Psychometrically Equivalent Korean Bisyllabic Words Spoken by Male and Female Talkers

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Richard W. Harris, Eunoak Kim and Dennis L. Eggett. Psychometrically Equivalent Korean Bisyllabic Words Spoken by Male and Female Talkers. 『언어청각장애연구』, 2003, 제8권, 제1호, 244-270. This investigation was undertaken to develop, digitally record, evaluate, and psychometrically equate Korean bisyllabic words for use in measurement of the speech reception threshold (SRT). Ninety familiar bisyllabic words were selected for evaluation. These words were recorded by both male and female talkers native to Seoul, Korea who spoke the standard Korean dialect. Psychometric functions were calculated, using logistic regression, for each of the 90 bisyllabic words for 20 normally hearing subjects who listened to these words at 15 intensity levels from 10 to 18 dBHL in 2 dB increments. The 36 best bisyllabic words were selected and then digitally adjusted, with respect to intensity, so that the threshold of each word was equal to the mean PTA (4.33 dBHL) of the normally hearing subjects. The mean slope (%/dB) for the bisyllabic words was 11.9%/dB for the male talker and 10.4 %/dB for the female talker. The result was the development of a list of 36 Korean bisyllabic words (male and female talker) which were homogeneous with respect to threshold audibility and also with respect to psychometric function slope. These psychometrically equivalent Korean bisyllabic words spoken by both male and female talkers are included on the *Brigham Young University Korean Speech Audiometry Materials* (Disc 1.0) compact disc.

Key Words: speech reception threshold, Korean, bisyllabic, speech discrimination, auditory word recognition, homogeneous

Ⅰ. Introduction

The speech reception threshold (SRT) and auditory word recognition score are among the most fundamental measures obtained during speech audiometry evaluations. The SRT is defined as the lowest level, in dBHL, at which an individual can correctly identify 50% of the spondaic words that are presented (American Speech-Language-Hearing Association [ASHA] Committee on Audiologic Evaluation, 1988). Speech audiometry materials in other languages have not been as well developed or standardized as those in English. However, according to a survey of American audiologists, 37 % perform speech audiometry in languages other than English (Martin & Sides, 1985). There is an obvious need to have recorded speech audiometry materials of high quality in different languages throughout the world.

Recently, there have been efforts to improve the quality of speech audiometry materials in Brazilian Portuguese, Italian, Polish, Russian, and Spanish (Aleksandrovsky, McCullough & Wilson, 1998; Christensen, 1995; Greer, 1997; Harris et al., 2001a, 2001b, 2002a, 2002b; Weisleder & Hodgson, 1989). In the midst of these efforts, important discoveries have been made as to how the structure of a language affects the efficacy of a word list.

Beginning in the 1960s, similar efforts in developing and improving Korean speech audiometry have been made by many scholars and physicians in Korea. Although many researchers have tried for many years to develop Korean speech audiometry, there are currently no standardized speech audiometry materials available for clinical use. In addition, clinicians have felt the great need to develop new speech materials because the currently available word lists contain words that are out of date and not commonly used in daily conversation (J. S. Kim, personal communication, October 14, 2001; M. S. Lee, personal communication, March 10, 2002).

The first contribution made to establish Korean speech audiometry was by Choi (1961) who was a physician in Chinhae Naval Hospital in Korea. Choi intended to develop Korean speech materials based on the characteristics of the Korean language. He reported that the most frequently used Korean word components consist of CV (40 %), CVC (25 %), V (7 %), and VC (10 %). In making word lists for speech discrimination testing, he eliminated certain consonants that sounded similar either in initial or final position. Choi reported that selected bisyllabic words had better audibility than unselected bisyllabic or monosyllabic words in his experiment. Using the same method employed in the creation of PAL PB-50, Choi developed a two pair digits list, a phonetically balanced monosyllabic word list, an articulation word list, a standardized two syllable word list, a question-answer type sentence list, and a pictorial list.

In 1962, Hahm created other speech test materials in the Korean language using the essential criteria by Hudgins et al. (1947) and Egan (1948). He compared the differences in the results of the psychometric function among selected bisyllabic, unselected bisyllabic, and monosyllabic words. The slopes of the curve of psychometric function for the three types of materials were 4%/dB for monosyllabic words, 5%/dB for unselected bisyllabic words, and 8%/dB for selected bisyllabic words between the range of 20% and 80%. Hahm developed four phonetically balanced monosyllabic full-lists (50 words each) and 36 spondaic words in Korean. These words were recorded on magnetic tape.

Soh, Park & Eun (1970) of the Hearing and Speech Clinic Presbyterian Medical Center, in Jeonju, Korea, worked with the Speech Pathology and Audiology Division of the Department of Allied Medical Sciences of the University of Hawaii to develop speech materials in Korean. The purpose of their research was to report scores of the SRTs and speech discrimination on patients possessing normal hearing and those possessing middle ear disorders. There were 296 participants: 68 normal hearing and 228 hearing impaired. Spondaic words were selected from a word list established by the Education Board of Korea. This list contained the most frequently used Korean words in daily conversation. Soh, Park & Eun selected phonetically balanced words from a Korean textbook published by the University of Maryland. The study showed that for the SRT, participants with normal hearing scored about 5 dB better than the participants with middle ear disorders, whereas neither group of participants had an advantage on the speech discrimination test at 40 dB sensation level (re: SRT).

In 1976, Lee studied Korean words for the frequency of occurrence of certain phonemes and the tendency to confuse these sounds. This study showed that nonsense monosyllabic words had the highest frequency of confusion, followed by meaningful monosyllabic words, and then by meaningful bisyllabic words. With nonsense syllables, the rate of confusion of the words was higher for vowels than for consonants, while the rate of confusion for meaningful words was exactly opposite. Lee reported that diphthongs caused a high frequency of confusion, while the plosive fortis caused the highest rate of confusion in consonants.

In the same year, Lee (1976) conducted a preliminary study using his own selection of words to establish Korean speech audiometry. Words were selected from Korean language textbooks for elementary schools. The purpose of this study was to compare differences in speech discrimination scores for different numbers of syllables, frequency of occurrence in daily conversation, and the effect of sound pressure level on word understanding. Lee reported that speech discrimination scores were best using four syllable words and declined as the number of syllables decreased. Moreover, scores were higher for words with a higher frequency in daily conversation, while poor scores resulted as the frequency of occurrence of the test word decreased. Participants produced the poorest scores using nonsense sounds.

In 1976, Kim conducted a study using his 50 meaningful monosyllabic words that were used most frequently in the textbooks of the Korean public elementary schools. By producing psychometric functions, he found that consonants are more important than vowels in affecting the performance of listeners. Kim also explained that the constitution of syllabic structure and its number of phonemes rarely affected performance.

In 1985, Park & Han reported the results of their study on the standardization of Korean phonetically balanced word lists for speech discrimination. Park & Han developed Chungnam National University PB-50 List A and B (CNU PB-50) using 100 nonsense monosyllabic words based on Egan's (1948) criteria. They compared their word lists with the three other lists reported previously by Hahm (1962), Soh et al. (1970), and Kim (1976). The average psychometric functions of the word lists by Hahm (1962), Soh et al. (1970), and Kim (1976) were steeper than the psychometric function of Park and Han's word lists. Park and Han claimed that their word lists were appropriate in diagnosing hearing loss because the psychometric function of the CNU PB-50 word lists were not as steep as the psychometric functions for the word lists by Hahm, Soh et al., and Kim.

Although a number of Korean researchers have attempted to develop and improve speech audiometric materials for several decades, they were unsuccessful in standardizing test materials. Many hospitals and clinics in Korea have used the word lists that were developed by Hahm in 1962. His 200 monosyllabic and 36 spondaic words are still the most frequently used lists today (M. S. Lee, personal communication, March 10, 2002). However, Hahm's list has its own weakness in which many of the words are not commonly used in daily conversation. For instance, there are only 2 out of 36 Hahm's spondaic words that were listed in the top 1000 frequency word list as found in *Frequency Analysis of Korean Morpheme and Word Usage* (Kim & Kang, 2000). Thus, many researchers and clinicians recognized the need to develop a new word list in Korean (J. S. Kim, personal communication, October 14, 2001).

Moreover, there has been no published research on high quality digital recordings of Korean speech audiometry that can be used to obtain measures of the speech reception threshold and speech discrimination. Thus, the present investigation was designed to develop digitally recorded bisyllabic Korean words which can be used to measure the SRT of those whose native tongue is Korean. Audiologists in Korea, and in other countries throughout the world, will have access to the first digitally recorded and most recent Korean speech materials to serve individuals whose native language is Korean.

This Korean speech audiometry project was designed to meet the following objectives: (1) to identify a native male and a native female Korean talker who use a standard Korean dialect (Seoul, Korea) to serve as talkers for the Korean speech audiometry recordings; (2) to construct a list of familiar bisyllabic Korean words for use in measurement of the SRT; (3) to create high-quality digital recordings of the selected Korean bisyllabic words; (4) to collect normative data on the bisyllabic words; (5) to select a subset of 36 words which are homogeneous with respect to audibility and psychometric function slope. Development of these Korean bisyllabic words will greatly assist the measurement of the SRT in individuals whose native language is Korean.

Ⅱ. Method

Subjects

All subjects participating in this study were natives of Korea. A total of 20 subjects

(8 male & 12 female), ranging in age from 18 to 29 years (M = 22.7 years), participated in the evaluation of the bisyllabic words. Summary statistics of the subject thresholds are listed in Table 1. Each participant had pure tone air-conduction thresholds 15 dBHL at octave and midoctave frequencies from 125 to 8000 Hz and had static acoustic admittance between 0.3 and 1.4 mmhos with peak pressure between 100 and +50 daPa (ASHA, 1990; Roup, Wiley, Safady & Stoppenbach, 1998).

Materials

Word lists

Bisyllabic words were selected for the SRT materials. Words were selected from a Korean frequency usage dictionary: *Frequency Analysis of Korean Morpheme and Word Usage* (Kim & Kang, 2000). Of the 200 bisyllabic words considered for evaluation, 90 words were selected for recording and evaluation in this study. Words that had poor recordings were eliminated from the word lists. In addition, words that had diphthongs in the initial position were avoided in the selection of bisyllabic words. The 110 words which were initially selected but not evaluated were eliminated for one, or more, of a number of reasons which included: (1) undesirable vocabulary, (2) considered to be unfamiliar by some of the judges, or (3) confusion with other words.

Talkers

Initial test recordings were made using seven native Korean-speaking individuals, three males and four females. All talkers were native Koreans, from the Seoul area, and spoke the standard Korean dialect. After the initial recordings were made, a panel of ten Korean judges evaluated the performance of each female talker while a panel of fifteen Korean judges evaluated the performance of each male talker. Both panels of judges were asked to indicate whether the vocal quality and accent of the talker is acceptable or unacceptable and then they were asked to rank order the talkers from best to worst on evaluation forms. The highest ranked talkers (1 male & 1 female) were selected as the talkers for all subsequent recordings.

Recordings

All recordings were made in a large anechoic chamber located on the Brigham Young University campus in Provo, Utah, USA. A Larson-Davis mode l2541 microphone was positioned at a 0 azimuth and was covered by a 7.62 cm windscreen. The microphone was connected to a Larson-Davis model 900B microphone preamp, which was coupled to a Larson-Davis model 2200C preamp power supply. The signal from the preamp power supply was then routed through an Apogee AD-800024-bit analog-to-digital converter; the digitized signal was stored on a hard drive for later editing. A 44.1 kHz sampling rate with 24-bit quantization was used for all recordings, and every effort was made to utilize the full range of the 24-bit analog-to-digital converter. Ambient noise levels in the anechoic chamber were < 0 dBSPL which allowed a signal-to-noise ratio of at least 65 dB during recording.

During the recording sessions, the talker was asked to pronounce each word several times. A native Korean judge rated each word for perceived goodness of production, and the best production of each word was then selected for inclusion on the test CD. Any word that had a clipped waveform was discarded. After the rating process, the intensity of each word to be included on the CD was edited using Sadie Disk Editor software (Studio Audio and Video Limited, 1996) to yield the same intensity as that of the 1000 Hz calibration tone contained on the CD. The CD containing the final edited words was produced on a PlexWriter 12/4/32 CD-R/W drive using a 44.1 kHz sampling rate and 16-bit quantization. The NS high dither option in the Sadie Disk Editor software was used to convert the recordings from 24 to 16 bit quantization.

Procedures

Custom software was used to control randomization and timing of the presentation of the words. The signal was routed from a computer-controlled CD-ROM drive to the external input of a Grason Stadler model 1761 (GSI-61) audiometer. The stimuli were routed from the audiometer to the subject via a single TDH-50P headphone. Prior to testing each subject, the inputs to the audiometer were calibrated to 0VU using the 1000Hz calibration tone on track 1 of the test CD. All testing was carried out in a sound suite that met American National Standards Institute (American National Standards Institutre [ANSI], 1991) standards for maximum permissible ambient noise levels for the ears not covered condition using one-third octave-bands.

Each subject participated in two test sessions after passing a screening exam. The first test session consisted of listening to SRT stimuli and speech discrimination stimuli recorded by either male or female talkers. In the second session each subject heard the recordings of the other talker. The order of the presentation of the male and female talker recordings was randomly selected for each subject. Each subject was allowed to have several rest periods during the test.

Evaluation of bisyllabic words

The entire bisyllabic word list was presented at 15 different intensity levels, ranging from 10 to 18 dBHL in 2 dB steps. Word order within each list was randomized prior to presentation, and each list was presented beginning with the softest intensity and increasing in 2 dB increments. Each subject listened to both the male and female talker recordings of the bisyllabic words. The order of presentation of the male and female talker recordings was randomly determined for each subject.

Prior to the evaluation of the bisyllabic words, the following instructions were given:

(Korean) 다양한 음향 높이에서 2음절 (두 글자)의 단어를 들으시겠습니다. 아주 작고 조용한 높이에서는 단어를 알아듣기 힘들 것입니다. 단어가 주어질 때마다 불빛으로 신호 해 드리겠습니다. 집중해서 잘 들어 주시고, 들으신 단어를 소리내어 따라 해 주십시요. 들으신 단어가 확실하지 않을 때는 추측해도 좋습니다. 추측할 단어가 없으면 조용히 다음 단어를 기다리십시요. 질문 있습니까?

(English) You will hear bisyllabic words, which may become louder or softer in intensity. At the very soft loudness levels it may be difficult for you to hear the words. An indication light

will come on, informing you that a word has been presented. Please listen carefully and repeat the word that you hear. If you are unsure of the word, you are encouraged to guess. If you have no guess, please be quiet and listen for the next word. Do you have any questions?

Calibration

The audiometer was calibrated prior to, weekly during, and at the conclusion of data collection. Calibration was performed in accordance with the specifications of the ANSI S3.6 (1996). No changes in calibration were necessary throughout the course of data collection.

Ⅲ. Results

After the raw data were collected, logistic regression was used to obtain the regression slope and regression intercept for each of the 90 bisyllabic words. The regression slope and regression intercept values were then inserted into a modified logistic regression equation that was designed to calculate the percent correct at each intensity level. The original logistic regression equation is as follows:

$$\log \frac{p}{1-p} = a + b \times \mathrm{dB} \qquad \text{(Equation 1)}$$

In Equation 1, p is the proportion correct at any given intensity level, a is the regression slope, b is the regression intercept, and dB is the intensity level in dBHL. When Equation 1 is solved for p and multiplied by 100, we obtain Equation 2.

$$\% = \left(1 - \frac{\exp(a + b \times \mathrm{dB})}{1 + \exp(a + b \times \mathrm{dB})}\right) \times 100 \qquad \text{(Equation 2)}$$

By inserting the regression slope, regression intercept, and intensity level into Equation 2, it is possible to predict the percent correct at any specified intensity level.

Percent correct recognition was calculated for each of the bisyllabic words for a range of 10 to 18 dBHL in 1 dB increments.

In order to calculate the intensity level required for a given proportion, Equation 1 was solved for *dB* (see Equation 3). By inserting the desired proportions into Equation 3, it is possible to calculate the threshold (the intensity required for 50 % intelligibility), the slope (% / dB) at threshold, and the slope (% / dB) from 20 to 80 % for each psychometric function. When solving for the threshold ($p = 0.5$), Equation 3 can be simplified to Equation 4.

$$\mathrm{dB} = \frac{\log \frac{p}{1-p} - a}{b} \qquad \text{(Equation 3)}$$

$$\text{50 \% threshold in } \mathrm{dB} = \frac{-a}{a} \qquad \text{(Equation 4)}$$

Table 2 (male talker) and Table 3 (female talker) contain the logistic regression slopes, intercepts, and calculations for the 50 % threshold, slope at 50 %, and slope from 20 % to 80 % for each bisyllabic word. Thresholds (50 % intensity) for the 90 bisyllabic words ranged from 0.2 to 14.6 dBHL (M = 7.5 dBHL) for the male talker words, and from 1.6 to 17.5 dBHL (M = 6.7 dBHL) for the female talker words. The slope of the psychometric functions, from 20 – 80 %, for the 90 bisyllabic words ranged of 3.7 to 14.6 % / dB (M = 9.1 % / dB) for the male talker words and from 3.7 to 16.3 % / dB (M = 8.0 % / dB) for the female talker words. In comparison to the slopes from 20 to 80 % for each psychometric function, the slopes at 50 % threshold were steeper ranging from 4.3 to 16.9 % / dB (M =10.5 % / dB) for the male talker words and 4.3 to 18.9 % / dB (M = 9.3 % / dB) for the female talker words.

Psychometric functions for each bisyllabic word were calculated (Equation 2) using the logistic regression intercept and slope values presented in Tables 2 and 3. The psychometric functions for each of the 90 bisyllabic words can be found in Figure 1A (male talker) and 1B (female talker). Inspection of Figure 1, and Tables 2 and 3, reveal a wide range in slopes among the 90 bisyllabic words. Psychometric function slope ranged from 4.3 to 18.9 %/dB. It is important that words used to measure SRT should have a steep psychometric function slope. To improve homogeneity of the bisyllabic words the 36 words that had the steepest psychometric function slopes for both the male and female talker recordings (8.9 %/dB or greater for male and female talkers) were selected for inclusion in the final CD. The threshold, the slope at threshold, and the slope from 20 to 80 % for the 36 selected bisyllabic words are listed in Table 4 (male talker) and Table 5 (female talker). Figure 2 contains the psychometric functions for the final 36 words for the male talker (A) and female talker (B) recordings, respectively. Psychometric function slopes at 50 % threshold for the 36 selected bisyllabic words ranged from 8.9 to 16.6 %/dB (M = 11.9 %/dB) for the male words and from 9.0 to 13.1 %/dB (M = 10.4 %/dB) for the female words. Careful inspection of Figure 2 reveals that there is much less variability in slope of the psychometric functions for the 36 selected bisyllabic words when compared to the slopes of the entire group of 90 words (Figure 1).

After the final 36 bisyllabic words were selected, there was still a wide range of variability in threshold among the words. In order to improve homogeneity among the 36 bisyllabic words, the intensity of each bisyllabic word was digitally adjusted so that the 50 % threshold of each word was equal to the mean PTA of the subjects in the bisyllabic study (4.33 dBHL). The adjustments necessary for each of the 36 selected bisyllabic words for the male and female talker recordings are presented in Table 4 and Table 5, respectively. Figure 3A (male talker) and 3B (female talker) contain the predicted psychometric functions for the 36 selected bisyllabic words after intensity adjustment to equate 50 % thresholds. Figure 4 presents the mean psychometric functions for the 36 selected male talker words and the female talker bisyllabic words and illustrates the slightly steeper mean slope for the male talker (11.9 %/dB) compared to the female talker (10.4 %/dB)

Ⅳ. Discussion

The main purpose of this research project was to develop a homogeneous subset of Korean bisyllabic words for use in measuring the SRT. This purpose was accomplished for recordings of a male and a female native Korean talker. The homogeneity of the subset of bisyllabic words can be seen by referring to Figures 3, which contain the predicted psychometric functions for the 36 selected bisyllabic words after intensity adjustment. These 36 male and female talker bisyllabic words are homogeneous with respect to audibility and psychometric function slope.

The slopes from 20 to 80% for the 36 bisyllabic words encompassed a range of 7.7 to 14.3%/dB (M = 10.3%/dB) for the male talker words and a range of 7.8 to 11.4 %/dB (M = 9.0%/dB) for the female talker words. The means for the slopes from 20 to 80% for the Korean male and female talker bisyllabic psychometric functions are in close agreement with means for SRT materials that have been reported in other languages. The mean slope for English spondaic words has been reported to be as low as 7.2%/dB (Wilson & Strouse, 1999) to 8%/dB (Hirsh et al., 1952) or as high as 12%/dB (Beattie, Svihovec & Edgerton, 1975). Both Hudgins et al. (1947) and Young, Dudley & Gunter (1982) reported the mean slope for English spondaic words to be 10%/dB. The mean slope for Polish bisyllabic SRT materials was reported by Harris et al. (2002a) to be 10.1%/dB for a male talker and 9.8%/dB for a female talker. The mean slope for Spanish trisyllabic SRT materials has been reported by Christensen (1995) to be 11.1%/dB for a male talker and 9.7%/dB for a female talker. In research involving Italian trisyllabic SRT materials, Greer (1997) reported a mean slope of 7.3%/dB for a male talker.

A great deal of research remains to be done in the field of Korean speech audiometry materials. Future research could examine the similarities between the mean SRT obtained with the 36 adjusted bisyllabic words from this study and the mean PTA of the test subjects. Future research could also include examining bisyllabic word homogeneity and performance for hearing impaired individuals.

In addition to the research that can be conducted on the current Korean speech audiometry materials, there is also a need to develop additional Korean speech materials. For example, speech materials could be created for children on the basis of word familiarity. There is also a need to develop high-quality recordings of Korean speech materials used in aural rehabilitation for those with cochlear implants.

In summary, the bisyllabic studies resulted in the development of a homogeneous subset of 36 bisyllabic Korean words for use in measuring the SRT. These bisyllabic words are homogeneous with respect to audibility and also with respect to psychometric function slope. The bisyllabic words for both the male and female talkers are contained on the CD entitled *Brigham Young University Korean Speech Audiometry Materials* (Disc 1.0). These homogeneous bisyllabic words can be utilized to measure the SRT in individuals whose native language is Korean.

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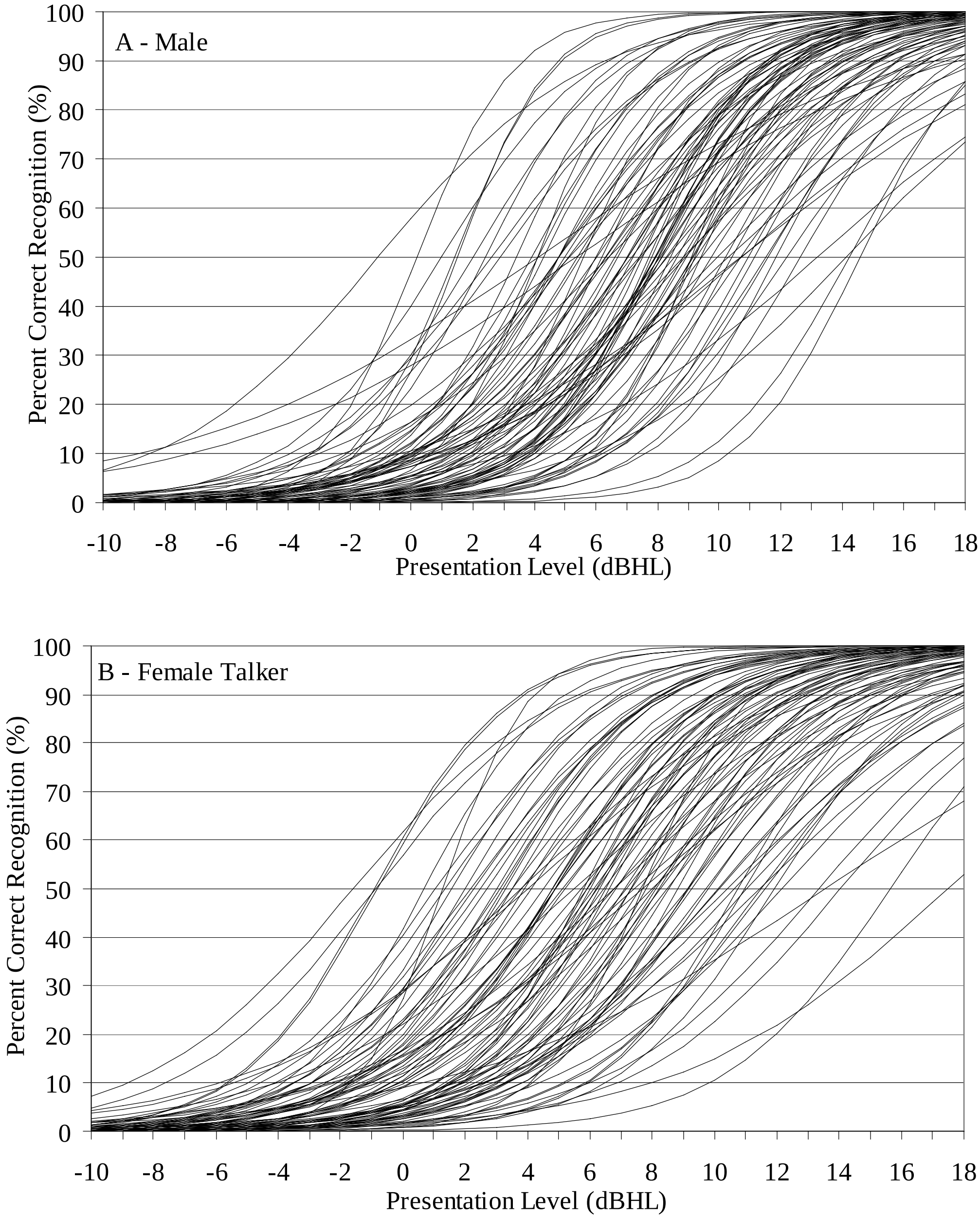

Figure 1. *Psychometric functions for 90 male talker (A) and female talker (B) Korean bisyllabic words*

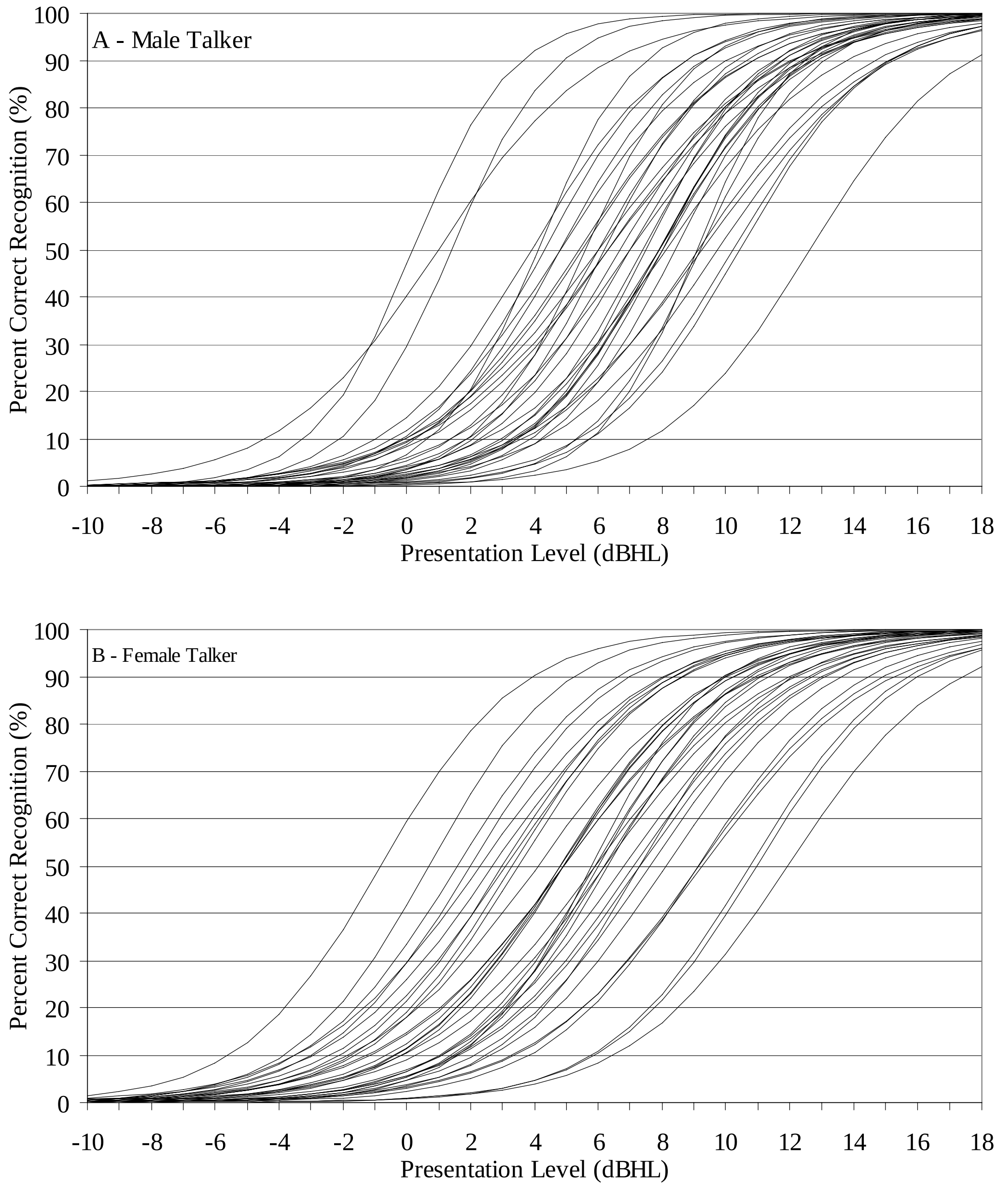

Figure 2. *Psychometric functions for 36 selected male talker (A) and female talker (B) Korean bisyllabic words*

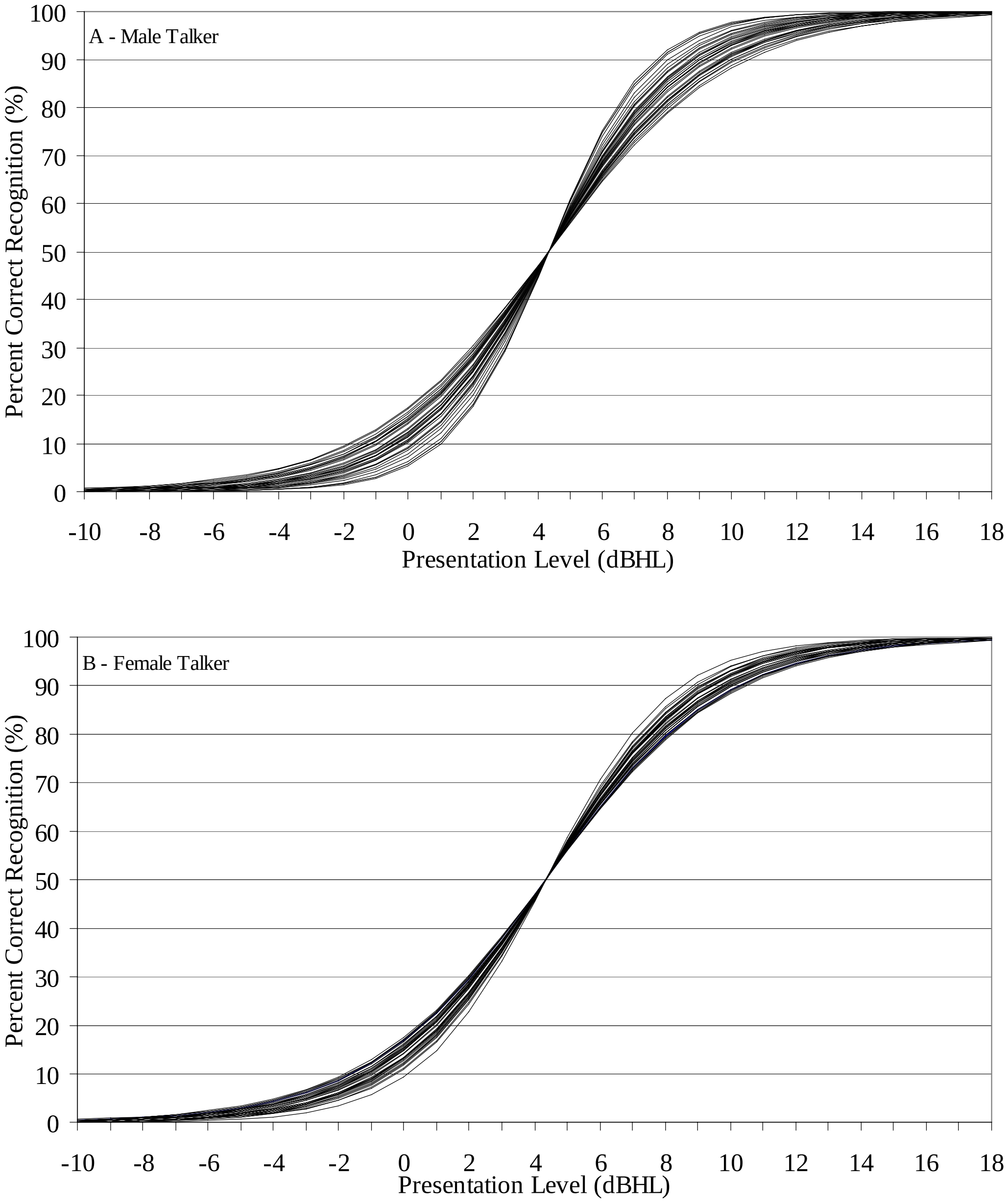

Figure 3. *Psychometric functions for the 36 selected male talker (a) and female talker (B) Korean bisyllabic words after intensity adjustment*

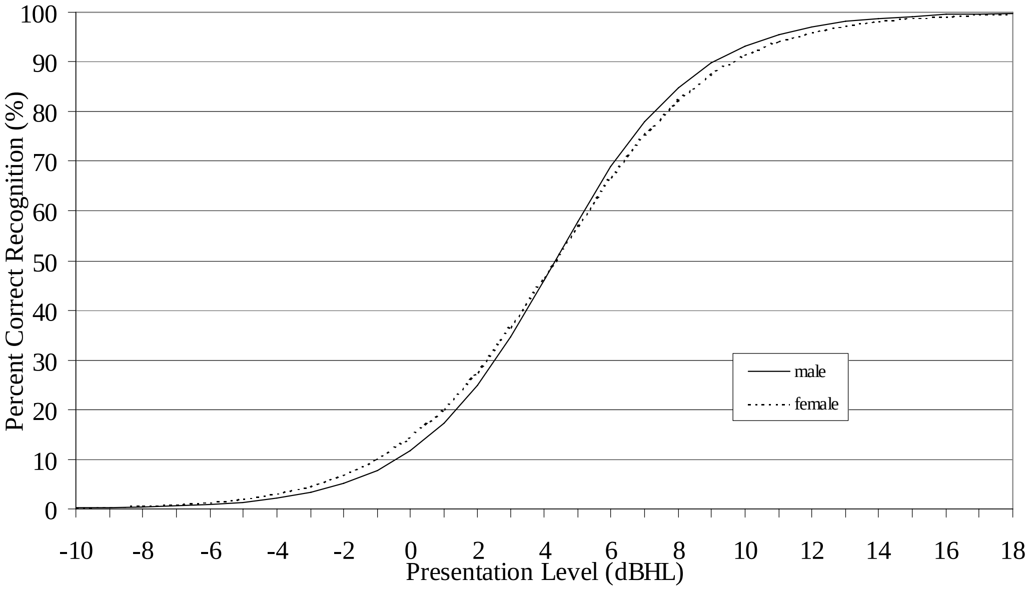

Figure 4. *Mean psychometric functions for the 36 selected male and female Korean talker bisyllabic words after intensity adjustment*

Table 1. *Age (in years) and Pure Tone Threshold (dBHL) Descriptive Statistics for the 20 Korean Participants*

	M	*Minimum*	*Maximum*	*SD*
Age	22.7	18	29	3.8
125 Hz	6.3	0	15	4.8
250 Hz	4.3	−5	15	4.4
500 Hz	4.0	−5	10	4.2
750 Hz	4.0	−5	10	4.2
1000 Hz	3.5	0	10	3.7
1500 Hz	4.8	−5	15	5.0
2000 Hz	5.5	0	10	4.6
3000 Hz	3.8	−5	10	3.6
4000 Hz	2.0	−5	10	4.1
6000 Hz	2.3	−5	10	5.0
8000 Hz	3.3	−10	15	6.3

Table 2. *Mean Performance for Korean Male Bisyllabic SRT Words*

Word	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	Change in dB[f]
개인	5.24	−0.47	11.8	10.2	11.2	6.8
건설	4.12	−0.55	13.7	11.9	7.5	3.2
경제	2.41	−0.38	9.6	8.3	6.3	2.0
광고	2.53	−0.25	6.3	5.5	10.0	5.6
교사	2.87	−0.48	11.9	10.3	6.0	1.7
교육	3.88	−0.49	12.3	10.6	7.9	3.6
기술	3.94	−0.50	12.4	10.8	7.9	3.6
나라	1.02	−0.35	8.8	7.6	2.9	-1.4
나무	1.77	−0.45	11.3	9.8	3.9	-0.4
남자	0.40	−0.41	10.2	8.8	1.0	-3.3
노래	0.88	−0.63	15.7	13.6	1.4	-2.9
노력	2.01	−0.42	10.5	9.1	4.8	0.5
누구	4.90	−0.47	11.7	10.2	10.4	6.1
다시	2.24	−0.35	8.7	7.5	6.4	2.1
다음	3.46	−0.48	12.0	10.4	7.2	2.9
당신	3.17	−0.39	9.7	8.4	8.1	3.8
대표	3.48	−0.38	9.4	8.1	9.3	4.9
대학	1.21	−0.50	12.6	10.9	2.4	-1.9
마음	1.63	−0.34	8.5	7.3	4.8	0.5
머리	1.76	−0.37	9.2	7.9	4.8	0.5
먼저	1.69	−0.33	8.2	7.1	5.1	0.8
모두	3.92	−0.40	10.0	8.7	9.8	5.4
모양	2.36	−0.22	5.5	4.8	10.7	6.4
문제	5.53	−0.44	10.9	9.5	12.6	8.3
문학	4.64	−0.40	10.1	8.7	11.5	7.2
문화	3.92	−0.43	10.7	9.3	9.1	4.8
민족	3.85	−0.48	11.9	10.3	8.1	3.8

				Slope from		
Word	a[a]	b[b]	Slope at 50%[c]	20 to 80%[d]	Threshold[e]	Change in dB[f]
바람	2.91	−0.22	5.5	4.8	13.2	8.8
방법	1.40	−0.27	6.8	5.9	5.1	0.8
변화	3.14	−0.30	7.4	6.4	10.6	6.2
부분	3.00	−0.32	8.0	6.9	9.4	5.1
사람	0.70	−0.17	4.3	3.7	4.1	−0.2
사랑	0.95	−0.18	4.4	3.8	5.4	1.1
사용	0.88	−0.34	8.5	7.4	2.6	−1.7
사이	1.64	−0.26	6.4	5.5	6.4	2.1
사회	2.35	−0.49	12.2	10.6	4.8	0.5
상태	4.42	−0.53	13.2	11.4	8.4	4.1
생각	3.33	−0.59	14.8	12.9	5.6	1.3
생명	5.23	−0.57	14.2	12.3	9.2	4.9
생산	4.66	−0.45	11.4	9.8	10.2	5.9
생활	4.45	−0.58	14.5	12.5	7.7	3.4
선생	3.51	−0.44	11.1	9.6	7.9	3.6
설명	2.65	−0.65	16.2	14.0	4.1	−0.2
세계	2.13	−0.20	5.0	4.3	10.7	6.4
세상	2.40	−0.23	5.8	5.0	10.3	6.0
소리	2.87	−0.43	10.9	9.4	6.6	2.3
시간	1.85	−0.54	13.6	11.8	3.4	−0.9
시대	2.54	−0.29	7.1	6.2	8.9	4.5
시작	2.41	−0.34	8.4	7.3	7.1	2.8
시장	2.52	−0.30	7.6	6.6	8.3	4.0
아들	2.28	−0.41	10.3	9.0	5.5	1.2
아이	2.74	−0.39	9.7	8.4	7.0	2.7
어디	3.75	−0.47	11.7	10.1	8.0	3.7
얼굴	2.13	−0.49	12.4	10.7	4.3	0.0
엄마	2.26	−0.36	8.9	7.7	6.3	2.0
여기	3.08	−0.46	11.5	9.9	6.7	2.4
여자	2.19	−0.36	9.1	7.9	6.0	1.7
연구	2.89	−0.41	10.3	8.9	7.0	2.7
예술	3.75	−0.51	12.6	10.9	7.4	3.1
우리	5.07	−0.54	13.5	11.7	9.4	5.1
운동	3.94	−0.37	9.2	8.0	10.7	6.4

				Slope from		
Word	a[a]	b[b]	Slope at 50 %[c]	20 to 80 %[d]	Threshold[e]	Change in dB[f]
이름	4.26	−0.53	13.3	11.5	8.0	3.7
이미	6.56	−0.46	11.5	10.0	14.2	9.9
이용	1.98	−0.40	9.9	8.6	5.0	0.7
이해	3.47	−0.44	11.0	9.5	7.9	3.6
인간	2.55	−0.30	7.5	6.5	8.5	4.2
자신	2.47	−0.33	8.3	7.2	7.5	3.1
자연	0.85	−0.43	10.6	9.2	2.0	−2.3
자유	2.02	−0.49	12.3	10.7	4.1	−0.2
전체	3.27	−0.47	11.7	10.1	7.0	2.7
정부	3.84	−0.43	10.7	9.3	8.9	4.6
정신	2.28	−0.26	6.4	5.6	8.8	4.5
정치	2.20	−0.41	10.2	8.8	5.4	1.1
조사	3.70	−0.26	6.5	5.7	14.1	9.8
존재	5.00	−0.46	11.4	9.9	11.0	6.6
중요	7.63	−0.52	13.1	11.3	14.6	10.2
지금	4.50	−0.58	14.4	12.5	7.8	3.5
지방	3.76	−0.44	10.9	9.4	8.6	4.3
지배	4.98	−0.43	10.7	9.3	11.6	7.3
친구	3.32	−0.54	13.4	11.6	6.2	1.9
통일	6.03	−0.66	16.6	14.3	9.1	4.8
표정	2.86	−0.35	8.7	7.5	8.3	3.9
하나	3.82	−0.43	10.8	9.4	8.8	4.5
하늘	5.80	−0.49	12.2	10.6	11.9	7.5
학교	0.13	−0.65	16.2	14.0	0.2	−4.1
학생	1.01	−0.67	16.9	14.6	1.5	−2.8
한국	2.98	−0.37	9.3	8.0	8.0	3.7
함께	4.53	−0.37	9.3	8.0	12.2	7.9
환경	3.65	−0.40	10.0	8.6	9.1	4.8
회사	2.19	−0.30	7.4	6.4	7.4	3.1
M	3.07	−0.41	10.5	9.1	7.5	3.2
Minimum	0.13	−0.67	4.3	3.7	0.2	−4.1
Maximum	7.63	−0.17	16.9	14.6	14.6	10.2
Range	7.51	0.50	12.6	10.9	14.4	14.4
SD	1.44	0.11	2.8	2.4	3.1	3.1

[a] *a* = regression intercept. [b] *b* = regression slope. [c] Psychometric function slope (% / dB) at 50 % was calculated from 49.999 to 50.001 %. [d] Psychometric function slope (% / dB) from 2080 %. [e] Intensity required for 50 % intelligibility. [f] Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects

Table 3. *Mean Performance for Korean Female Bisyllabic SRT Words*

Word	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	Change in dB[f]
개인	3.99	−0.35	8.7	7.5	11.5	7.2
건설	1.53	−0.37	9.3	8.1	4.1	−0.2
경제	2.90	−0.46	11.5	9.9	6.3	2.0
광고	3.57	−0.42	10.5	9.1	8.5	4.2
교사	2.14	−0.44	10.9	9.4	4.9	0.6
교육	2.15	−0.36	9.1	7.9	5.9	1.6
기술	4.79	−0.44	10.9	9.5	11.0	6.6
나라	0.51	−0.37	9.3	8.1	1.4	−3.0
나무	1.44	−0.44	10.9	9.5	3.3	−1.0
남자	1.23	−0.40	10.0	8.6	3.1	−1.2
노래	1.52	−0.43	10.9	9.4	3.5	−0.8
노력	1.05	−0.39	9.8	8.5	2.7	−1.6
누구	4.83	−0.41	10.1	8.8	11.9	7.6
다시	3.59	−0.37	9.2	7.9	9.8	5.5
다음	3.34	−0.34	8.6	7.4	9.7	5.4
당신	2.87	−0.48	11.9	10.3	6.0	1.7
대표	3.78	−0.41	10.3	8.9	9.1	4.8
대학	0.98	−0.75	18.9	16.3	1.3	−3.0
마음	1.79	−0.31	7.8	6.8	5.7	1.4
머리	0.76	−0.35	8.7	7.5	2.2	−2.2
먼저	1.59	−0.41	10.2	8.8	3.9	−0.4
모두	3.06	−0.40	10.0	8.7	7.6	3.3
모양	1.26	−0.23	5.7	5.0	5.5	1.2
문제	4.80	−0.45	11.1	9.7	10.8	6.4
문학	2.62	−0.25	6.3	5.5	10.4	6.1
문화	2.77	−0.34	8.6	7.4	8.1	3.7
민족	4.15	−0.47	11.8	10.2	8.8	4.5
바람	2.86	−0.34	8.4	7.3	8.5	4.1
방법	0.39	−0.36	9.1	7.8	1.1	−3.3

Word	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	Change in dB[f]
변화	2.58	−0.33	8.2	7.1	7.9	3.5
부분	3.45	−0.28	7.1	6.1	12.2	7.8
사람	0.89	−0.22	5.6	4.8	4.0	−0.3
사랑	−0.48	−0.30	7.6	6.6	−1.6	−5.9
사용	0.91	−0.37	9.2	7.9	2.5	−1.8
사이	1.70	−0.23	5.7	4.9	7.4	3.1
사회	0.34	−0.49	12.1	10.5	0.7	−3.6
상태	2.67	−0.45	11.3	9.8	5.9	1.6
생각	1.95	−0.41	10.1	8.8	4.8	0.5
생명	3.05	−0.53	13.1	11.4	5.8	1.5
생산	3.35	−0.46	11.5	9.9	7.3	3.0
생활	1.39	−0.43	10.8	9.4	3.2	−1.1
선생	1.79	−0.37	9.1	7.9	4.9	0.6
설명	2.06	−0.43	10.7	9.3	4.8	0.5
세계	2.31	−0.17	4.3	3.7	13.6	9.2
세상	1.99	−0.25	6.2	5.4	8.0	3.7
소리	1.66	−0.32	8.1	7.0	5.1	0.8
시간	1.60	−0.35	8.9	7.7	4.5	0.2
시대	2.95	−0.29	7.3	6.3	10.1	5.8
시작	3.43	−0.42	10.4	9.0	8.2	3.9
시장	3.06	−0.30	7.6	6.6	10.1	5.8
아들	2.31	−0.37	9.3	8.0	6.2	1.9
아이	1.76	−0.36	9.0	7.8	4.9	0.6
어디	2.84	−0.39	9.7	8.4	7.3	3.0
얼굴	0.70	−0.44	10.9	9.5	1.6	−2.7
엄마	1.30	−0.43	10.8	9.4	3.0	−1.3
여기	2.67	−0.43	10.8	9.3	6.2	1.9
여자	0.88	−0.44	11.0	9.5	2.0	−2.3
연구	2.85	−0.25	6.2	5.4	11.5	7.1
예술	3.41	−0.37	9.2	8.0	9.3	4.9
우리	4.28	−0.30	7.6	6.6	14.0	9.7
운동	2.86	−0.35	8.7	7.5	8.3	3.9
이름	3.27	−0.40	10.1	8.7	8.1	3.8
이미	3.99	−0.30	7.5	6.5	13.4	9.0

				Slope from		
Word	a[a]	b[b]	Slope at 50%[c]	20 to 80%[d]	Threshold[e]	Change in dB[f]
이용	2.92	−0.27	6.9	5.9	10.6	6.3
이해	4.65	−0.60	15.1	13.1	7.7	3.4
인간	3.10	−0.47	11.7	10.2	6.6	2.3
자신	2.95	−0.32	8.1	7.0	9.1	4.8
자연	1.24	−0.33	8.1	7.0	3.8	−0.5
자유	1.60	−0.24	5.9	5.1	6.8	2.4
전체	3.49	−0.38	9.5	8.3	9.2	4.8
정부	1.90	−0.28	7.0	6.1	6.8	2.5
정신	1.84	−0.35	8.8	7.7	5.2	0.9
정치	2.61	−0.38	9.6	8.3	6.8	2.5
조사	4.00	−0.34	8.6	7.5	11.6	7.3
존재	4.04	−0.23	5.8	5.0	17.5	13.2
중요	5.93	−0.38	9.5	8.2	15.6	11.3
지금	3.09	−0.47	11.9	10.3	6.5	2.2
지방	3.12	−0.28	7.1	6.1	11.0	6.7
지배	3.62	−0.46	11.6	10.0	7.8	3.5
친구	2.82	−0.40	9.9	8.6	7.1	2.8
통일	2.04	−0.42	10.4	9.0	4.9	0.6
표정	0.90	−0.24	6.0	5.2	3.8	−0.5
하나	2.28	−0.32	8.0	6.9	7.2	2.8
하늘	2.20	−0.34	8.6	7.4	6.4	2.1
학교	−0.38	−0.46	11.6	10.0	−0.8	−5.1
학생	−0.43	−0.47	11.7	10.1	−0.9	−5.2
한국	1.68	−0.22	5.5	4.7	7.7	3.4
함께	2.15	−0.35	8.8	7.6	6.1	1.8
환경	0.88	−0.38	9.6	8.3	2.3	−2.0
회사	1.20	−0.34	8.6	7.4	3.5	−0.8
M	2.37	−0.37	9.3	8.0	6.7	2.4
Minimum	−0.48	−0.75	4.3	3.7	−1.6	−5.9
Maximum	5.93	−0.17	18.9	16.3	17.5	13.2
Range	6.40	0.58	14.6	12.6	19.1	19.1
SD	1.27	0.09	2.2	1.9	3.7	3.7

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 2080%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects

Table 4. *Mean Performance for Selected Korean Male Bisyllabic SRT Words*

				Slope from		
Word	a[a]	b[b]	Slope at 50%[c]	20 to 80%[d]	Threshold[e]	Change in dB[f]
건설	4.12	−0.55	13.7	11.9	7.5	3.2
경제	2.41	−0.38	9.6	8.3	6.3	2.0
교사	2.87	−0.48	11.9	10.3	6.0	1.7
교육	3.88	−0.49	12.3	10.6	7.9	3.6
기술	3.94	−0.50	12.4	10.8	7.9	3.6
나무	1.77	−0.45	11.3	9.8	3.9	−0.4
남자	0.40	−0.41	10.2	8.8	1.0	−3.3
노래	0.88	−0.63	15.7	13.6	1.4	−2.9
노력	2.01	−0.42	10.5	9.1	4.8	0.5
누구	4.90	−0.47	11.7	10.2	10.4	6.1
당신	3.17	−0.39	9.7	8.4	8.1	3.8
대표	3.48	−0.38	9.4	8.1	9.3	4.9
모두	3.92	−0.40	10.0	8.7	9.8	5.4
문제	5.53	−0.44	10.9	9.5	12.6	8.3
사회	2.35	−0.49	12.2	10.6	4.8	0.5
상태	4.42	−0.53	13.2	11.4	8.4	4.1
생각	3.33	−0.59	14.8	12.9	5.6	1.3
생명	5.23	−0.57	14.2	12.3	9.2	4.9
생산	4.66	−0.45	11.4	9.8	10.2	5.9
선생	3.51	−0.44	11.1	9.6	7.9	3.6
설명	2.65	−0.65	16.2	14.0	4.1	−0.2
아들	2.28	−0.41	10.3	9.0	5.5	1.2
아이	2.74	−0.39	9.7	8.4	7.0	2.7
어디	3.75	−0.47	11.7	10.1	8.0	3.7
얼굴	2.13	−0.49	12.4	10.7	4.3	0.0
엄마	2.26	−0.36	8.9	7.7	6.3	2.0
여기	3.08	−0.46	11.5	9.9	6.7	2.4
여자	2.19	−0.36	9.1	7.9	6.0	1.7
예술	3.75	−0.51	12.6	10.9	7.4	3.1
이름	4.26	−0.53	13.3	11.5	8.0	3.7
전체	3.27	−0.47	11.7	10.1	7.0	2.7
정치	2.20	−0.41	10.2	8.8	5.4	1.1
친구	3.32	−0.54	13.4	11.6	6.2	1.9
통일	6.03	−0.66	16.6	14.3	9.1	4.8
학교	0.13	−0.65	16.2	14.0	0.2	−4.1
환경	3.65	−0.40	10.0	8.6	9.1	4.8
M	3.18	−0.48	11.9	10.3	6.8	2.4
Minimum	0.13	−0.66	8.9	7.7	0.2	−4.1
Maximum	6.03	−0.36	16.6	14.3	12.6	8.3
Range	5.90	0.30	7.6	6.6	12.4	12.4
SD	1.33	0.08	2.1	1.8	2.7	2.7

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 2080%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects

Table 5. *Mean Performance for Selected Korean Female Bisyllabic SRT Words*

				Slope from		
Word	a[a]	b[b]	Slope at 50 %[c]	20 to 80 %[d]	Threshold[e]	Change in dB[f]
건설	1.53	−0.37	9.3	8.1	4.1	−0.2
경제	2.90	−0.46	11.5	9.9	6.3	2.0
교사	2.14	−0.44	10.9	9.4	4.9	0.6
교육	2.15	−0.36	9.1	7.9	5.9	1.6
기술	4.79	−0.44	10.9	9.5	11.0	6.6
나무	1.44	−0.44	10.9	9.5	3.3	−1.0
남자	1.23	−0.40	10.0	8.6	3.1	−1.2
노래	1.52	−0.43	10.9	9.4	3.5	−0.8
노력	1.05	−0.39	9.8	8.5	2.7	−1.6
누구	4.83	−0.41	10.1	8.8	11.9	7.6
당신	2.87	−0.48	11.9	10.3	6.0	1.7
대표	3.78	−0.41	10.3	8.9	9.1	4.8
모두	3.06	−0.40	10.0	8.7	7.6	3.3
문제	4.80	−0.45	11.1	9.7	10.8	6.4
사회	0.34	−0.49	12.1	10.5	0.7	−3.6
상태	2.67	−0.45	11.3	9.8	5.9	1.6
생각	1.95	−0.41	10.1	8.8	4.8	0.5
생명	3.05	−0.53	13.1	11.4	5.8	1.5
생산	3.35	−0.46	11.5	9.9	7.3	3.0
선생	1.79	−0.37	9.1	7.9	4.9	0.6
설명	2.06	−0.43	10.7	9.3	4.8	0.5
아들	2.31	−0.37	9.3	8.0	6.2	1.9
아이	1.76	−0.36	9.0	7.8	4.9	0.6
어디	2.84	−0.39	9.7	8.4	7.3	3.0
얼굴	0.70	−0.44	10.9	9.5	1.6	−2.7
엄마	1.30	−0.43	10.8	9.4	3.0	−1.3
여기	2.67	−0.43	10.8	9.3	6.2	1.9
여자	0.88	−0.44	11.0	9.5	2.0	−2.3
예술	3.41	−0.37	9.2	8.0	9.3	4.9
이름	3.27	−0.40	10.1	8.7	8.1	3.8
전체	3.49	−0.38	9.5	8.3	9.2	4.8
정치	2.61	−0.38	9.6	8.3	6.8	2.5
친구	2.82	−0.40	9.9	8.6	7.1	2.8
통일	2.04	−0.42	10.4	9.0	4.9	0.6
학교	−0.38	−0.46	11.6	10.0	−0.8	−5.1
환경	0.88	−0.38	9.6	8.3	2.3	−2.0
M	2.33	−0.42	10.4	9.0	5.6	1.3
Minimum	−0.38	−0.53	9.0	7.8	−0.8	−5.1
Maximum	4.83	−0.36	13.1	11.4	11.9	7.6
Range	5.21	0.17	4.2	3.6	12.8	12.8
SD	1.23	0.04	1.0	0.8	2.9	2.9

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 2080%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects

국문초록

단어간의 대등한 명료도를 갖는 한국 어음청취역치 검사어표의 제작

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본 연구의 목적은 청력검사시 어음청취역치 측정에 사용될 한국어 이음절 검사어표를 제작하는 것이다. 일상 생활에서 사용 빈도가 높은 90개의 이음절을 한국어 형태소 및 어휘 사용 빈도의 분석(김흥규 & 강범모, 2000)이란 자료를 통해 선택하였다. 이 검사용 단어들은 한국어 표준말을 구사하는 각각의 남녀에 의해 디지털 방식으로 녹음되었다. 각 단어들을 정상 청력자 20명에게 10 에서 18 dBHL 까지 2 dB 간격으로 청취하게 한후, 15 개의 자극강도에서 인지도를 측정하였다. 90 개의 단어중 인지도 성적이 가장 좋은 36개의 단어를 선택한후, 각 단어의 역치가 연구에 참가한 20명의 정상 청력자의 평균 순음역치(4.33 dBHL)와 같도록 디지털 방식으로 조절하였다. 36개의 이음절에 대한 평균 인지도 곡선(%/dB)은 남자 목소리로 녹음된 것이 11.9%/dB 이고, 여자 목소리로 녹음된 것이 10.4%/dB로 나타났다. 단어간에 인지도가 서로 대등하도록 제작된 이 36 개의 이음절은 남녀 각각에 의해 브리감 영 대학교 한국 어음 청력 검사어표(Disc 1.0) 컴팩트 디스크에 녹음 되었다.

핵심어: 어음청취역치, 한국어, 이음절, 어음변별, 청각적 단어재인, 동질성

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