

Development of an Audio Compact Disc for Speech Audiometry Testing

N. Trimmis¹, N. Markatos¹, K. Malaperdas¹, T. Papadas²

¹Department of Speech Pathology. Technological Educational Institute of Patras.

²Department of Otolaryngology. University Hospital of Patras.

INTRODUCTION

Because difficulty in hearing and understanding speech evokes the greatest complaints from patients with hearing impairments, it is logical that tests of hearing function should be performed with speech stimuli (Martin & Clark, 2006). Speech audiometry that is properly conducted with calibrated equipment and standardized recorded speech material can be a useful tool for audiological testing (Martin, 1997).

Today, most audiologists prefer monitored live-voice (MLV) testing, as they feel it provides more flexibility in delivering the stimuli and often takes less time. However, the psychometric characteristics of speech stimuli delivered by MLV are different from time to time with the same speaker, and certainly are different among speakers. With live voice it is difficult to monitor the test words to a consistent hearing level and standardization is impossible from client to client and clinic to clinic (ASHA, 1988). On the other hand, there are significant advantages to using pre-recorded materials. Primarily, they provide a consistency of presentation of a set of test materials that is independent of the expertise of the clinician, which give reproducible recognition curves.

Word recognition tests for Modern Greek were first developed in the second half of the twentieth century (Kogias, 1961; Manolidis, 1964; Iliades et al, 1978). However, speech audiometry has not become an established clinical procedure in Greece. Most of the word lists comprising the above tests did not satisfy the criteria of phonemic balance (PB), familiarity, equal average difficulty and reduced variability, so introducing much uncertainty. This fact accounts for the lack of support to make any Modern Greek speech test material available digitally recorded on compact disc (CD).

Recently, in order to improve Modern Greek speech test materials, Iliadou and colleagues (2006) developed three 50-word lists. Trimmis and colleagues (2006) developed 4 phonemically balanced (PB) 50-word lists with less redundancy based on the above criteria.

The present study describes the development of an auditory CD for speech audiometry testing in populations who speak Modern Greek in order to ensure that the speech test material is always at the same level.

MATERIALS AND METHODS

A typical speech audiometric evaluation usually includes 2 measures. The first, which is a threshold for the identification of speech material, is called the speech recognition threshold (SRT). The second is the maximum word recognition score (WRS) (Silman & Silverman, 1991).

Selection of Materials

The materials included on the CD were the four lists for assessing WRS performance, each of which contains 50 open-set PB bisyllabic words, developed by Trimmis and colleagues (2006). These lists are intended for people older than 12 years of age. For each word correctly understood the patient receives a score of 2%. No word lists for SRT testing exist in Modern Greek to the time of this writing.

Selection of Speakers

Initial recordings were made using two groups of native Modern Greek professional speakers (3 male and 3 female). All speakers were from Athens, and each spoke the standard Modern Greek dialect. Next, 2 native Modern Greek-speaking judges (speech therapists) evaluated each speaker's performance based on standard dialect, vocal quality, fluency and articulation (Table I)

Standard dialect	0	1	2	3	4	5
Vocal Quality	0	1	2	3	4	5
Fluency	0	1	2	3	4	5
Articulation	0	1	2	3	4	5

Table I. Speaker's evaluation form

The highest ranked speaker from each group (1 male and 1 female) was selected to be the speakers for the final recordings.

Recordings

All 200 words were recorded in a large one-room Industrial Acoustic Company booth (Model 402-A) located at the Technological Educational Institute of Patras campus in the Speech and Hearing Clinic. An AKG model C-1000-S condenser microphone covered by a windscreen and positioned at optimum distance, a FireWire Solo sound card interfaced to a PC computer, and digital signal processing software (Adobe Audition, Version 1. Adobe Systems Incorporated, San Jose, CA) were used for all recording and editing tasks. Each word was produced several times with minimum suprasegmental features. The judges, one male and one female, rated the repetitions of each word for perceived quality of production, and the best production of each word was selected. Each digitized word (sampling frequency of 44.100K Hz, single channel and 16-bit resolution) was placed in a unique file for later editing.

Editing of Materials

Following the rating, each file was edited using Adobe Audition software for:

- Noise elimination (Click/Pop eliminator, Hiss reduction and Noise reduction functions).
- Minimizing the silence (before and after the stimulus item).
- Equalization (Group-Waveform-Normalize function to a level of -20dB) according to the "Equal speech level method" of ISO 8253-3.

Mean values of word length and total RMS power per list for the female speaker are presented in figures I and II respectively.

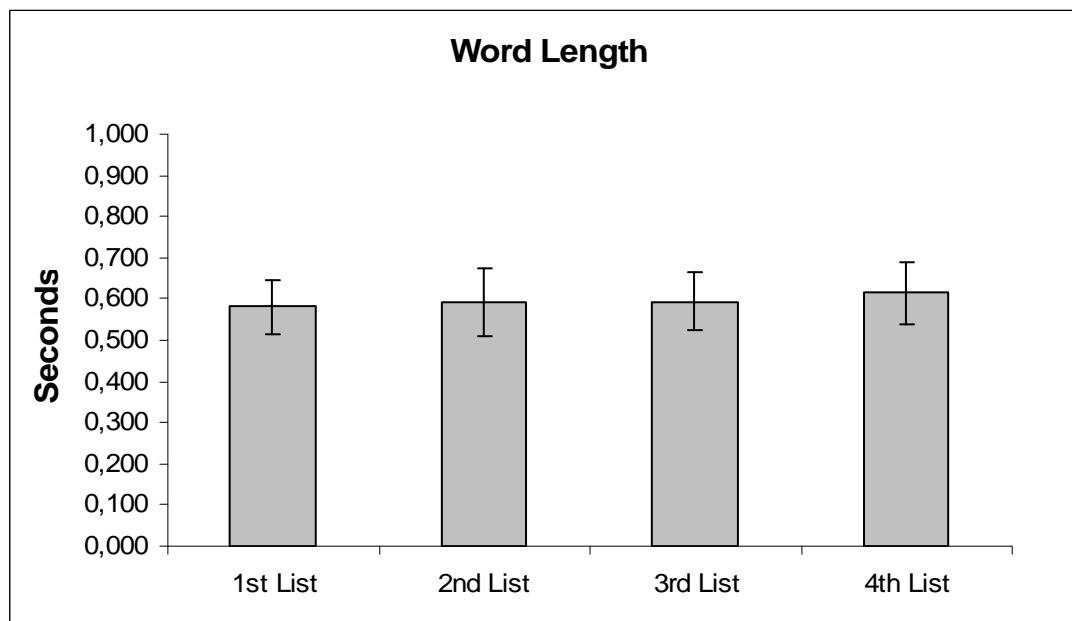


Figure I. Mean word length and SD per list (female speaker).

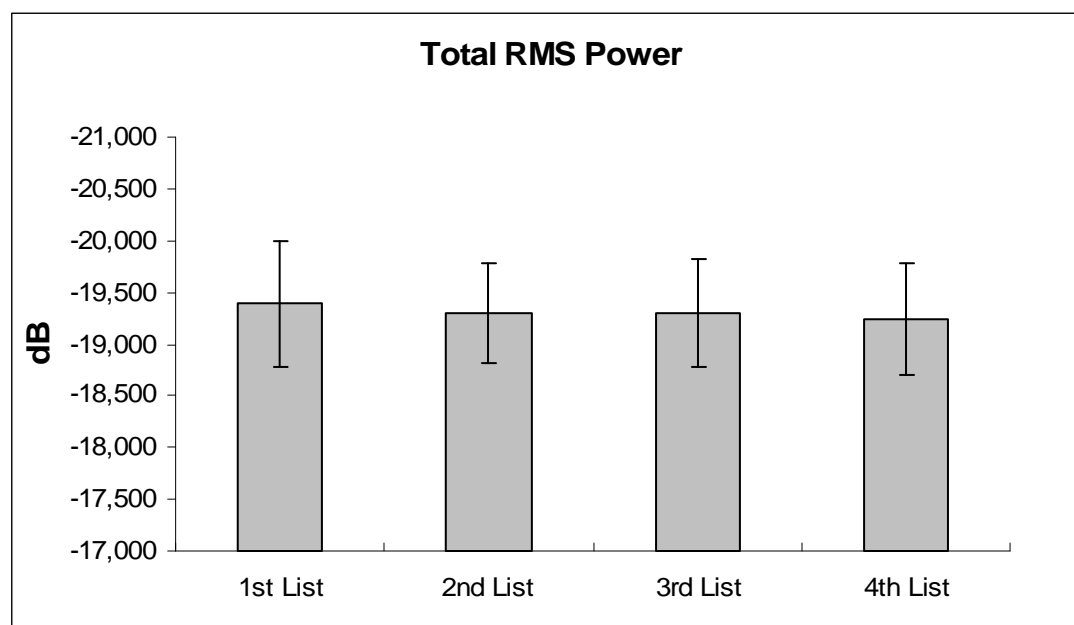


Figure II. Mean 'Total RMS Power' and SD per list (female speaker).

Additionally, each resulted file was edited for:

- High-pass (cut-off frequency 2100Hz).
- Low-pass (cut-off frequency of 1000Hz).
- 45% Compression
- 65% Compression

in order to reduce redundancy of the speech signal for investigation of Auditory Processing Disorders (APD) (Bellis, 2003).

RESULTS

An audio compact disc has been developed. The disc contains 24 tracks for each speaker with the same 50 bisyllabic words in each track, a 1000-Hz calibration tone of 30 seconds duration at the beginning of each track that reflects the peaks of the speech materials as monitored on a calibrated VU meter (the calibration tone was recorded at the same 'Average RMS Power' of the words) and interstimulus intervals of 5 seconds. Tracks 1 through 8 are used for WRS testing and contain the initial four 50-item lists and a randomization of each list. Tracks 9 through 24 are used for APD testing and contain the same 4 lists low-pass, high-pass, 45% and 65% compressed (Table II).

Table II. Materials contained on each track of the CD (female speaker).

Track	Material	Time	Track	Material	Time
1	List 1-WRS	5:09:058	13	List 1-High Pass	5:09:058
2	List 2-WRS	5:09:590	14	List 2-High Pass	5:09:590
3	List 3-WRS	5:09:681	15	List 3-High Pass	5:09:681
4	List 4-WRS	5:10:747	16	List 4-High Pass	5:10:747
5	List 1-WRS Random Order	5:09:058	17	List 1-45% Compression	4:55:982
6	List 2-WRS Random Order	5:09:590	18	List 2-45% Compression	4:56:274
7	List 3-WRS Random Order	5:09:681	19	List 3-45% Compression	4:56:324
8	List 4-WRS Random Order	5:10:747	20	List 4-45% Compression	4:56:910
9	List 1-Low Pass	5:09:058	21	List 1-65% Compression	4:50:170
10	List 2-Low Pass	5:09:590	22	List 2-65% Compression	4:50:356
11	List 3-Low Pass	5:09:681	23	List 3-65% Compression	4:50:388
12	List 4-Low Pass	5:10:747	24	List 4-65% Compression	4:50:761

A carrier phrase was not included since there are arguments in the literature both for and against the use of it (Gelfand, 1975; Lynn and Brotman, 1981; Martin, 1997).

DISCUSSION

Modern Greek test material for clinical applications of speech audiometry is now available as a CD.

Human speech is the most important sound we listen to. It is more engaging and meaningful to the patient than pure-tones or other artificial stimuli. The development of the audio CD technology has enhanced the quality of materials available to audiologists for use in diagnostic and rehabilitation procedures. This technology offers the following advantages (Wilson, 1993):

1. High-fidelity recordings with enhanced signal to noise ratio.

2. Identical recordings from one disc to another.

3. A recording medium that does not deteriorate as a function of use and time, and, therefore, does not need replacing.

4. Almost instantaneous access to any track (i.e., no winding or rewinding to access a particular word list).

At the time of writing this preliminary report on the development of the recorded materials for speech audiometry, we are in the process of standardization. A large number of native Modern Greek speakers are being given the tests in order to determine P-I functions for different normal hearing age groups. Results from the standardization of tracks 1 through 4 (female speaker) on 100 normal listeners show good consistency at each presentation level (Figure III).

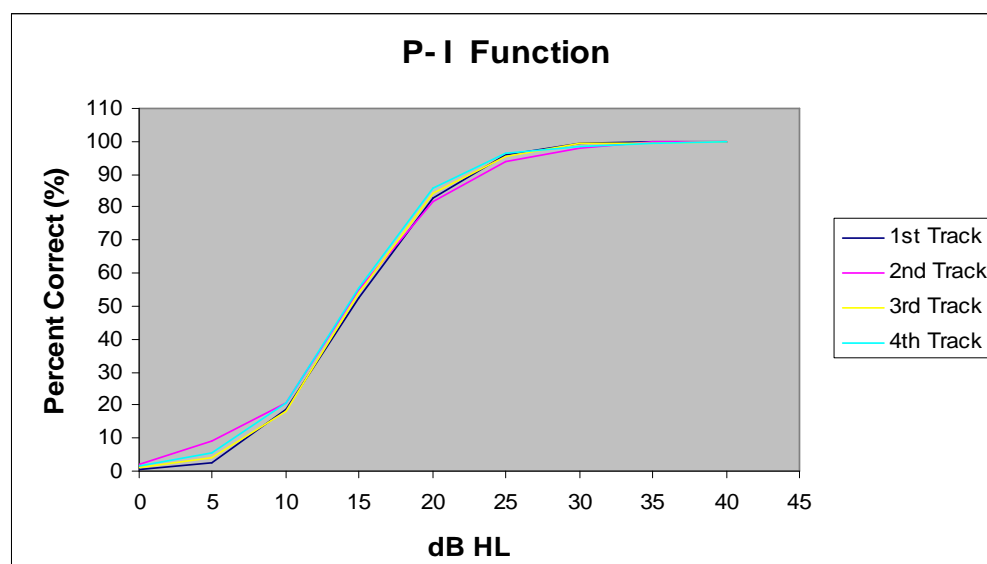


Figure III. Mean percent of monaural (Right Ear) P-I Functions for tracks 1 through 4 (female speaker).

We are therefore, in the process of acquiring experience in the administration of the CD speech materials which will undoubtedly lead to further developments.

REFERENCES

- Martin FN, Clark JG. Introduction to Audiology. 9th Edit. Pearson Education, Inc.; 2006.
- Martin M, editor. Speech audiometry. 2nd ed. London, England: Whurr Publishers Ltd; 1997.
- American Speech-Language Hearing Association. Guidelines for determining threshold level for speech. ASHA. 1988; 30:85-89.
- Kogias A. How to choose words for speech audiometry. Acad Med 1961; 25:265.
- Manolidis L. Development and use of speech audiometry in the Greek language [dissertation]. Thessaloniki, Greece: Aristotle University; 1964.
- Iliades T, Arvanitidis V, Giannakakis A & Magganaris T. The value of speech audiometry. Otorhinolaryngological Society of North Greece; 1978.
- Iliadou V, Fourakis M, Vakalos A, Hawks JW, Kaprinis G. Bi-syllabic, Modern Greek word lists for use in word recognition tests. Int J Audiol 2006; 45:74-82.
- Trimmis N, Papadeas E, Papadas T, Naxakis S, Papathanasopoulos P, Goumas P. Speech Audiometry: The Development of Modern Greek Word Lists for Suprathreshold Word Recognition Testing. Mediterr J Otol 2006; 3:117-126.
- Silman S, Silverman CA. Auditory diagnosis: principles and applications. San Diego, Calif: Academic Press, Inc; 1991.
- Bellis TJ. Assessment and Management of Central Auditory Processing Disorders in the Educational

Setting: From Science to Practice. 2nd Ed. San Diego, CA: Singular Publishing Group; 2003.

Gelfand SA. Use of a carrier phrase in live voice speech discrimination testing. *Journal of Auditory Research* 1975; 15: 107-110.

Lynn GE, Brotmann SR. Perceptual significance of the CID W22 carrier phrase. *Ear and Hearing* 1981; 2:95-99.

Wilson RH. Development and Use of Auditory Compact Discs in Auditory Evaluation. *Journal of Rehabilitation Research* 1993; 3: 342-351.