooks necessitated the additional use of second grade textbooks. Any words that thought to possibly represent inappropriate content were eliminated from the study. Next, 50 elementary school teachers (fifty female; average age, 41,94 years; SD, 6.73).with a minimum of 5 years first-grade teaching experience and 50 parents (fifty female; average age, 33,30 years; SD, 4.31) who had normal hearing children in the first grade rated the selected words on a 3-point scale of familiarity. To further enhance familiarity, the 416 words that were rated as most familiar by both teachers and parents were judged by 300 children (50 children per grade; 25 male-25 female; average age, 8.98 years; SD, 1.74) as either familiar or unfamiliar. All 389 words rated as familiar were selected for construction of the final lists.

Method of response

Another important issue to consider when developing word recognition tests for children is what kind of response format will be used to elicit responses.

Speech recognition tests can be divided into two groups based on the response formats: closed-set and open-set. A closed-set test is easier for the listeners because a limited set of response alternatives, known to the patient, are provided. In contrast, an open-set test, where the patient repeats the word that they hear, allows no chance for correct responses through guessing. Therefore, open-set testing is more representative of real world listening performance. Open-set speech audiometric procedures can be applied with great reliability to children beyond ages 4 or 5 years [6, 7]. As a result, the open-set format was chosen for the test developed in this study.

Phonemic Balance

Word lists designed for WRS testing are traditionally phonemically balanced, meaning that the different phonemes of the test must appear with the same relative frequencies as in everyday spoken language. The rationale is that if a person is unable to perceive a certain phoneme, the difficulty he experiences is more severe for phonemes with higher frequency of occurrence (4). Additionally, lists of a speech test are considered interchangeable if each has the same phonemic balance implying that the lists have equal properties under all test conditions. There are 30 phonemes in Modern Greek spoken language which is the official language of Greece, and the most widely spoken by Greeks today. Table 1 displays the phonemic alphabet and frequency of occurrence of phonemes of Modern Greek language [8].

**Table 1**. Frequency of occurrence of phonemes in Modern Greek spoken language and frequency of lists 1 and 2.

| | Phonemes IPA Symbol | Frequency Spoken Language | List 1 Frequency (%) | List 2 Frequency (%) |
|---|---|---|---|---|
| 1 | **a** | 12,26 | 11,85 | 11,85 |
| 2 | **ɛ** | 10,40 | 9,95 | 9,95 |
| 3 | **i** | 14,25 | 13,74 | 13,74 |
| 4 | **o** | 9,49 | 9,48 | 9,48 |
| 5 | **u** | 2,50 | 2,37 | 2,37 |
| 6 | **r** | 4,18 | 4,27 | 4,27 |
| 7 | **θ** | 1,11 | 0,95 | 0,95 |
| 8 | **ð** | 2,04 | 1,90 | 2,37 |
| 9 | **b** | 0,26 | 0,47 | 0,47 |
| 10 | **d** | 0,54 | 0,47 | 0,95 |
| 11 | **ts** | 0,11 | 0,47 | 0,47 |
| 12 | **dz** | 0,02 | 0,47 | 0,47 |
| 13 | **p** | 4,36 | 4,74 | 4,27 |
| 14 | **m** | 3,69 | 3,32 | 3,32 |
| 15 | **f** | 1,28 | 1,42 | 1,42 |
| 16 | **v** | 0,88 | 0,47 | 0,47 |
| 17 | **t** | 7,54 | 7,11 | 7,11 |
| 18 | **z** | 0,54 | 0,95 | 0,95 |
| 19 | **s** | 7,68 | 7,58 | 7,11 |
| 20 | **n** | 6,17 | 6,16 | 6,16 |
| 21 | **g** | 0,12 | 0,47 | 0,47 |
| 22 | **l** | 2,77 | 2,84 | 3,32 |
| 23 | **k** | 2,62 | 2,37 | 2,84 |
| 24 | **χ** | 0,60 | 0,47 | 0,47 |
| 25 | **ɣ** | 0,74 | 0,95 | 0,95 |
| 26 | **c** | 1,79 | 1,90 | 1,42 |
| 27 | **ç** | 0,88 | 0,95 | 0,95 |
| 28 | **j** | 0,98 | 0,95 | 0,47 |
| 29 | **ʎ** | 0,11 | 0,47 | 0,47 |
| 30 | **ɲ** | 0,10 | 0,47 | 0,47 |
| | Total | 100,00 | 100,00 | 100,00 |

Number of scorable list items

The problem of deciding how many items each list of a WRS test must contain requires consideration of the following three factors:

First, duration of the test. Longer lists require longer measurement time, but clinicians want a short test because time plays an important role in clinical audiometry.

Second, variability of test scores. Longer lists decrease variability and therefore increase reliability. Based upon the number of test items, 95% confidence bands have been developed in order to determine if two WRS's are considered significant [9, 10, 11]. These bands become narrower with increasing test size. This reduction in variance obtained is considerable when the list size is small, but becomes progressively smaller as the test size becomes progressively larger[12].

Third, small lists contain an inadequate number of phonemes in order to approximate phonemic balance. Egan (1948) found that the minimum number of words in each list in order to achieve phonemic balance is 50.

Careful consideration of the previously listed factors suggested the number of words in each list to be 50.

Lexical stress

In Modern Greek there are no spondaic words since every word of two or more syllables has stress on one of its vowels. The vowel that carries the stress is pronounced at a higher pitch and is slightly longer and louder [14]. However, syllabic stress will not cause perception of a different phoneme and thus will not affect phonemic balance[8]. Therefore, distribution of stress was kept equally in each list. That is, 25 words stressed on the first syllable and 25 words on the second syllable.

Phonemic dissimilarity

The criteria for phonemic dissimilarity were those used in our previous research [8].

Interlist Equivalency

The next step in the development of the paediatric WRS test included establishment of PI functions at several suprathreshold levels with the different lists. The word lists should be of equal difficulty (less than 8% variability)[4].

Subjects

The individuals who participated in this study included 90 normal hearing children (45 boys and 45 girls; average age, 8,43 years; SD, 1.92), 20 conductive hearing loss children (5 boys and 5 girls; average age, 8,75 years; SD, 1.76), and 10 sensorineural hearing loss children (5 boys and 5 girls; average age, 8,92 years; SD, 1.84) . All subjects ranged in age from 6 to 12 years and were native speakers of Modern Greek with no known history of speech or language disorder, learning disability or other cognitive disorders. All normal-hearing children had pure tone thresholds of ≤ 15 dB HL at all octave frequencies ranging from 250 Hz to 8000 Hz, whereas the hearing-impaired groups had similar pure tone thresholds.

Recording of Test Items

Recordings were made using a native female voice actor in a sound isolated booth. During the recording sessions, the talker was asked to produce each word at least five times at a normal rate with natural prosody. Two judges (university students) rated the repetitions of each word for the perceived quality of production, and the best production of each word was selected. The recording apparatus and editing tasks were those used in our previous research [8].

Procedure

All testing was performed in a sound chamber that exceeded standards for the ambient noise level for audiometric rooms. The signal was routed from a PC to the external input of a GSI 61 audiometer. The stimuli were routed from the audiometer to the subject via supra-aural TDH-49 headphones. Prior to testing each subject, the inputs to the audiometer were calibrated to 0 VU using the 1 kHz calibration tone.

The subjects were not familiarized with the bisyllabic words prior to testing. For the normal-hearing group, each list was presented monaurally (right ear) at nine different intensity levels, ranging from 0 to 40 dB HL, starting at 0 dB HL and ascending in 5 dB HL steps to minimize non-auditory factors such as memory effects. For the hearing-impaired groups, each list was presented initially at pure tone average (PTA) ascending thereafter at 5 dB HL steps. The order of the presentation of words within each list was

randomized for each subject and for each intensity level. This randomized word order of words within each list yields more reliable and valid results [15].

## RESULTS

Based on the aforementioned criteria, two phonemically balanced 50-word lists with equal distribution of syllabic stress were developed (Table 2).

**Table 2**. The two bisyllabic word lists for use in pediatric WRS testing.

| List 1 | | | | List 2 | | | |
|---|---|---|---|---|---|---|---|
| Stress 1st syllable | | Stress 2nd syllable | | Stress 1st syllable | | Stress 2nd syllable | |
| IPA | Modern Greek | IPA | Modern Greek | IPA | Modern Greek | IPA | Modern Greek |
| θia | θεία | fakes | φακές | pano | πάνω | ceri | κερί |
| kori | κόρη | arni | αρνί | zugla | ζούγκλα | okto | οκτώ |
| pites | πίτες | ftoxos | φτωχός | tonos | τόνος | palto | παλτό |
| nici | νίκη | ceros | καιρός | ora | ώρα | efçi | ευχή |
| θelo | θέλω | zesto | ζεστό | triti | Τρίτη | lemos | λαιμός |
| meno | μένω | sira | σειρά | ena | ένα | ksino | ξινό |
| spiti | σπίτι | sçini | σχοινί | θesi | θέση | kalo | καλό |
| bota | μπότα | tiri | τυρί | tsai | τσάι | fai | φαΐ |
| karta | κάρτα | jali | γυαλί | ɣiða | γίδα | koda | κοντά |
| tsepi | τσέπη | ura | ουρά | stema | στέμμα | avɣa | αυγά |
| ema | αίμα | ɣati | γατί | ɣuna | γούνα | zumi | ζουμί |
| mesa | μέσα | afti | αυτί | ðixti | δίχτυ | eɲa | εννιά |
| topi | τόπι | nero | νερό | pleno | πλένω | peði | παιδί |
| kano | κάνω | puli | πουλί | dzami | τζάμι | steno | στενό |
| pagos | πάγκος | ɣonis | γονείς | mati | μάτι | saci | σακί |
| saka | σάκα | lepto | λεπτό | petra | πέτρα | pani | πανί |
| ðino | δίνω | epta | επτά | nanos | νάνος | ftero | φτερό |
| meres | μέρες | pezos | πεζός | eðra | έδρα | scili | σκυλί |
| jeɲa | γένια | ðuʎa | δουλειά | buti | μπούτι | psomi | ψωμί |
| meli | μέλι | vuna | βουνά | kotes | κότες | eʎa | ελιά |
| dzaci | τζάκι | stilo | στυλό | roði | ρόδι | nisi | νησί |
| çoni | χιόνι | naos | ναός | mila | μήλα | proi | πρωί |
| teda | τέντα | kupi | κουπί | treɲa | τρένα | θeos | Θεός |

It was not possible to construct more than two lists due to material limitations. The lists are composed primarily of common nouns that are well within the children's receptive vocabularies (Table 3).

**Table-3:** Grammatical category of bisyllabic words included in the lists.

| | List 1 | List 2 |
|---|---|---|
| Noun | 39 | 39 |
| Verb | 4 | 1 |
| Adverb | 2 | 2 |
| Adjective | 3 | 3 |
| Numeral | 2 | 4 |
| Pronoun | 0 | 1 |
| Total | 50 | 50 |

Following monaural presentation of the lists, the percent of correct values were used to construct PI functions. The PI functions for the normal-hearing group for mean scores and standard deviations of the two paediatric bisyllabic lists are revealed in figure 1.

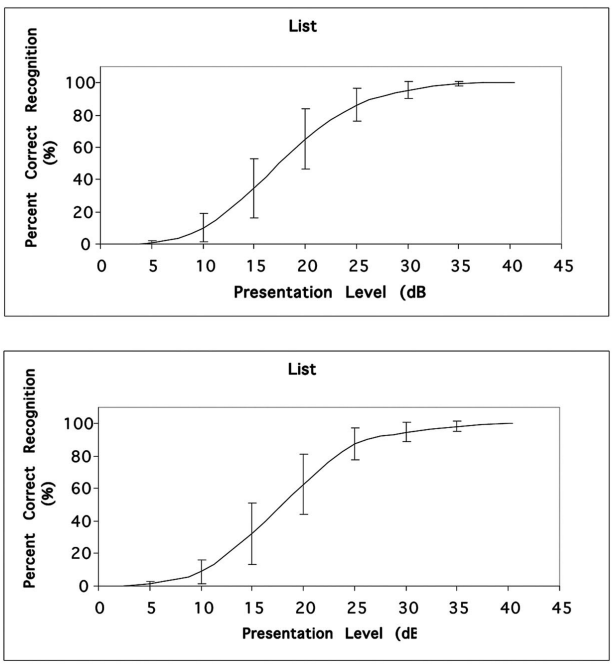


**Figure-1:** Monaural (right ear) PI function of 90 normal-hearing children on the two lists and standard deviations.

As can be seen in Table 4, mean word scores increased from 0,93% (List 1) and 1,20% (List 2) at 5 dB HL to 100% (both lists) at 40 dB HL, with an average slope per decibel of 5.08% in the first and 5.24% in the second list in the rapidly rising portion of the function between 10 and 25 dB HL.

**Table-4:** Mean values of the monaural (right ear) percent correct scores and standard deviations for the two lists.

| | List 1 | List 2 |
|---|---|---|
| 0 dBHL | | |
| M | 0,00 | 0,00 |
| SD | 0,00 | 0,00 |
| 5 dBHL | | |
| M | 0,93 | 1,20 |
| SD | 1,28 | 1,47 |
| 10 dBHL | | |
| M | 10,13 | 8,80 |
| SD | 8,90 | 7,51 |
| 15 dBHL | | |
| M | 34,53 | 32,40 |
| SD | 18,65 | 19,07 |
| 20 dBHL | | |
| M | 65,20 | 62,53 |
| SD | 18,67 | 18,46 |
| 25 dBHL | | |
| M | 86,26 | 87,47 |
| SD | 10,28 | 9,78 |
| 30 dBHL | | |
| M | 95,40 | 94,80 |
| SD | 5,34 | 6,13 |
| 35 dBHL | | |
| M | 99,33 | 98,40 |
| SD | 1,63 | 2,85 |
| 40 dBHL | | |
| M | 100,00 | 100,00 |
| SD | 0,00 | 0,00 |
| Slope from 10 to 25dBHL | 5.08%/dB | 5.24%/dB |

The effect of conductive hearing loss on the PI function is largely one of reduced sensitivity (Figure 2). In neurosensorial disorders, the PI function tends to be flatter and the maximum score is reduced (Figure 3).

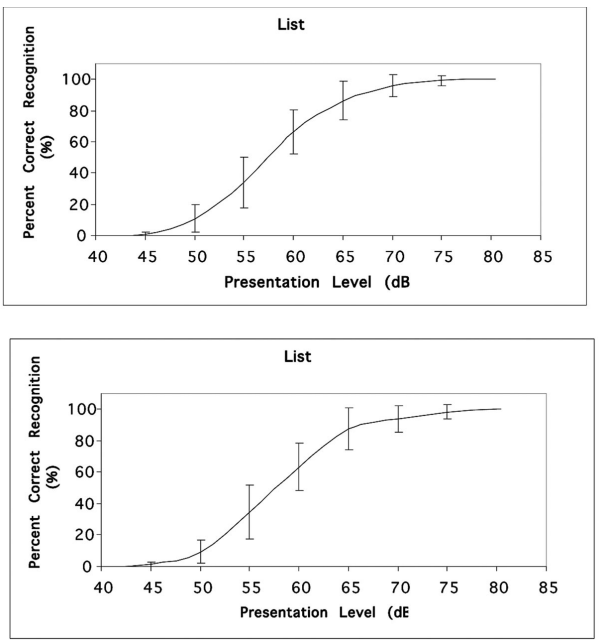


**Figure-2:** Monaural (right ear) PI function of 20 conductive-hearing-loss children on the two lists and standard deviations.

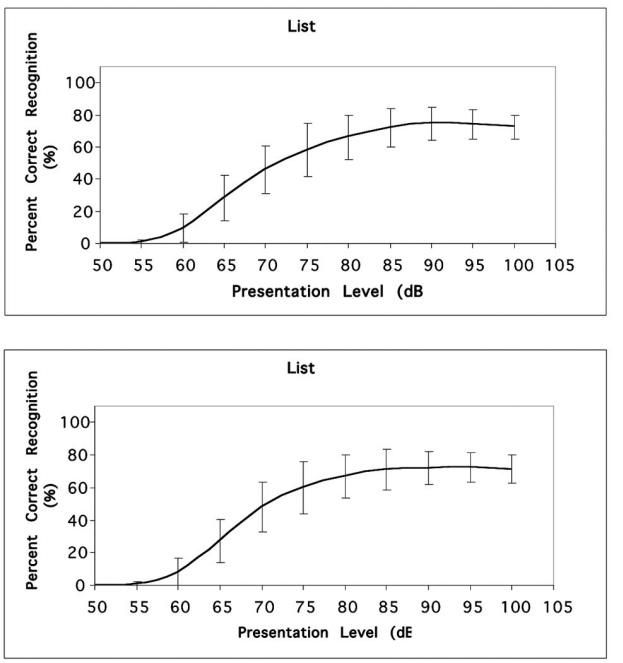


**Figure-3:** Monaural (right ear) PI function of 20 sensoryneural-hearing-loss children on the two lists and standard deviations.

## DISCUSSION

In this study a WRS test was developed for Modern Greek speaking children between 6 to 12 years. This test consists of low-redundancy bisyllabic words. Each list contains no more than 211 phonemes, since the present study was not aimed at testing children's vocabulary, but rather their speech intelligibility for known words.

Comparison of the mean scores and standard deviations of the 2 lists reveals the absence of significant differences (Table 4). Additionally, the performance functions obtained in this study are generally consistent with those commonly encountered in the literature for traditional speech recognition test materials developed in other languages.

The mean slopes of PI functions for English paediatric WRS materials are very comparable. Watson (1957) found a mean slope of 5%/dB for the Manchester Junior lists at the linearly rising section of the curve. Markides (1978a) reported a 4.2%/dB for 6 year olds, a 4.8%/dB for 7 and 8 year olds, and a 5%/dB for 9, 10 and 11 year olds from 10 - 90% WRS for the AB isophonemic word lists. In general, a steeper PI function results when the task is simpler.

These data suggest that the lists developed in this study are reasonably equivalent for the number of subjects tested since none of the mean scores differ from the overall mean score by more than 8%.

This test is based on whole word scoring. In an effort to avoid patient fatigue and save time during testing audiologists have began presenting only half (25 words) of the full lists thus decreasing reliability. Gelfand (1998) found that based on the binomial model, 450 scoreable items are needed to achieve optimal reliability for a word recognition test. Therefore, some researchers have turned to phonemic scoring as a means for increasing the number of items scored while decreasing the number of words presented, thereby controlling balance between validity and testing time. However, construction of such a test in Modern Greek necessitates the use of nonsense syllables which is in contrast with the criteria adopted in this study.

An important next step would be to examine the test-retest reliability of the lists.

As this is the first paediatric speech test developed in Modern Greek, these word lists can be modified for assessment of (central) auditory processing disorders (C)APD testing in children. Some of the English WRS tests for children have also been applied to (C)APD evaluation [18, 19].

In conclusion, this study has succeeded in developing an initial set of word recognition materials for Modern Greek school aged children. It retains the principal features of the most commonly accepted speech recognition tests (i.e., words presented in an open-set format, verbal responses, and right/wrong scoring). Our experience with the test indicates that it is a simple test to administer and that the children have little difficulty in comprehending the nature of the task.

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