

**Turkish- Digital Speech Audiometer: Comparison of Live and Compact Disc Performances in Subjects with Normal Hearing and with Hearing Loss**

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**Abstract**

**Objective:** Presently, there is no digitally recorded speech audiometer in Turkey. In this study, homogenous Speech Reception Threshold (SRT) and Speech Discrimination (SD) word lists were developed for each frequency of auditory and slope. Digital records were prepared. Digital SRT and SD tests were presented with live audio and compact discs and possible differences between these two tests were investigated. The aim of the study is to compare the scores of Speech Discrimination (SD-obtained with list of one syllables words equivalent of digital psychometric) and Speech Recognition Threshold (SRT- obtained with Spondaic Words Lists ) with live and compact disc performances in subjects with normal hearing and with hearing loss.

**Materials and Methods:** SRT (Spondaic Words) and SD (one syllables words) lists, which were formed from the most familiar words in Turkish, were applied to 55 subjects with normal hearing (38 subject) and hearing loss (17 subjects) with live and compact disc performances following pure tone hearing test.

**Findings:** (a) Normal group: There was a significant difference between the right ear SRT compact disc and the right ear SRT live tone thresholds (p: 0.001) and between the left ear SRT compact disc and the left ear SRT live voice thresholds (0.002). The average pure tone compatibility was observed as +7 with SRT. There was significant difference in the SD test. (B) Hearing loss group: Subjects with both normal hearing and with hearing loss revealed improved results in compact disc performance compared to live sound performance (difference of 2.40 dB).

**Results:** (1) It was found that the results of compact disk tests were better than those of live tone. Compact disk provides equity in processing of frequency-severity-duration which, in return, regulates the functions of spectral (coding) and temporal decoding. (2) Spondaic words (words with two syllables) in SRT provided better results of hearing and were more efficient in finding a threshold compared to the words with three syllables. (3) There was a correlation found across psychometric functions of digital Turkish speech audiometer with a diagnostic significance. Digital psychometric equivalent of STR and SD word list can be diagnostically used in Turkish speech audiometer.

**Key words:** Speech audiometer, Speech Reception Threshold; Threshold Measurement with Spondaic Word, Speech Discrimination Test, Turkish, Compact Disk; One syllable words with SD stimulant; Spondaic words with SRT stimulant; Compact Disk; live voice; normal hearing, hearing loss.

### **Introduction**

Speaking is the oral expression of ideas and thoughts that successively take place in a daily communication of real life. By listening to hearing, we process the dynamics of speech (frequency and suprasegmental features) and perceive the speech. Hearing tests of air and bone pathways conducted in audiology assess peripheral hearing pathways and speech audiometer measurements provide data on hearing pathways, concerning the area from the ear lug to the brain. These measurements are important in terms of giving information about daily hearing function and peripheral-central auditory disorders (1). We hear these voices in daily life at the lowest and most comfortable sound levels. When the audiologist assesses audiology by standard measures, it is necessary to find the lowest hearing threshold level and speech discrimination score. The Speech Reception Threshold (SRT) and Speech Discrimination (SD) tests are used for this purpose.

Pure tone hearing test uses tonal voices to find the lowest hearing threshold. Tonal voices are artificial sounds in the audiometer and are not found in nature. Therefore, in determining the lowest hearing threshold in daily life, it is assessed with speech stimulus. Lowest hearing threshold (dB HL) should be determined with familiar word lists commonly used in daily life.

Various factors have an influence on the results obtained from speech audiometry. Most crucial factors to be considered are familiarity and homogeneity of the word. In creating assessment lists for speech audiometry, not only phonetic features, but also violence and word start and end times are important. In addition, the recording lists should be created in a standard audio laboratory with standardized equipments (2,3).

Many countries have shifted from the use of live tone to compact discs in speech audiometry (4-7). Hughes & Scott began using disc-recorded material in lieu of live tone presentation in the speech audiometer in 1967. In our country, up to date, the speech audiometer has been made only by using live tone.

There are very few studies on the development of Turkish speech audiometry. Seven Turkish vocabulary lists have been developed in our country to be used in adults in speech audiometry to this date (8). ASHA recommends the use of spondaic words in the SRT test and the digital presentation of word lists in speech audiometry (9). It is indicated that the compatibility of audiometric tests with digital lists may increase with such use (2,10).

Until this day, in Turkey, live voice tests have been carried out with 3 syllable words for SRT test and 1 syllable words

for SD test in speech audiometer. In this study, the new SRT and CD word lists were created from the most familiar words used in Turkish and the SRT lists were formed from spondaic words (spondees). For the first time in Turkey, spondaic words have been used in our study. SRT test in audiology is used to confirm the accuracy- of the patient's average pure tone and to determine the severity of the most comfortable presentation of the SD test (3,11). The SD test provides clues for comprehension of hearing through listening in everyday life communication. It also tests auditory system features of audiologist as well as auditory comprehension skills for the next function (language processing). For this reason, word lists must be formed with familiar words that are frequently used in Turkish. Normal SD

### **Materials and Methods**

Forming SRT and SD words (16,17). One-syllable and spondaic words (spondee) widely used in Turkish were chosen. They were scored on a scale from to one to five based on familiarity .1) Unrecognized, 2) Very rarely recognized, 3) Very little known, 4) Somewhat familiar, 5) Very familiar. SRT and SD record lists were created from the most familiar words.

- SRT registry form: 17 familiar, but partially abstract spondaic words were

scores reveal important test results to assess whether they refer to cochlear pathology across 88% -100%, 88% -40% (32% is also present) or to retro cochlear pathology across 40% -20% .

In speech audiometer, male and female voices are used (12,13), but male voice should be preferred (14,15,2). No matter how much caution is exercised, this may create a difference in speech audiometry and affect the national standard of testing. For this reason, it is important to make standard presentation using male voice in compact disc presentations. The purpose of this study is to examine whether there are differences between the newly developed SRT and SD vocabulary lists and digital psychometric equivalent word lists and live presentations.

chosen. The rest was made of formal and concrete words. 7 lists of 6 words were created (See Appendix 1. Spondaic Words).

- SD registry form: Of one syllabic words, only 51 were partially abstract, others were formal and were selected from concrete words. A total of 5 lists of 25 words were created (See Appendix 2. List of one syllables Words).

Sound Recordings:

The words were said monotonously; no sound was emphasized and stressed.

1) Spondaic words (SRT): The spondaic words were articulated and recorded in a professional sound studio by a male TRT speaker at a magnitude of 65 dB. It was chosen based on the 2 criterion: the reception by children and formality of the word. Non-formal words were not included in the test.

2) One syllable words (SD): One syllable words were chosen by Dr. at Richard Harris at American-Brigham Brigham Young-University, Audiology & Speech-Language Pathology Department, Speech Lab. by carrying out frequency, severity, duration, and phonological analysis. The selected words were articulated by a male Turkish teacher working in the same department and the sounds were recorded.

3) Sound recordings were transferred to compact disc.

(4) Both SRT and SD words were re-recorded with 3 seconds intervals between them.

5) Record file was transferred to the audiometer.

**Compact disc speech audiometer:** The words are uploaded to audiometer. The sound media is transmitted to the subject's ear with 3 seconds intervals

6) Sound recordings were burned on the media for the relevant test ( SRT or CD).

7) The words were transmitted to the patient's ear with 3 seconds intervals.

8) The patient repeated the transmitted sound.

The SRT and CD tests used different lists for the comparison of live tone and CD. In other words, the lists used for live tone test were not used for CD test (to prevent rote). For example, the words used in the live tone SRT were not used in the CD SRT test and a different list was presented.

Test analyzer may use the following options based on the features and age of the subject:

1) Test analyzer can choose the words as he/she finds appropriate. He/she can present them at any given time.

2) Test analyzer can use successively saved word option by providing 3 seconds intervals between them (See Figure 1).

and the subject repeats the transmitted sound. SRT threshold and % of SD are calculated.



Figure 1. Uploading of SRT and SD words to audiometer and presenting them to the subject

**Adjusting the severity of the sounds in the word:** Severity of each sound that makes up the word is homogenous. Each sound is recorded

on an equal voice basis which shortens the duration of the test as the number of errors will be minimized.

## Results

### (A) Normal group:

There was no significant difference found between live right ear (mean: 8 dB) and left ear (mean: 8.5 dB) presentations. There was no significant difference either in the left ear (mean: 6 dB) and the right ear (mean: 7 dB) with the compact disc.

There is a relationship between CD COMPACT DISK RIGHT SRT and LIVE TONE RIGHT SRT at a level of 99 % significance ( $p = 0.001 < 0.01$ ). When Spearman's correlation coefficient ( $r = 0.647$ ) is taken into account for this relation, it is seen that CD COMPACT DISK RIGHT SRT and LIVE TONE

RIGHT SRT have a positive moderate correlation.

There is a relationship of 99 % significance level ( $p = 0.002 < 0,01$ ) between CD COMPACT DISK LEFT SRT and LIVE SOUND LEFT SRT. When Spearman's correlation coefficient ( $R = 0.566$ ) is taken into account for this relation, it is seen that CD COMPACT DISK RIGHT SRT and LIVE SOUND RIGHT SRT have a positive moderate correlation.

There is no relationship between CD COMPACT DISK RIGHT and LIVE TONE RIGHT SD at 99% significance level ( $p = 0.131 > 0.01$ ).

There is no relationship between CD COMPACT DISK LEFT SD and LIVE

SOUND LEFT SD at 99% significance level ( $p = 0.369$ ).

- In examining the number of decibels between live tone and compact disc presentations, it was observed that there was a difference of 2.43 dB and 2.40 dB for Left and Right Ears,

respectively, which was found to be significant for the test result ( $p < 0.05$ ).

(b) Hearing loss group: It was found that CD performance results of subjects with both normal hearing and hearing loss were better than those of live tone.

Table 1. SRT Hearing Scores

SRT-Left Ear		Feature	SRT-Right Ear	
Min-Max	$\bar{x} \pm SD$		$\bar{x} \pm SD$	Min-Max
10 - 105	57.62 $\pm$ 29.28	Live Sound	51.15 $\pm$ 27.32	10 - 105
10 - 105	54.07 $\pm$ 30.00	CD Sound	46.92 $\pm$ 27.75	10 - 105

Table 2. SD Hearing Scores

SD- Left Ear		Feature	SD- Right Ear	
Min-Max	$\bar{x} \pm SD$		$\bar{x} \pm SD$	Min-Max
25 - 105	66.20 $\pm$ 25.75	Live Voice Decibel Level	59.8 $\pm$ 23.21	25 - 105
2 - 25	16.85 $\pm$ 7.70	Live Voice Score	17.63 $\pm$ 6.88	2 - 25
8 - 100	66.96 $\pm$ 31.25	% of Live Voice	70.52 $\pm$ 27.52	8 - 100
25 - 105	65.58 $\pm$ 25.43	Live Voice Decibel Level	59.42 $\pm$ 22.82	25 - 105
3 - 25	19.41 $\pm$ 6.86	Live Voice Score	19.78 $\pm$ 6.61	2 - 25
12 - 100	77.22 $\pm$ 27.16	% of Voice Tone	79.11 $\pm$ 26.43	8 - 100

Table 3. Review of decibel differences between live sound and CD presentations

SRT	Live Voice Threshold Score	CD Threshold Score	Difference	p
Left Ear (n: 26)	57.62 dB	55.19 dB	2.43 dB	0.002
Right Ear (n: 25)	50.20 dB	47.80 dB	2.40 dB	0.008
All Ears (n: 51)	53.98 dB	51.57 dB	2.41 dB	0.000

Based on the speech threshold values, average of the left ear live tone and CD thresholds were 57.62 and 55.19 dB, respectively. It was found that the CD sound performance was better than the live tone, that there was a difference of 2.43 dB between two performances and that this difference was significant for the test result ( $p < 0.05$ ). These findings

### Discussion

Pure-tone tests used in audiology can test normal hearing and hearing loss, yet, cannot test how a person perceives and comprehends the communication (18). For this reason, the SRT and SD tests are crucial in finding the lowest threshold severity in daily life communication and in having an idea of auditory and language processing function, respectively.

Compact disc and live tone test results of SRT and SD were similar in normal hearing and hearing loss groups in our study. The use of spondaic words in both normal hearing and hearing loss group was found to be more effective

were also seen to be the same in the right and all ears.

Relationship between pure tone hearing thresholds (PSH) and SRT: Compatibility of pure tone hearing thresholds and pure tone averages (PSA) was found to be between -8 and +6 dB. +7 dB.

than the three syllable words. It was also found that digital presentation values are better than live tone results, providing easier hearing. 1 dB and 2 dB hearing thresholds were observed in normal hearing and hearing loss groups, respectively. It is also reported in previous studies that spondaic words and digital presentation are effective in finding the lowest intensity (19-21).

SRT test results are better with compact disc presentation since:

- CD presentation affects frequency-intensity-duration processing, temporal and spectral (coding) functions.

- CD presentation has an equal severity control over all phonemes forming a word.
- CD presentation provides a clear hearing of each phoneme and improved frequency coding of all the phonemes forming the word.
- CD presentation has an equal delivery time of each word.
- CD presentation is effective in preventing the sound distortion of the stimulus until it reaches to the subject's ear.

SRT test results are poor with live tone presentation since:

- Live tone presentation may create different voice tones due to the speaker's high or low pitch voice which may lead to frequency difference.
- Test analyzer may use different a different set of duration and severity when articulating a word. This may also cause a difference in the duration of the stimulus to the subject's ear. Some phonemes may be transmitted to the ear earlier than expected while some phonemes may not be transmitted to the ear in the same period which may harm clarity. When digitally recorded Turkish SRT and SD word lists are psychometrically evaluated with SRT and SD functions, CD presentation is found to have more advantages compared to live speech presentation. It is anticipated that this is due to the fact that severity control of CD is equal for each phonemes forming the word and

that the frequency and duration which form the word is equal and that it prevents the sound distortion of the stimulus until it reaches to the subject's ear. Live tone presentation may create different voice tones due to the speaker's high or low pitch voice which may lead to frequency difference. In addition, different set of duration and severity may be used when articulating a word which may lead to the sound distortion of the stimulus before it reaches to the subject's ear. With live tone, expertise and experience of test analyzer may have an effect on the presentation whereas CD allows a standard presentation for each subject. These findings were considered to crucial in terms of determining the reference severity of the SRT test for speech discrimination.

When we compared live tone and compact disc results to find the lowest hearing threshold in our study, we observed that there was no significant difference in SD test, although there was in SRT. This finding is predominantly related to the function of the right hemisphere for speech reception threshold and of the left hemisphere for speech discrimination. These findings are shown to be compatible with hearing physiology when speech reception and speech discrimination functions of right and left hemisphere, respectively, are considered together.

In another word, the SRT's threshold test is compatible with the SD test as it is a supra-threshold test since SD test is presented at the most comfortable level. As a result of our study, shifting to the use of CD presentation in Turkey is necessary since:

- CD presentation will eliminate all errors deriving from differences such as severity, tone and emphasize of voice in a test.
- CD presentation will provide credibility for test results by eliminating aforementioned differences.
- CD presentation will be an important step to follow up world standards.

As a result of our study, the use of CD was recommended to each participant for a standard presentation speech audiometer tests.

It is observed that the spondaic words (words with two syllables) are easier to hear than three syllable words and are

more effective these words in threshold finding.

We found that the use of spondaic words in SRT when processing the dynamics of speech (frequency and suprasegmental features) was more effective in finding the lowest hearing threshold (intelligibility). Homogenous Speech Reception Threshold (SRT) and Speech Discrimination (SD) The word lists we created are homogenous for each frequency of auditory and slope. This finding suggests that these lists can be more effective than the three syllable words that we have been using in audiology clinics of Turkey (22-24,13). However, further studies are required for comparison and measurement of this finding.

As a result of our study, Turkish digital psychometric equivalent SRT (spondee) and SD word lists were recommended for use in speech audiometry.

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Appendix 1. Spondaic Words (Speech Reception Threshold (SRT) (Total number of words: 42). Concrete words: written in black (25 in total). Abstract words: written in red (17 in total).

SPONDAIC WORDS LIST		SCORE (1), (0)
1	kara-göz/black eye	
2	dolma-biber/bell pepper	
3	ay-dede/ the moon	
4	buz-dolabı/ fridge	
5	ayak-kabı/shoes	
6	kara-deniz/black sea	
1	ana-yol/main road	
2	baş-parmak/thumb	
3	sivri-sinek/mosquito	
4	baba-anne/father-mother	
5	kahve-rengi/brown	
6	kov-boy/cowboy	
1	çek-yat/couch bed	
2	kuş-burnu/rose hips	
3	kalem-traş/pencil sharpener	
4	bilgi-sayar/computer	
5	çanak-kale/Dardanelles	
6	ayşe-gül	
1	kar-topu/snowball	
2	boğaz-ıçı/ the Bosphorus	
3	anıt-kabir/ mausoleum	
4	kızıl-ay/the red crescent	
5	kara-biber/black pepper	
6	bay-kuş/owl	
1	karnı-bahar/ cauliflower	
2	beşik-taş	
3	baş-kent/capital	
4	ana-dolu/Anatolia	
5	kör-ebe/ blind man's buff	
6	top-kapı	
1	ak-baba/vulture	
2	gök-kuşağı/rainbow	
3	sarı-yer	
4	ağaç-kakan/woodpecker	
5	ak-deniz/Mediterranean	
6	eski-şehir/old city	
1	baş-bakan/prime minister	
2	ala-balık/trout	
3	boz-ayı/brown bear	
4	aslan-ağzı/ antirrium	
5	gök-delen/skyscraper	
6	sarı-yer	

Appendix 2. List of one syllables Words (Speech Discrimination (SD): Concrete words: written in black (74 in total). Abstract words: written in red (51 in total).

LIST I	LIST II	LIST III	LIST IV	LIST V
Ay/Moon	At/Horse	Ağ/Web	Alt/Below	Bay/Mr.
Tel/Wire	Et/Meat	Ders/Lesson	Bez/Cloth	Ek/Addition
Öp/Kiss	Ön/Front	Oy/Ballot	Fön/dryer	Koş/Run
Ot/Grass	On/Ten	Toz/Dust	Kot/jeans	Ok/Arrow
Üç/Three	Yün/Wool	Kül/Ash	Tüy/feather	Tüm/Whole
Fiş/Receipt/Plug	Dış/Out	İç/Drink/Inside	Çiş/pee	Git/Go
Boy/Height	Buz/Ice	Bol/Plenty/Loose	Bir/one	Bu/This
Cep/Pocket	Cam/Glass	Çam/Pinewood	Çan/bell	Çift/Double
Duş/Shower	Çil/Freckles	Diş/Tooth	Dans/dance	Düz/Flat
Fil/Elephant	Dost/Friend	Fay/ Fault line	Far/headlight	Film/Film
Göl/Lake	Göz/Eye	Gök/Sky	Gaz/accelerator	Gir/Enter
Hoş/Pleasant	Harf/Letter	Hız/Speed	Son/final	Kıl/Bristle
Jip/Jeep	Yön/Direction	Ruj/Lipstick	Dağ/mountain	Sağ/right
Kol/Arm	Kız/Girl	Kaz/Dig/Goose	Kaç/run	Aşk/love
Dil/Tongue/Language	Bel/Waist	Sol/Left	Kel/bald	Rol/Role
Mum/Candle	Muz/Banana	Mor/Purple	Çöp/waste	Tül/Veil
Nar/ Pomegranate	Sen/You	Gün/Day	Renk/color	Yan/Side/Burn
Pil/Battery	Pul/Stamp	İp/Rope	Küp/cube	Fen/Science
Ray/Rail	Gör/See	Dar/Tight	Kar/snow	Sert/Hard
Su/Water	Saç/Hair	Sis/Fog	Sus/shut up	Park/Park
Beş/Five	Şort/Short	Kaş/Eyebrow	Şef/chief	Şu/That
Tır/Truck	Kurt/Wolf	Tığ/ Crochet needle	Tam/full	Sırt/Back
Ev/Home	Sev/Love	Zevk/Pleasure	Ses/sound	Eş/Partner
Yol/Road	Yok/Absent	Yem/Feed	Yar/cut/love	Yağ/Oil
Zar/Dice	Yaz/Write/Summer	Süz/Filter	Saz/ a stringed instrument/segment	Diz/Knee